BEYOND BUILDING: 
DESIGNING SUSTAINABILITY FOR HUMANS

by
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A thesis
presented to Ryerson University
in partial fulfillment of the
requirements for the degree of
Master of Architecture
in the program of
Architecture

Toronto, Ontario, Canada, 2020
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Beyond Building: Designing Sustainability For Humans

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Abstract

Advancements in building design and technology have greatly lessened the environmental impact of cities and homes—however architecture encompasses much more than building performance. Contemporary sustainable design removes the burden of behaving in a sustainable manner from the occupant and hides it behind high efficiency equipment and passive design strategies. This approach to design makes up for irresponsible human behavior, it mitigates the outcome of a behavioral problem. This thesis explores how architecture may be able to step beyond autonomous efficiency and better engage its occupants with their environmental impact and the resources they consume. It explores how architecture may be able to bring legibility to systems of resource consumption that are currently obfuscated from building occupants and ultimately advocate a mode of use in servitude of sustainable goals.
Thank you to Miljana Horvat who provided me the guidance and support I needed to complete this thesis. You instilled a sense of rigor into me without which this work would never have been finished.

Thank you to Mark Gorgolewski for asking the hard questions and pushing me to think about things in new ways.

Thank you to Jurij Leshchysyn for helping me think outside of the box.

Thank you to Marco Polo for taking the time to sincerely read my thesis in addition to those of my peers. Your genuine passion for my work encouraged me to continue whenever I felt lost.
To my family,

for your unwavering love and support.

To my friends,

for making the hardest days a little easier.
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1987 saw the release of the publication, Our Common Future, by the World Commission on Environment and Development. The publication was the first to use the term sustainability in the context of environmental preservation. Since then, there has been a major shift in society’s attitude towards resources. In 2006, Al Gore debuted An Inconvenient Truth, which ushered in a new era of environmental concern by clearly illustrating the fragility of Earth’s complex ecological systems. In the following years, manufacturers found new success in marketing their products with a myriad of environmentally driven monikers. With everything from automobiles to take-out containers seemingly adopting ‘green’ sensibilities, architecture was a perfect fit for driving the sustainable narrative. Worldwide, 30% of greenhouse gas emissions are produced by buildings. This figure does not account for the processing of materials and construction process which would surely increase it. Within Canada, households alone account for 10% of the country’s water consumption, an act less innocuous than it may seem. Furthermore, these two factors only account for a small portion of an extensive list of ways that buildings contribute to environmental issues. Architects eventually began to accept their responsibility in the matter, and the term ‘sustainable design’ began to appear within academia and practice. Through policy changes and a growing interest in its effect on the climate, architecture became one of the largest avenues for pushing the sustainable narrative. As a field of study and practice, architecture encompasses many aspects of building design, however only some of them are being used to drive sustainability. For the most part, sustainable design today utilizes the technological aspects of architecture to pursue the goal of improved building performance. This thesis asks how aspects of architecture beyond the technological can be put to use for the same purpose. Architects use form, material, space and other such basic design strategies that play on human perception, emotion, and a variety of other phenomenological aspects—can these same design strategies be used towards the goal increasing the sustainability of buildings?

// Introduction
“But while [sustainable design] is changing the way architects work, and the technical detailing of buildings, its impact on the expressive qualities of architecture, beyond overtly ‘ecological’ buildings that wear their green credentials like a hair shirt, is still hard to discern.”

Sustainability is a concept that has been woven into many aspects of contemporary society. Nearly everyone today has an awareness of climate change and a position on their place in the context of the larger discourse. Given the scope of the issue, almost all aspects of day to day life contribute in one way or another towards the further scarring of the planet. Many of the actions and decisions people make throughout each day are influenced by the architecture around them.

Within the broader architectural discourse, sustainability is currently a prominent topic, however the focus is predominantly positioned outside the more venerable discussions on architectural theory. This disjunct relationship prevents architecture from fully acting on sustainability and instead passes this disconnect along to the building’s occupants. Put simply, sustainability is mostly associated with building performance, a topic often precluded from architectural theory and discussions related to experience and aesthetics.

Architects and building scientists focusing on building performance are occupied with reducing the energy requirements of buildings and in some cases, creating buildings that produce a surplus of energy. Net zero and energy positive buildings as objects unto themselves can be, for the most part, considered sustainable. In simulations and on paper, these buildings solve one of the largest roadblocks to achieving a sustainable future, however the reality does not align with these ideals. Buildings are more than objects in space, they enclose humans. Humans have the potential to behave in unsustainable ways regardless of the building’s performance, and architecture may have the capacity to act on that behavior.
This is not to say building performance should be ignored, it is an integral component towards a completed sustainable building, however alone it is not enough. Modifying the measure of a building’s environmental footprint to include the actions of those who use, pass through, and otherwise interact with it, suggests that architecture as a design process, imbibe the importance of sustainability. Where sustainable building performance operates on quantitative data and calculable outcomes, architecture can also operate on qualitative experiences and emotionally driven responses. If the actions people make throughout their day have an environmental impact, and many of these actions are influenced by the architecture around them, can architecture then advocate a mode of use in service of sustainable goals? This thesis explores how architecture can engage with issues of sustainability through its more qualitative attributes relating to the human, and questions what a more encompassing sustainable design looks like.

Endnotes
3 Weston, *100 Ideas That Changed Architecture*. 
CHAPTER I
1.1 Why Sustainability?

*Sustainable? Green? Eco-Friendly?*

Why has sustainability become such a prominent concern? Perhaps it is the recent influx of bleak reports from climate scientists purporting a new geological epoch titled The Anthropocene.\(^1\) The sensation of immediacy evoked by such reports reaches out to people on a personal level, the effects of human actions are beginning to present themselves in a measurable manner. Climate change now has temporality, where not so long ago it only described a loose and undefined future. This chapter will explore the meaning of sustainability, the factors that sustainability is measured by, and the relationship between this concept and buildings.

A generally accepted definition of sustainability is “The ability to maintain a defined behaviour or system indefinitely”\(^2\), however in the context of the environment, and for the purposes of this thesis, sustainability can be defined as “the rate of raw material and resource consumption that can be maintained indefinitely”.\(^3\) At face value this refers to the obvious; the overuse of resources such as fossil fuels such that they will eventually be depleted. And while this is true, there are other less apparent aspects of 21st century life, that would likewise be considered unsustainable in terms of the aforementioned definition.

A topic of great concern in recent years is the deforestation occurring in the Amazon. Aside from the more apparent issues such as habitat degradation and decreases in biodiversity,\(^4\) deforestation has taken a significant toll on soil fertility which reduces its ability to support future growth.\(^5\) A major cause of Amazonian deforestation, particularly in Peru, is for the production of palm oil, “the most widely consumed vegetable oil in the world”.\(^6\) The current demand for this resource in a wide variety of processed foods and cosmetics is unsustainable as it exceeds the Earth’s natural production capacity.\(^7\) A massive disconnect between consumers and the production of this resource exists due in part to geographical separation, industrial processing, and a lack of transparency from manufacturers. It is therefore difficult to fault the average consumer for being unaware that in purchasing a box of crackers or a new palette of makeup, they may be contributing to the desertification of the Amazon.
“Today, far too many people are clueless about where their tap water comes from; where their wastes go when they’re put in the garbage, recycling, or toilet; which plants and animals are native versus introduced or invasive; or how their electricity is generated. Most individuals underestimate the magnitude of their own environmental impacts.”

Humans require resources to live, as do all other living beings on planet earth. To live sustainably however asks humans to consider the source and impacts of consuming these resources. Some have more well-known environmental impacts such as fossil fuels, while others, like palm oil, are harmful in less apparent ways. The reality is that many people are not confronted with the destructive nature of many of their consumption habits and therefore do not consider changing their relationship with the resources they use.
Energy, Water, & Waste

Much of the discussion on issues of environmental sustainability focuses on climate change and greenhouse gases. It has become abundantly clear to scientists that climate change is a real and dangerous threat. Years of studying the issue has concluded that the main cause of these changes to the climate system is greenhouse gas emissions. The atmosphere is composed of a variety of greenhouse gases, and in general, they absorb and emit radiation that the Earth reflects back from the sun. Many of the greenhouse gases are natural such as carbon dioxide, methane, ozone, and even water vapour, while others are anthropogenic such as halocarbons and gases containing chlorine and bromine. On the surface it may seem that the natural greenhouse gas emissions are entirely out of human control due to the fact that they are naturally occurring. The reality however, is that while humans did not manufacture them, they are responsible for releasing them into the atmosphere in such vast quantities.

The term sustainability again comes into play, however for a different reason. The environmental changes that are occurring can not indefinitely sustain life on earth as it currently exists. The beloved polar bear is not alone in its current state of fragility, a primary concern is the continued viability of agriculture for humans. Many crops including corn, wheat, soybean, and rice exhibit significant decreases in yield when subjected increases or decreases to temperature. With an ever growing population, a decline in food production could be catastrophic. What then are the sources of greenhouse gas emissions and how can they be modified to steer away from such a grim future? A main contributor in Canada to the emission of greenhouse gases is the combustion of fossil fuels, mostly in the energy sector. Despite this, only 19% of Canada’s overall electricity production is a direct source of emissions. The remaining 81% is composed of renewables—nuclear energy production is included here, however the long-term sustainability of that process is too intensive of a discussion for this thesis.

Renewable energy sources are not only more common now than ever, they are being created at an exponential rate. Organizations such as the International Environment Agency (IEA) were unable to predict the rate at which renewable energy would grow, and woefully underestimated where the technology would be today. At the current rate of growth, there will be more than enough renewable energy by 2050 to power not only one planet Earth, but many. To many, this fact may be surprising. Perhaps it is due to human engagement, or the lack thereof, with the technology of energy production. Aside from passing a field of wind turbines on the highway, or observing an array of photovoltaics on a neighbour’s roof, it is unlikely that most people have the opportunity to interact with this technology at all. Consider something nearly every Canadian interacts with daily, their smartphone.
Figure 1.2: Wind Turbines, The Western Producer, 2019
Before June 29th, 2007, the cellphone was nothing more than a simple communication device, a slightly more nimble walkie-talkie. Apple’s introduction of the iPhone on the aforementioned date, set on course a change not only in terms of technological advancement, but in the way humans go about their lives. Since then, the rapid development and improvements to the smartphone have not only been staggering, but also tangible, occurring in the palm of everyone’s hands. The proliferation of smartphones is rather synonymous with that of renewable technology, however the former has been at the population’s fingertips while the other was growing and improving out of sight.

Greenhouse gas emissions and energy production are by no means the only area of concern when it comes to sustainability. For a planet that is mostly covered in water, it seems counterintuitive that this resource is one which requires attention, however the quantity of water is not the sole concern, “variations in the storage, fluxes and quality of water” are directly tied to the wellbeing of animals, plants, and virtually all ecosystems.

Individuals have a wide range of experiences and therefore unique understandings of resource. The United States exhibits significant variability of precipitation patterns, and these patterns directly drive land surface hydrological systems. Even along the same coast, the Pacific-Northwest is a humid climate with frequent precipitation, while the Southwest is quite dry with frequent periods of drought. This means that people in the humid Pacific-Northwest might view water as an abundant resource, while those in the dry Southwest consider it a more precious resource. In Canada water abundance is perhaps less of a concern, however water quality most certainly is. While most Canadians living in urban centres with robust water supply infrastructure would probably not think twice about filling a glass straight from their faucet, the majority of First Nations’ water systems are classified as at risk for contamination. These two distinct groups of people have drastically different relationships with this resource.

Regardless of the perceived abundance or quality of water, it is a resource which, managed incorrectly, will become more and more scarce and contaminated in the coming years, even for Canadians in major metropolitan areas. Unlike fossil fuels which will eventually be depleted, water is a renewable resource. Though despite this, mismanagement of water supplies—“overpumped groundwater sources, depleted river flows, salinization, and thermal, chemical, and biological contamination” — can lead to water scarcity and contamination. Human demand of this resource, even in water-rich North America can leave whole ecosystems with insufficient water, devastating plant and animal life.

**Note:** data from the United States is occasionally used interchangeably with data from Canada. This is only done in appropriate situations where it can be assumed that similar conditions would exist in both countries.
Figure 1.3: Over-pumped River, Will Seberger/Zuma Press, 2019
It is apparent that sustainability is a topic of great importance and that more awareness of resource consumption is going to be required going forward, however what does this have to do with architecture? Canadian households alone account for 33% of electricity consumption and about 10% of the country’s overall water use. Therefore a significant portion of the consumption of these two resources occur within the scope of architecture.

Buildings use electricity for a wide variety of outputs. From building-oriented technologies such as heating and cooling systems to objects of direct human engagement such as televisions, electricity is required to operate most aspects of a home. Buildings in North America spend the largest share of electricity use on space heating—an average of 30%—however this figure varies depending on regional climate. Other significant factors are cooling, lighting, refrigeration and water heating. Each of these elements are generally standard to most new homes and for many Canadians, constitute an expected standard of living. Earlier this chapter mentioned that globally, humans are on track to reach an entirely renewable future. While there should still be pressure on people to consume energy more carefully, the time will likely soon come when there is almost no resulting environmental degradation from energy consumption. As this is a future that is near and highly probable, this thesis will avoid focusing on issues of energy consumption.

In addition to consuming energy, buildings also consume water for various purposes. According to the Canada Mortgage and Housing Corporation, on average, an individual Canadian consumes 6,879L of water per month. Figure 1.4 provides a breakdown of various sources of water consumption within the home visualizes this volume. The data can provide some interesting insights into behaviours within the home. Using a typical 7.6L per minute showerhead as an example, the average Canadian showers for the equivalent of 5.5 minutes per day—or any other combination totaling 158 minutes per month. Using standard, or otherwise low-efficiency fixtures, the average Canadian does laundry around 19 times per month, flushes the toilet between 6 and 7 times per day and runs the dishwasher a couple of times per week. These are all generalizations and can vary depending on factors such as the efficiency of the fixtures in question, the duration of use for time-dependant fixtures such as showers and inconsistent use patterns from day to day.

Even still, these metrics remain somewhat meaningless. Residential water comes from a seemingly never-ending supply through pipes hidden deep beneath homes and city streets, and there is no point of reference for how much or how little is a reasonable amount to consume. Returning to the earlier discussion of sustainability and questioning how water can be sourced and used within the aforementioned definition of sustainability provides a much clearer understanding of this issue.
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<th>Consumption/Month</th>
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</thead>
<tbody>
<tr>
<td>Shower</td>
<td>229 L/Day</td>
<td>6,879 L/Month</td>
</tr>
<tr>
<td>Baths</td>
<td>4000 L/Day</td>
<td>1239 L/Month</td>
</tr>
<tr>
<td>Faucets</td>
<td>906 L/Day</td>
<td>2898 L/Month</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>90 L/Day</td>
<td>270 L/Month</td>
</tr>
<tr>
<td>Laundry</td>
<td>1401 L/Day</td>
<td>4203 L/Month</td>
</tr>
<tr>
<td>Toilets</td>
<td>1239 L/Day</td>
<td>3717 L/Month</td>
</tr>
<tr>
<td>Other</td>
<td>996 L/Day</td>
<td>3006 L/Month</td>
</tr>
<tr>
<td>Outdoor</td>
<td>837 L/Day</td>
<td>2511 L/Month</td>
</tr>
</tbody>
</table>

The average Canadian consumes about 229L of water per day, or 6,879L per month. The adjacent cubes help to visualize the scale of this volume of water next to a human.

Water consumption can occur indirectly as a side-effect of producing other consumables. For example, the 4000L cube of water in Figure 1.4 indicates the average daily volume of water required to produce a typical Canadian’s intake of animal products.

*Figure 1.4: Canadian Water Usage, Mitchell Cairns-Spicer, 2020*
Many ‘off-grid’ sustainable design projects rely on natural water sources — rainwater harvesting, well water, and lake pumping to name a few. Since these types of houses quite often necessitate specific conditions in rural locations to be as successful as they are, consider how a typical suburban home in one of Toronto’s many suburban neighbourhoods might do the same. Figure 1.5 depicts a conceptual house with a gross floor area of 200m² divided across two floors, representative of a typical detached house in Toronto. In terms of rooftop water collection, a house of this size would provide a total catchment area of 100m².

When designing a rainwater collection system, the catchment area is defined by the two-dimensional footprint of the roof surface, not the actual surface area of the sloped roof. Assuming the harvested rainwater was treated to become potable, Figure 1.6 graphs the CMHC’s average water consumption data for a family of four against monthly rainfall data for the city of Toronto. These graphs demonstrate how rainfall alone provides just barely enough water to maintain current consumption levels for only one of these uses at a time. It would therefore be impossible to sustain current water consumption levels using the catchment area of a typical Toronto home.
Figure 1.6: Canadian Household Water Usage By Fixture, Mitchell Cairns-Spicer, 2020

Water Volume (L)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Monthly Water Consumption

3,624L / Month

4,956L / Month

5,640L / Month

data from: CMHC & Government of Canada
If the catchment area of a typical home can not sustain the consumption habits of its occupants, how much bigger would it need to be? Figure 1.7 represents the size of catchment area required to collect enough rainwater to meet the consumption needs of a single person. Pictured is both the required catchment area for a typical Canadian and a typical European. The average consumption of water in Europe is significantly lower than in Canada, therefore requiring a much smaller catchment area. While it is theoretically possible for someone to build a house with a catchment area of this size, simply enclosing the area beneath it, even at a single storey, would result in a living area much larger than what would be appropriate for a single individual. Figure 1.8 depicts a conceptual home with the catchment area atop an appropriately scaled living area for both a single individual as well as a family of four. To understand the incredible size of these conceptual homes, Figure 1.8 also depicts them inserted into the context of a neighbourhood on a typical Toronto suburban site of 15m by 35m.

These studies not only help to visualize the incredible water consumption levels of the average Canadian, but also reinforce the need for a behavioural change. With growing interest in using on-site production of electricity and even food, the size of suburban homes simply do not permit the same to occur for water. The available catchment area of a typical home does not accommodate the vast amounts of water being consumed by households. It is worth noting that this excludes a situation where a smaller household size occupies a large home, such as a couple with no children living in a suburban home with a 15m by 35m lot. In such a case, the available catchment area would allow them to consume double the amount of water each, relative to a family of four living in the same home. It is unrealistic to suggest producing homes based on the conceptual drawings of Figure 1.8, therefore the amount of water an individual consumes should be reduced by a significant factor, an outcome necessitating changes to the way people think about water, and the way they use it.
Figure 1.8: Catchment Area Sizing in Suburban Neighbourhood, Mitchell Cairns-Spicer, 2020
Endnotes


3. Ibid.


11. Ibid.


17. Ibid.

18. Ibid.

19. Ibid.


22. Ibid.

23. Ibid.


2.1 Current Modes of Sustainable Design

On the surface, sustainable building design has come to the forefront of architectural discourse within practice and academia in recent years. When considering what constitutes a ‘sustainable design’ however, it becomes clear that this approach to making buildings has in fact been around since Terra Amata, the earliest known building constructed by a human hand.\(^1\) Though not driven by the desire to satisfy scientifically calculated performance criteria, early forms of architecture can be considered sustainable forms of building due to inherent necessity.\(^2\) With time, and thanks to tremendous technological advancement, buildings moved away from this inherently sustainable model and became the greenhouse gas emitting, water consuming, ecosystem damaging objects that many are today. A lot of these advancements in building design have not only become expected standards of living, but the United Nations considers “access to safe drinking water, adequate sanitation, energy for cooking, heating, lighting, food storage or refuse disposal”\(^3\) as human rights. While suggesting that everyone return to living in stick huts may be the most sustainable solution in theory, it is entirely impractical. Sustainable design today operates within the context of human needs and desires since the majority share of a building’s water and energy use goes towards occupant comfort.\(^4\)

Over the course of the past several decades, architects have conceived of sustainable design in a variety of unique ways. Simon Guy and Graham Farmer developed a set of six ‘logics’ for describing sustainable design which they based upon an array of existing ‘green buildings’.\(^5\) The first of their logics focuses entirely on performance-based design, while the remaining five incorporate more qualitative elements of architecture. Guy and Farmer employ these logics for the purpose of understanding the motivation for different approaches to sustainable design. For the purposes of this thesis, only the outcomes of these various approaches are of interest, and so they can be distilled into two categories which and will be referred to as; Performance-Sustainability, and Design-Sustainability. The former describes buildings which are designed to meet quantitative performance standards based on energy use and carbon emissions. These buildings are best described as high-efficiency machines that rely heavily upon mechanical equipment to operate correctly.

The latter category describes buildings which incorporate sustainable thinking into the architectural design process. These buildings often feature extensive passive strategies and consider broader social, political, and environmental issues. While they often employ active mechanical strategies, they are not as overtly technological as performance-sustainability buildings. This thesis aims to explore a way of thinking about buildings beyond these two models, however first it is important to understand the current landscape of sustainable design.
**Performance-Sustainability**

Buildings are closely related to issues of sustainability due to their reliance upon energy and water to operate. A common approach to addressing these issues is through improving building performance—the efficiency of mechanical systems within the building. In his book *Dimensions of Sustainability*, Andrew Scott criticizes this approach, “energy has too often become the domain of either the engineer to tweak the mechanical system or its controls or become the domain of the techno-enthusiast to bolt on renewable energy without examining the larger role and form of the architecture”. It is often the case, especially in large scale projects, that the architect relinquishes many of the energy and performance decisions to the engineer. Scott criticizes this practice as it disconnects all of those decisions from the larger architectural context. In doing so, the architecture can not inform the energy decisions and those decisions can likewise not inform the architecture. Guy and Farmer published the article *Reinterpreting Sustainable Architecture* in which they also criticize the technologically-centric approach to sustainable design. They explain that different architects and designers have come up with vastly different ideologies about how architecture should engage with sustainability. This blossoming of ideas resulted in a lack of clarity amongst academics and professionals, which the authors argue, resulted in defaulting to a more technologically driven approach. They claim, “typical are suggestions that if we are to achieve sustainable buildings then architecture should become more objective”. They lament the notion that incoherent ideas surrounding how architecture should respond to environmental needs should be set aside to be debated upon later, and in the meantime, buildings should become more objective and technological in nature. Such buildings mostly disregard qualitative concerns of architecture and are designed with a focus on performance.

As sustainable design has become more prevalent, and often required, many different strategies and guidelines have emerged to help designers and builders achieve more efficient buildings. One of the most prominent, and earliest sustainable design guidelines is LEED. LEED is both enforced and encouraged by governments worldwide, and in Canada alone, there are over eighteen million square meters of LEED certified construction. While LEED does account for some human health and quality of space aspects of the design, the majority of its checklist focuses on maximizing efficiency and performance. *LEED Canada for Homes 2009 Checklist* puts significant emphasis on water and energy use. With regard to the former, the checklist considers; rainwater systems, greywater systems, efficiency of fixtures, and flow rate of faucets and showers. With regard to energy, the checklist considers; heating and cooling technology, quality of HVAC design, R-values, air leakage rate, window design, water heating and distribution systems, lighting efficiency, appliance efficiency, and energy sources. Further to this structuring of its rating system,
LEED requires that buildings be measured against a baseline ‘reference building’. The reference building may be specified with less efficient mechanical equipment, however any passive design strategies incorporated in the actual building must also be reflected in the reference building. This process encourages designers to opt for reducing energy consumption through the implementation of high efficiency mechanical equipment simply because it will garner them a greater delta when compared to the reference building, and therefore a higher LEED rating.

Performance-sustainability buildings are by no means bad buildings, they play a significant role in the push towards lowering environmental impacts. They are however limited in their ability to engage their occupants with the importance of sustainable behavior which is the focus of this thesis. Perhaps this approach to design will always be necessary for large scale commercial buildings such as office towers, though when it comes to more intimately scaled buildings, there are significantly less limitations to the architectural design process.

**Design-Sustainability**

Whereas performance-sustainability buildings rely mostly upon mechanical equipment to provide occupant comfort, design-sustainability begins integrating sustainable thinking earlier on in the design process resulting in an architecture that unashamedly expresses its sustainable functions. This often results in a building that passively performs many of the tasks otherwise performed by mechanical systems and engages with sustainability in more meaningful ways. The architecture in this approach is far more connected to sustainable design principals and as a result, reflects this through its various design qualities; massing, materiality, space, etc. Though this category is not intended to simply define passive buildings, such strategies are certainly more prevalent within these types of buildings. Where a performance-sustainability building may appear visually identical to a less sustainable building—as all of its sustainable functionality is hidden away in mechanical spaces—design-sustainability buildings often stand out thanks to their incorporation of passive strategies such as deep overhangs or sawtooth windows. The design aspect of these buildings goes beyond passive strategies however. This category of sustainable building encapsulates a wide variety of approaches to design. Using Guy and Farmer’s logics, design-sustainability includes: buildings aimed towards preserving local biodiversity, buildings connecting people to nature, buildings engaging people with vernacular lifestyles, buildings focused on human health, and buildings aimed at improving social cohesion. While not an exhaustive list, it is enough to help differentiate design-sustainability from performance-sustainability.
Room For Improvement

In the paper *Sustainable Architecture as a Cultural Project*, authors John McMinn and Marco Polo advocate for a shift from a technological approach to sustainable design towards one that incorporates aspects of vernacular design and knowledge.\(^\text{15}\) The paper includes a variety of case studies on buildings which demonstrate this approach, one of which is the Nicola Valley Institute of Technology (NVIT) in Merrit, British Columbia. The design of the school integrates various elements from traditional aboriginal architecture. From positioning on site, to material selection, the architects referenced aboriginal building techniques to inform their design. Visually, the building has a clear ‘sustainable’ expression—it is placed into a hill, includes a green-roof, minimal glazing, and local materials. When it comes to the operation of the building, it draws on aboriginal design techniques as well, however it implements them in a technologically-dominant way. The building references the ventilation principal of a tepee, though it abstracts it to such an extent that the resulting architectural expression of it is unclear. Using a two-story atrium and operable roof vent, air travels through the building in a vaguely similar manner to a tepee, however without any design cues to signal this process, the atrium—as beautiful as it is—is more so a performance-focused design. Beyond the building’s passive measures, it relies upon a, “fully integrated environmental system with advanced controls to optimize performance”.\(^\text{16}\) So while the building can very easily be categorized as a design-sustainability building, it does not shy away from falling back on highly technological solutions which are obfuscate the sustainable functions from the occupant.

*Figure 2.4: Nicola Valley Institute of Technology, Maclean’s, 2020*
It is commendable how the Nicola Valley Institute of Technology tries to reframe sustainable design towards a social cause—McMinn and Polo laud the building for how it “demonstrates how First Nations clients can express their cultural identity not through the sentimental replication of traditional formal typology, but by espousing the principles of green building in a contemporary re-interpretation of the imperative of environmental stewardship”.17 The design itself clearly respects cultural identity and it does so without being ‘tacky’, however the traditional design loses most of its ability to communicate environmental stewardship in the transition to a more contemporary aesthetic. As honorable as the building’s intentions are, its ability to express the importance of sustainable behavior is masked behind a design more focused on modernizing traditional aboriginal building techniques. The traditional form of a tepee is very clear in its communication about its function. The ubiquitous knowledge of its method of construction and the communal engagement in the act of its erection(citation) allowed its function to be universally understood. Much like the igloo and its widely understood method of insulating, these traditional buildings are symbols of their respective modes of operation. To abstract these symbols to the extent the NVIT did strips away their locally understood meaning.

These types of design-sustainability buildings embed ideas of sustainable design deeply into the architecture and are more aligned with the ideas being put forward in this thesis, however they fail to completely break away from performance-oriented thinking. For the most part, these types of buildings continue to direct the responsibility of sustainability unto themselves — objects requiring optimization — without acknowledging the behaviours and habits of the occupants within. To push sustainable design further would require the building to acknowledge its role, simply a facilitator of energy use at the hands of the humans within it, and likewise remind those humans of the impacts of their actions.
Endnotes


7 Guy and Farmer, “Reinterpreting Sustainable Architecture: The Place of Technology.”

8 Ibid.

9 Ibid.


12 Ibid.


14 Guy and Farmer, “Reinterpreting Sustainable Architecture: The Place of Technology.”

15 McMinn and Polo, “SUSTAINABLE ARCHITECTURE AS A CULTURAL PROJECT.”

16 Ibid.

17 McMinn and Polo, “SUSTAINABLE ARCHITECTURE AS A CULTURAL PROJECT.”
CHAPTER III
3.1 Architecture, Humans, & Sustainability

Within this discussion of sustainability and architecture, it is important not to lose sight of the more profound and emotional qualities that architecture brings to the table. One of the major questions this thesis puts forward asks how architecture can better engage people in issues of sustainability. This chapter explores this question and evaluates whether or not architecture may be able to directly communicate ideas, concepts, and knowledge to its occupants through design.

The complexity of architecture is equitable to its subtlety, a true understanding of its intentions is often difficult to discern without the careful explanation by its creator. Consider the work of Carlos Scarpa, particularly his detailing. Scarpa’s Campiello bridge in Venice has significant cultural identity embedded within it. The material choice and detailing make reference to shipbuilding and Venice’s historical reliance on transport and trade. The design itself does not directly convey this information—perhaps at most it expresses a nautical aesthetic. Despite this, the bridge manages to find itself on numerous Venetian travel guides, which suggests that regardless of expressed intention, the design is able to provide delight. Conveying information through architecture alone can be challenging, especially when it shares the complexity of the meaning found in Scarpa’s bridge. This is not to say that architecture can not convey anything, however unlike the precision of knowledge that can be conveyed through the written word, architecture communicates in a more rudimentary way. In his essay *Give Me a Gun and I Will Make All Buildings Move*, Bruno Latour neatly summarizes this notion of architectural communication with the word ‘translation’. “Drawing and modeling do not constitute an immediate means of translation of the internal energies and fantasies of the architect’s mind’s eye, or a process of transferring ideas from a designer’s mind into a physical form, from a powerful “subjective” imagination into various ‘material’ expression”. So here Latour is using translation to describe the
Figure 3.1: Carlo Scarpa Bridge & Rail Detail, Karen August, 2008
transfer of an architectural concept to the completed building in a clearly understandable manner. When considering the concepts of typical architectural theory such as spirituality, emotion, politics, craft and others, there are countless buildings which successfully convey these meanings on various levels. Is it therefore possible for sustainability to be conveyed in a similar manner?

Research outcomes show that architectural design of the human environment has an impact on both people’s moods and their behaviors. The environments humans occupy have changed quite dramatically since the times of early hunter gatherers, but that’s not to say that we are masters of our environment. In their discussion on a set of psychological studies of architecture’s impact on social behavior, Andrew Baum and Stuart Valins posit the relationship between humans and their surroundings. “While we tend to think of ourselves as masters of the environment, we are necessarily involved in a continuous interchange with our surroundings.” There is an ever-evolving dynamic engagement between humans and the environments they find themselves in. Whether these environments are natural or part of the built world, humans always exist within an environment and are subject to its influences.

Humans are influenced by their environments, but environments are likewise influenced by humans. Most of the developed world spends their time in the built environment, an organization of solids and voids, conceptualized, designed, and built by humans. Architects are tasked with designing suitable environments for people to occupy, and as with anything, there has been significant debate on what is most suitable for humans. The Darwinian Henderson Challenge is a process whereby the interests of the self become secondary to the fitness of the surrounding environment. It suggests that the individual must be placed in the fittest environment unto which it will adapt. Ultimately the outcome of this process is presumed to be superior from a holistic perspective, despite the initial difficulties it presents to the individual. The vast majority of architecture defies this principal through its inherent desire to please and provide comfort. Architecture though, has a unique ability to convey information and ideas in ways unlike other artistic mediums, and it is often through difficulties and discomfort that these ideas are best conveyed. Consider storage solutions found in many homes, such as kitchen cupboards or built-ins found in a living room. In general, they are designed to provide ample storage for various items while maintaining a tidy appearance. For some who participate in a lifestyle of overconsumption, the cupboard’s ability to obfuscate the reality of mass consumerism only acts to further enable it, a damaging act on the environment. Imagine if the same kitchen cupboards became
harder to open as more and more superfluous items were stored there. An architecture that challenges how people expect it to operate may be uncomfortable to the individual, however it brings with it the possibility to create awareness, change behavior, and move the collective in positive direction. It is easy to imagine an architecture that increases the difficulty of how people engage with it, however the Darwinian Henderson Challenge does not necessitate a negative experience.

Architecture that challenges conventions could provide even greater pleasure than it would otherwise be expected to. In this way, the intended awareness and behavioural changes result from a positive experience, seemingly self-directed as opposed to promulgated by the architecture. Olson Kundig Architects who are known for the complexity of their ‘scarpa-esque’ detailing, produced a beautiful mechanical door handle for their Montecito Residence project [fig 3.2]. Unlike a traditional door handle, this design forces the user to stop and examine it for a moment to discern its method of operation. Enjoyment can be found through the involved tactility of operating the door’s mechanism. Though the door handle does not operate on issues of sustainability, the design principal may be translated to suit that outcome.
It is difficult to answer the question of how best to design architecture to meet human needs as there are a great variety of humans with their own sets of unique desires and needs. An architecture that goes beyond current sustainable design strategies would be one that is effective at meeting human needs while simultaneously reducing their environmental impact. Architecture has been used to convey meaning for thousands of years. From the Egyptians who built megastructures in honor of the dead and to map the cosmos, to Le Corbusier’s Unité d’Habitation which was designed to his system of human proportions, architecture goes beyond simply building and incorporates ideas, beliefs and traditions.

Within the contemporary period, architecture’s method and ability to communicate has been a topic of debate. In a 1971 conference on architecture and human behavior, Australian professor Jon Lang suggested that much of the architecture coming out at the beginning of the 1970s was unresponsive towards humans. Contrary to Lang’s perspective, Robert Venturi, one of the most dominant voices during the transition from modernism to post-modernism, argued in his 1966 manifesto *Complexity and Contradiction in Architecture*, that modernist architecture was mostly void of communicated meaning. In his criticism, Lang is referring to the postmodernist style that was born in part due to Venturi’s manifesto. This style of architecture greatly departed from the modernist approach of ‘form follows function’ and returned meaning to the forefront of design. It is important to recognize that the absolutist perspective of each of these men did not necessarily paint an accurate picture. Modernist architecture certainly had meaning embedded in it, however it was less accessible to the layman. Postmodernism on the other hand is so evident in its intended meaning that these buildings often lack the depth of modernist work. Consider Scarpa’s bridge again in contrast with the Sydney Opera House. While not technically a postmodern building — Venturi would argue it to be modernism taken to the extreme — the Sydney Opera House certainly places symbol above all else in the design. The allusions to a ship are abundantly clear thanks to the nested shells very clearly expressing the form of sails. Comparing this with Scarpa’s bridge which also references the idea of ships, the latter is harder to read, however there are significantly more layers of meaning to uncover. These two approaches of architectural ‘translation’ are effective in their own ways as the idea that they are trying to translate is easily symbolized — as is the case for the Opera House — or are able to be represented through craft and material — the case for Scarpa’s bridge. It becomes more difficult to translate ideas through architecture when those ideas do not lend themselves to any method of representation or symbolism however.
3.2 Design For Sustainable Behavior: A Case Study

In her doctoral research on how product design might influence sustainable behaviors, Debra Lilley proposed a framework which outlines a range of behavioral influences that can be achieved through design. At the one end, all of the power is placed in the product. This uses persuasive methods to change the way people think and act, and often does so without their knowledge. On the other end, the product can put the power in the hands of the user which simply guides change, relying on the user to understand what the product is trying to convey. In the middle is what Lilley refers to as Behavior Steering, whereby the product actively encourages the user to behave in ways intended by the designer by clearly showing affordances and constraints.

Lilley’s framework is a distillation of her broader research outcome which is a set of design strategies for influencing behavior. Each of these strategies can be placed at a point along the range provided by her framework. Since these strategies are targeted towards product design, not all of them are directly applicable to architecture, however there are several key strategies which may help to provide a scope for architecture’s ability to influence behavior.

affordances: the way an object’s various properties suggest how it may be interacted with, i.e. a doorhandle that suggests it should be either pushed, pulled, or turned.

![Figure 3.3: Power in Decision Making, Debra Lilley, 2011](image-url)
The first of Lilley’s strategies is ‘Design Oriented Education’ which is situated towards the ‘user’ end of her scale. This design strategy aims to bring consumable products to the forefront of people’s awareness by physically revealing them. Beyond this, the products within this strategy encourage new forms user engagement with resources. The example provided by Lilley is a ‘power aware cord’, which visually represents the flow of electricity between the outlet and device it is powering. There are many possible avenues to explore when it comes to adapting this principle to an architectural context. As discussed in Chapter I, buildings facilitate the use of resources and very often, this resource consumption obfuscated from the occupant. When humans consume water within a building, the resource itself is seen when in use, however only in a curated fashion. The design of a home’s plumbing system is such that the stream of water is only visible in the brief window between the faucet and drain. This design does not allow for one to be faced with the gross consumption volume over the course of a given time. There are various possible design outcomes to make the method of consuming water one which aligns with design oriented education, though the driving principle would be a clear demonstration of the quantity and rate of water being consumed by the occupant.
Moving towards the ‘product’ end of Lilley’s scale is the strategy, ‘Design Oriented Rewarding Incentive and Penalty’. In this strategy, the product engages with the user in a more active way by providing either rewards or consequences depending on its use. In terms of sustainability, the product is a point of engagement between the user and a resource and would therefore provide a reward when used sparingly, or a consequence if used in excess. Lilley provides the example of the ‘Flower Lamp’ designed by Interactive Institute which changes shape based on the household energy use trends. During periods of low energy use, the lamp is in full ‘bloom’, while during periods of intense energy use, it retracts into a closed tube shape. The reward for sustainable energy use is therefore an improved quality of lighting, and likewise the consequence for excessive energy use is a dramatic reduction in the quality of lighting. The intention is that users would desire the higher quality of lighting, and therefore be motivated to behave in a more sustainable manner. Another example is the aforementioned concept of a kitchen cupboard that becomes more difficult to open as it fills up with unnecessary items. It is easy to imagine numerous ways that Lilley’s concept of incentive and penalty can be applied to elements of resource use throughout the home.
Further towards object driven change is the strategy, ‘Design Oriented Technical Intervention’ which uses technological means to influence and control user behavior. The example Lilley provides is the ‘Energy Curtain’, again by Interactive Institute [fig. 3.7]. This curtain is composed of two parts; the inner-face of fabric interwoven with fibre optics, and the outer-face of solar cells. A battery is used to store the energy collected throughout the day, and at night powers the fibre optics to illuminate the interior space. The curtain is designed such that its functionality is reliant upon how it is used, “it prescribes a certain physical gesture and habitual activity in order to effect the aesthetic and functional transformation of the context”. Studies were performed by placing the energy curtain in people’s homes and monitoring the occupants’ behaviors. It resulted in several surprising effects, most notably a family who rearranged their furniture to take advantage due to re-evaluating the importance of natural light. The previous strategies relied heavily upon user agency — the product demonstrates resource use and asks the user to reconsider their behavior — where instead, this strategy begins to act more so on the subconscious, creating opportunity for the user to begin to change their habits and behaviors without being fully aware of why. The reliance upon this subconscious effect makes this particular strategy difficulty to design for, as there is no certainty in the outcome. The previous strategies offer a clearer cause and effect, meaning that their impact on user behaviour is more easily predictable.
The final strategy is one where the object is entirely responsible for the decision making and operates in a sustainable manner without the need to change the user’s behavior. Lilley simply titles it, ‘Clever Design’. This is the strategy employed in performance-sustainability designs. It is one that operates outside the occupant’s awareness and is the simplest form of sustainable design. It assumes the occupant will behave in an unsustainable manner and through technological solutions, does its best to mitigate the impact of that behavior. Lilley provides the example of an ‘integrated toilet and washbasin’, a form of greywater system. These integrated systems function by reusing water drained from the sink for use in the toilet. The principle behind this system is well intentioned, however it does not effectively communicate its function with the user and therefore has little to no impact on their behavior. Unlike the previous strategies which provided prompts and incentives for the user to act in a desired manner, this one does not offer the user such agency.
Further to Debera Lilley’s development of these various strategies of designing for sustainable behavior, she performed observational studies to determine the potential effectiveness of them. She concluded that there is opportunity to affect behavior and it can be done through the implementation of her various strategies. She noted that it is particularly effective to provide people with options when engaging with products so that they have the opportunity to “think about their behavior and take responsibility for their actions”.

Lilley followed up these observational studies with interviews from which she was able to discern the barriers preventing people from engaging in sustainable behavior. The barriers noted by the participants reflect the design strategies proposed by Lilley; being unaware of resource consumption, being unaware of the connection between actions and environmental effects, and the assumption that the product was sustainable on its own without the need for modified behavior.

Lilley’s exploration into this topic is a pragmatic one, and though it is based on product design, it can easily be adopted into architecture. The following design exploration was inspired by Lilley’s framework of behavioural influence. The intent of the exercise was not to identify a solution or an ideal, but instead to explore various ways that her work could be interpreted through architecture.

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Re-framing the Washroom
A Design Exploration

As discussed in Chapters I & II, water is a resource which is often taken for granted, however due to its important role in ecosystems, temperature regulation, and human survival, it is important that people pay attention to their consumption habits. Since the majority of water is used in the washroom, it is a suitable place to begin exploring ways of bringing awareness to the use of water as a resource, and shape behavior towards using it in more sustainable ways.

Figure 3.8 depicts a typical washroom composed of a toilet, sink(s), and a bathtub/shower. Though not expressed visually, this washroom is a high-performance sustainable design. Through the technological aspects of this space such as low-flow faucets, grey water systems, and dual-flush toilets, this washroom is able to reduce water consumption regardless of occupant use habits.
Such strategies, while effective, do not provide the occupant with any insight into the impacts of their water consumption, nor do they provide the occupant with the option to engage in more sustainable behavior. The following design research investigation looks to explore how the architectural design of the bathroom might change to offer additional support in reducing water consumption by recognizing the agency of the occupant.

The first steps of the exploration [Fig. 3.9 & Fig. 3.10] were to modify basic tectonic and visual elements to disrupt the user’s experience of the space. Generally, bathrooms are comfortable spaces, often designed with greater attention to detail than other rooms in a house. This comfort and delightful design creates a space that encourages people to prolong their use of it, which could lead to excess use of water. Using a displeasing coloured filter over the lighting would create a feeling of discomfort, perhaps discouraging the user to spend a prolonged period of time in the shower. Offsetting the tiles creates a physical discomfort which might curb the user’s desire to use the space, only entering when necessary.
The next iterations of the space [Fig. 3.11] look at stripping the washroom of its tectonic elements that could be considered beautiful and enjoyable. In doing so, the intent was to reframe the washroom as a utility space. By taking away the focus from the broader architectural elements, the objects (sink, toilet, and shower) become more clearly defined. In this case, the goal is for the occupant to consider the washroom as pure utility, and only use it as necessary.

The final design investigations into the washroom explore strategies which are more engaging for the occupant [Fig. 3.12]. The first strategy integrates a water trough within the design of the washroom. The trough operates by collecting drained water from the sink and shower throughout the day. The intent is to clearly illustrate the amount of water being consumed. This accumulation of water is otherwise entirely obfuscated from the occupant. Displaying the result of their water consumption in this way, forces the occupant to consider their water use habits.
The second strategy implements a water pump which would require manual operation from the occupant to allocate enough water for its intended use. The water allocation tank is visible through a glazed portal which demonstrates the water for a certain use in its totality as well as clearly visualizes the rate of consumption.

A lot can be learned from exploring these various design strategies. Though none of the approaches provide a convincing method of shaping behavior towards a more sustainable outcome on their own, there are successful elements that can be carried forward into further design research. Using architectural elements to render spaces uncomfortable is provocative and interesting from a conceptual point of view, however it makes little practical sense. It is possible that this approach could result in the occupant decreasing their water consumption, however it would not be as a result of a newfound understanding of water’s importance, it would simply be as a result of feeling uncomfortable in the space — a change in behaviour but not a meaningful one. The final strategies begin to look beyond basic tectonic modifications, however the way they have been implemented is rather primitive and lacking focus. The possibility of visualizing water use as a sum of daily consumption is an analogue of Lilley’s concept of Design Oriented Education, which she has proven to be an effective tool and is something that is carried through to future design work in this thesis.

The most critical takeaway from this exercise came from addressing the architectural elements such as the floor, walls and lighting, leaving behind the actual elements that facilitate direct engagement with water. No matter how much the space itself changed around them, the sink, shower, and toilet remained the same. If the goal is for architecture as a design medium to engage people in a deeper level of thought about their resource consumption and change their behavior in a meaningful way, then it is possible that the boundaries of what is considered architecture within a space such as the washroom would need to be expanded. By beginning to consider the toilet, the sink, and the shower as elements of the home’s architecture rather than discrete objects, many new avenues of design open up.

Lilley’s research is pragmatic in that it demonstrates tangible and practical design strategies for changing behaviour. As an artistic medium, architecture goes beyond the pragmatic, it has the capacity of eliciting emotional responses, something absent from Lilley’s work. The problem with discussing architecture’s more subtle qualities is that they are nearly impossible to measure due to differences in each individual’s experience of it. As with any art form, a particular building may elicit a powerful reaction from one person while another may find it to be banal. Despite this, it is worth exploring what causes such strong reactions towards architecture to occur and if it is possible to use that phenomena in pursuit of a more sustainable design.
3.3 Extraordinary Architecture Experiences

Architecture may have the capacity to change the way people think and even behave, but how can this be harnessed, and how can design translate such an abstract notion to tangible reality? Phenomenology is often turned to as a general way of helping explain the immeasurable qualities of architecture. By definition, phenomenology is the study of direct human experiences, where those experiences are directed towards objects in the world. Though there is a wide range of potential experiences that fall under the study of phenomenology, architects are particularly fond of emotion, perception, and memory. Peter Zumthor consciously designs in ways that aim to elicit emotional responses. He does so through various means, though he is perhaps most renowned for his understanding of material.

While some architects such as Zumthor have an intuitional understanding of the experiences described by phenomenology and the strategies that can be used to elicit them, little work has been done to explicitly quantify such experiences. Understanding what causes such experiences in architecture is difficult, especially given much of the current body of literature exploring this subject. Many investigations into this question frame architecture as object and only discuss aesthetic experiences. Within architectural education, often instructors have unique understandings of phenomenology, and the pedagogy of this topic can therefore become muddled.
“The sense that I try to instill into materials is beyond all rules of composition, and their tangibility, smell, and acoustic qualities are merely elements of the language that we are obliged to use. Sense emerges when I succeed in bringing out the specific meanings of certain materials in my buildings, meanings that can only be perceived in just this way in this one building.”
Philosophy is a common avenue for seeking an answer to the meaning of phenomenology, however much of the discourse within this area of study is far too abstract to be of much practical use in architectural design. As described by Julio Bermudez in his book Architecture, Culture, and Spirituality, “a Premodern position will normally present beauty as a disinterested, non-rational and emotionally arousing experience that is immediately accessible through sense of perception, and with the ability to deliver profound insights and pleasures—and possibly the transcendent.” Referring to philosophers such as Kant, Schopenhauer and Stolnitz, Bermudez is describing their position on phenomenology as something that is outside of practical reasoning and only measurable within an individual’s experience. He goes on to explain how “Few philosophers have really studied architecture, and even fewer interrogated its relationship to beauty and experience in any depth”.

Frustrated with the lack of answers found in the abstraction of philosophy, Bermudez was driven to derive a scientific method of determining if profound experiences can occur when experiencing architecture, and what causes them. Ultimately, he conducted a series of nearly 3,000 polls which asked people to explain their most profound architectural experiences, or EAEs (Extraordinary Architecture Experiences):

“An encounter with a building or place that fundamentally alters one’s normal state of being. By ‘fundamental alteration’ it is meant a powerful and lasting shift in one’s physical, perceptual, emotional, intellectual, and/or spiritual appreciation of architecture. In contrast, an ordinary experience of architecture, however interesting or engaging, does not cause a significant impact in one’s life”.

Due to the strongly worded description of an EAE, the numerous poll response alone confirm that such experiences occur. To help frame the significance of the study’s results, Bermudez notes that, “Nature reserves lasting memory only to those events that are significant in our lives”. Of all respondents, 64% noted a ‘strongly vivid’ recollection of their EAE, 34% noted a ‘moderately vivid’ recollection of their EAE, and the remaining respondents described their recollection as ‘vague’. In addition to this, the study also found that EAEs are not necessarily frequent (with 61% of respondents reporting less than five lifetime EAEs), however they are powerful and vivid, as 87% of respondents reporting that EAEs are the most memorable of all “very strong life experiences”.

Bermudez explains that when asked to recall the qualities of their EAEs, the overwhelming majority of respondents described them as “emotional, sensual/perceptual/physical”. Based on the results, he concludes that most EAEs involve both inward and outwards perceptions with regard to the body. He states that “EAEs involve a simultaneous perception of both sides of the subject-object interface”.

**EAE**: Short for Extraordinary Architecture Experience, it is a term coined by Julio Bermudez to quantify the otherwise transcendent experiences that are elicited for many people when encountering architecture. Most often, the architecture that elicits such an experience is foreign in design such as places of worship, cultural centres or any other building that can be described as being outside of a conventional design.
Of most notable importance to the topic of this thesis is that 55% of respondents reported “insight” to be a primary outcome of their EAE (45). According to Bermudez, the results of his study reveal the psychological state of people undergoing an EAE. He explains that the mind of someone undergoing such an experience, “is not one burdened by analytical or interpretive operations. Instead, it is one that is effortlessly and immediately gaining insight via the body, sensations, emotions and intuitions” (45). Such experiences are therefore quite primal, they operate on a basic level of sensory input.

Perhaps the most interesting outcome of this study however was that the average distance between respondents’ homes and the buildings from which they experienced EAEs was nearly 6000 km. Though the study itself did not provide any direct insight into why this may be the case, Bermudez postulates that there is a ‘pilgrimage effect’ at play, whereby the distancing from one’s area of comfort and the immersion into a foreign culture causes the mind to rely on “direct perception, emotion, and intuition” (45) to drive consciousness rather than the traditional analytical structure of cognitive operation which occurs when the mind is in a familiar place (45). Bermudez is claiming that familiarity is a barrier to these experiences. To look beyond architecture momentarily, Russian formalists suggest that defamiliarization of language is the method by which poetry stands separately from other forms of writing (45). The results of Bermudez’s study suggest the same for architecture, that experiences beyond the ordinary occur when familiar expectations of architecture are disrupted. Returning to Zumthor’s text, Thinking Architecture, there is beauty in the way his words are precisely echoed by the results of Bermudez’s study. Zumthor describes his childhood understanding of poetry to be an arrangement of allegories, metaphors and other such acrobatic language. He came to learn however that poetry is “unexpected truth”.\(^{21}\) He draws a parallel to architecture, where often it is thought of as compelling arrangements of geometry and space, however instead he suggests that, “It is concerned with insights and understanding, and above all with truth…it may possess subtle qualities, which, at certain moments, permit us to understand something that we were never able to understand in quite this way before”.\(^{22}\)

To Zumthor, architecture’s artistic role and its ability to communicate with people was intuitively understood. Bermudez set out to discover if this intuitive understanding possessed by certain architects was founded in lived experiences, and to quantify these experiences scientifically, beyond the conjecture of philosophical theory. The results of his study give credence to the belief that architecture can communicate with people on a level beyond the aesthetic. The study manages to identify the aspects of architecture which allow for EAEs but is it possible to use them as a toolset for creating a design that communicates something more practical such as the importance of sustainability? The following design exploration attempts to adapt what was learned from Bermudez’s work.
Experience Pavilion
A Design Exploration

The design exploration takes the form of a wilderness pavilion. The program of a pavilion is a response to the types of buildings reported in Bermudez’s study, as they were all visited buildings rather than occupied buildings. By siting the building in a natural setting, it removes all contextual architectural elements, the first step towards enabling a foreign experience to be created. For many Canadians, there is a widely shared aesthetic of what a wilderness pavilion should resemble. Typically these types of buildings are constructed using wood sourced from the site itself, they often take the form of an A-frame cottage, and are usually quite simplistic in their construction. The design of this pavilion however offers a cold, monolithic aesthetic, confronting its users with a starkly different appearance than would otherwise be expected.

The building’s purpose is to engage its users with various ways that they engage with water. The method by which the building asks the user to engage with water however is intended to be entirely unfamiliar. The previous design research identified that the fixtures in a washroom are closely tied to people’s understanding of that space. A person can identify a washroom as being a washroom no matter what form it takes, so long as it contains a sink, toilet, and shower. These objects and their arrangement are familiar and provide a sense of comfort. In order to create a foreign environment, the pavilion removes this familiarity and comfort by reframing these various modes of engagement.

To access drinking water in a typical home, it is generally drawn from a faucet, either in a sink or watercooler, and collected in a cup. The pavilion does away with the faucet, and creates a wildly different mode of engagement. At the end of one of a long and narrow space are three tubes hanging from a glazed portion of the ceiling [Figure 4.11]. Above the glazing is a water trap which directly feeds the tubes below. The user is presented with the available water above them and asked to place their mouth on a piece of the building itself to draw the water out. Instead of hiding a long and complex process behind a faucet, this design strips it down to its essential components the source of water and the transfer of it to the human. The pavilion reveals something about this resource, while also creating an alien experience in an attempt to evoke new questions and thoughts.
Figure 3.14, Unfamiliar Water Consumption, Mitchell Cairns-Spicer
The pavilion likewise reimagines the process of defecation, urination, and bathing. Much like the faucet, the toilet and shower are deconstructed and reframed in more architectural terms. Instead of a washroom being an arrangement of objects where walls, floor and ceiling are secondary to the function of the space, this design imagines the toilet and shower as a room, where the floor and ceiling are inherent parts of the system. The function of the toilet and shower are split between two levels. The lower level provides an object which approximates a toilet seat, however the actual function of the toilet is performed by various parts of the building. Where the washroom is typically a space of refuge and privacy, a large glazed wall instills a sense of discomfort and unease, sensations that are compounded by the orientation of the toilet seat, asking the user to turn their back on the open wall. While using the toilet, waste falls to a drainage grate below. The building does not provide toilet paper, and so the user must climb the stairs and clean both themselves and the building using the shower. This process draws the user into a system they are otherwise disconnected from. Like the intended outcome of the water tubes, this foreign experience is intended to leave the user with questions and thoughts about their relationship with water consumption in the washroom.

Figure 3.15: Experience Pavilion Section, Mitchell Cairns-Spicer
This design exploration remains a speculative exercise and the outcomes are intended to be provocative and exploratory rather than representative of a proposed architectural response. The anti-program of the pavilion allowed the design to explore beyond the confines of realism, pushing humans to an uncomfortable extreme. The main problem that the pavilion presents is that one person would likely have a different experience and response to the building from another. To some the building may elicit feelings of disgust, and to another it may provide them a sense of connectedness with nature. The design had an intent from the outset but the experience of each individual encountering it would be impossible to predict. Though the pavilion did not result in useful design elements, it ultimately points towards the variety of reactions individuals have towards architecture, and how this one factor positions Bermudez’s work as an interesting way of measuring experience, but not a tool for creating it.
Bermudez’s study concluded that exposure to an entirely foreign space increases the likelihood of the occupant receiving insights from the architecture. What is not mentioned in the study is that foreign is subjective, and what might be foreign to one is familiar to another. Conceptualizing a design with the intent of it being foreign is hindered by this incongruity of human experience. Bermudez’s research is unique in that it attempts to understand and quantify highly immaterial experiences. While he has brought a new understanding to these experiences and measured them in a way that clarifies their existence, this does not mean that this knowledge can be used to construct spaces with the intent of eliciting such experiences. His research focused on the architectural outcome that causes such experiences to occur, rather than the design process that produced them. When Zumthor designs a building with the intent of creating an experience, he can not control how every individual will receive it. It is likely that for many, stepping into his Field Chapel would elicit some sort of profound reaction, however it would also be quite different for each individual. Those who are spiritual may find an entirely different experience than those who are not. Zumthor’s claim of designing “meanings that can only be perceived in just this way in this one building” is surely a beautiful idea, however the reality is that buildings can only be designed with an intended way of being perceived, as each individual may perceive it in their own unique way.

Architecture has a unique ability to communicate with people through a range of communicative modes. Towards the more pragmatic end of the spectrum are the design strategies developed by Debera Lilley. Her idea of communication in design offers design tools which allow architecture to communicate simple ideas very clearly. Through proven research, she determined effective methods of using design to communicate various concepts of sustainability in such a way that it had lasting effects on the user’s understanding and behaviour. On the other end of the spectrum is the research performed by Julio Bermudez into the more elusive and experiential qualities of architecture. This research is centred around concepts more venerable within the discourse of architectural theory and have been particularly romanticized by academia and certain architects. Bermudez was able to quantify and prove that architecture has the capacity to elicit strong emotional, spiritual, and transcendental reactions. The design exploration however highlighted that despite the ability to measure such experiences, it is not always the experience intended by the designer.

If the goal is for architecture to communicate ideas about sustainability and shape human behaviour to become more sustainable, then a pragmatic approach is more appropriate. Sustainability is concerned with many things, but most of it is best communicated in a clearly understandable method. There is a place for architecture that attempts to connect people with nature and resources through emotional experiences, however for the purposes of affecting change, a clear and pragmatic design approach is necessary.
Endnotes

1 Alan Sherlock, “Regional Identity through the Detailing of Carlo Scarpa” (2013).
4 Baum and Valins., 1
9 Ibid.
10 Ibid.
13 Ibid.
15 Ibid.
22 Ibid.
CHAPTER IV
Aesthetics as a Result

The previous chapter focused on design strategies that facilitate a transfer of knowledge, concepts, and ideas from architecture to humans. There are however nearly endless manners by which these strategies can take shape, and so it is critical to explore the concept of aesthetics. It seems as though aesthetics is often a dirty word in the architectural discourse. To some, it distills the complexity of architectural design into a single, one-dimensional word. Frank Lloyd Wright proclaimed that many of the buildings to come out of the modernism movement were 'taste-built' rather than 'thought built'. By this Wright means that while early modern architecture was developed from a practice of designing based on theories and ideas, the aesthetic that resulted from these ideas eventually became imitated by so-called modernist architects who simply designed their buildings to resemble the most popular ones of the time. A glass box on stilts was an appropriate architectural solution on a flood-plain in Illinois during the social context of the mid-century — a novel idea — however many of the countless white-painted-steel glazed boxes that have been constructed across the world since that time have been imitations of Mies's most recognizable work. They were designed to chase the aesthetic of the Farnsworth House which has seemingly become analogous with modernism. Prior to the Farnsworth House, there was nothing that resembled it from an aesthetic standpoint. There are aspects of theory which Mies perhaps borrowed from other modernist architects, regardless, the result was a novel aesthetic. While Frank Lloyd Wright may not have been fond of Mies' theories on design, he had greater disdain for the imitators, “Unhappily I feel that this great ideal which I so long ago, early in my life, came to love and diligently practiced has been betrayed, unintentionally betrayed, but — none the less — betrayed by its world-be friends who fell to imitating it without understanding it”. His frustration was with the architects who understood modernism as an aesthetic movement, one of glass and steel. The reality, to Wright at least, was rather quite contrary. He saw modernism as a rejection of the imposing nature of classical ideals. Architecture to Wright should be an expression of life, common sense, and nature rather than an expression of artificial order which defined the ‘Classic’. He criticized banks that resembled Greek temples, and universities that resembled cathedrals, he agreed with Mies that form follows function, “but more important now Form and Function are One”.

4.1 Aesthetics
In other words, modernism to Wright is the result of responding to the site and occupants using common-sense while ignoring tradition and preconceived form, while the work of imitators is the result of looking at existing architecture and developing an eclectic amalgamation of ‘tasteful’ aspects of the aesthetic without regard for why it looks that way. Discussing aesthetics is a dirty word because of the imitators. An architectural design process that begins with a preconceived aesthetic is one that can not appropriately respond to the various contextual factors the building will be situated in. If aesthetics are preconceived, then the design process is ultimately rendered superficial and meaningless.
Aesthetics are important, it is what differentiates one building from another, it is what allows architecture to express ideas, meaning and emotion, it is the way humans most often connect and relate to built form. But aesthetics in an architectural project that strives to respond to issues of resource consumption and situate itself in the natural world are not a starting point, they are not part of the process but rather a result of it. Frank Lloyd Wright took the position that a design process which begins with an aesthetic in mind will develop an objectively worse architecture. This thesis makes no such bold claim, rather it suggests that to achieve a design outcome of a building that reimagines how people engage with water and instantiates a sustainable way of living, the architecture’s aesthetic should be allowed to simply be a product of a design process that considers the complex relationship between water, humans, and built form.

**Aesthetics and Sustainability**

Considering aesthetics as a product of a sustainable design process rather than a tool for design is not novel, and there has been abundant discourse on the topic of aesthetics and sustainability. The book *Aesthetics of Sustainable Architecture* provides a variety of different perspectives on this topic. Of particular note is the contribution by Glenn Hill,

> “Architecture has increasingly become both a primary site of commodity accumulation and one of its most significant commodities. This process has implicated architecture in ever-increasing patterns of energy and resource use, contributing significantly to what is now viewed as a global condition of unsustainability.”

Hill identifies one of the main points of this thesis, that architecture is a facilitator of resource consumption, and additionally identifies architecture as a primary resource itself. He continues to point out “In modernity, there is neither commitment to a geographical place nor acceptance of placement within a social order. We are physically migratory, readily relocating ourselves, our family, our home and our workplace”. Architecture is just as much a commodity as a pair of shoes. Since the end of the classical era, leaving behind ‘authoritative architectural vocabulary’, modernism swept in and brought with it ever-evolving and branching trajectories of taste and aesthetics. Hill explains that there are a variety of ‘interpretive communities’ who each have authority over their own aesthetic preferences and have contributed to what he calls the ‘aesthetic economy’. Home-buyers may base their aesthetic preferences on what they see on HGTV, while architects may base theirs on architectural journals and award winning projects.
Both interpretive communities see their aesthetic preferences as being correct, and they are, as there is no single governing principle to claim authority over the correct architectural aesthetic. The Parthenon can be considered objectively beautiful when measured against the authority of beauty that existed at the time of its construction, however Frank Lloyd Wright is just as justified in disagreeing. The various interpretive communities are their own authority of beauty. These interpretive communities are also subject to changing preferences, meaning old aesthetic preferences will eventually appear outdated and be replaced with the newest trend. While these changing preferences may seem innocuous, they have major implications on sustainability. Evolving tastes and aesthetic trends lead to continuous construction, demolition, and remodelling of buildings, a process which is inherently unsustainable as it contributes to a continuous consumption of resources.7 How can this possibly be overcome though? Architecture certainly can not influence the entire global population to set aside their developed aesthetic preferences and ignore evolving trends.

Hill looks towards a different approach with his concept of ‘Moral Aesthetics’. He explains how aesthetics can be linked to a moral position such as an architect using a certain material because it consumes less resources to produce it. This decision is based on a moral principle, however results in an aesthetic outcome. Moral aesthetics do not consider formal issues unless they are inherent to the moral goal (i.e using a large overhang as a sun shade, or sloping a roof to collect rainwater). Hill is essentially taking the same position as Frank Lloyd Wright, however approaching it from a more intentional perspective of sustainability.

The difficulty in taking this approach lies in the architect’s ability to set aside preconceived desires for formal outcomes. Hill explains that a formal view would be “that the building’s significance lies in its ability to subsume the sustainable technology within the visual order of the architecture (rather than exposing them as clutter)”.8 The implication here being that an ideal moral aesthetic would avoid creating order with the building’s sustainable technologies for the sake of order, and allow them to be expressed in their naturally functional manner. This comes back to the discussion on the aesthetic economy and assertion that perpetuating it is inherently unsustainable. By subsuming sustainable technology into the formal vision of the building, it consequently places sustainable architecture in a position where it faces aesthetic obsolescence. At this point Hill’s stance on sustainable design seems to simply reframe the position of form follows function, however he goes on to argue for an architecture that does substantially more.
“Rather than instantiating a sustainable way of living, as significant early environmental architecture attempted, sustainable architecture now focuses on technological strategies to maintain an arguably unsustainable way of being for the least energy and resource cost.” As sustainable design has entered into the mainstream of architecture, specifically residential design, it has fallen prey to the same aesthetic economy that seems to plague contemporary homes. As such, sustainable design is often masked by popular aesthetic trends, identified and demanded by an interpretive-community composed mainly of home-buyers. Landscape architect, Elizabeth Meyer believes that architecture may be able to achieve more than satisfying one’s visual pleasure. She suggests that architecture can perhaps “contribute to the revealing of something foundational in relation to the environmental crisis itself…the revealing of ecological systems as the ground for human existence”. She envisions an architecture that relinquishes its confinement of being a passive object and takes upon the role of being an active working system. Of course, with the multitude of mechanical systems that constitute a building, it is far from being a static object, however from the perspective of aesthetics, buildings are mostly passive. What both Hill and Meyer suggest is that there is an aesthetic of sustainability that reveals the importance of natural systems and how humans fit within them. Hill concludes that “if sustainable architecture is to be truly sustainable it cannot simply be an assemblage of energy reducing technologies wrapped in a delightful aesthetic package”. This sentiment has been repeated throughout this thesis and now more than ever asks the question, what does a truly sustainable architecture look like?

The answer to that question is not easy nor is it direct. Consider for a moment Corbusier’s five points of architecture which he considered to contribute to the ideal dwelling. He developed these points from the perspective of enabling and supporting contemporary lifestyles. This thesis argues that contemporary lifestyles are unsustainable, therefore requiring dwellings that act in opposition to Corbusier’s vision, and begin to shape new modes of living. Where Corbusier’s points describe the architecture of a machine for living in, Hill and Meyer suggest looking beyond our species and consider how dwellings can be machines that engage in constructive relationships with ecological systems, ultimately revealing a truth that contemporary sustainable architecture masks.

It is important to understand that the concept of moral aesthetics and the other ideas put forth by Hill and Meyer are idealistic and can not realistically describe an absolute design process. The components of a building that relate to issues of sustainability can all likely be designed using the approaches in this chapter, but the remaining aspects of the house that are disconnected from these concepts — hereafter referred to as auxiliary spaces — would need to draw inspiration from elsewhere.
In their text, *Sustainable Architecture as a Cultural Project*, John McMinn and Marco Polo argue “energy efficient buildings that fail to address cultural needs and values may suffer premature obsolescence and invite major modification or outright demolition and replacement, undermining ambitions for sustainability”.12 They suggest that placing importance on cultural needs and traditions engages people’s ‘self-definition’ and ‘place-identity’ with sustainable thinking.19 McMinn and Polo’s position comes from a critical perspective of the current approaches to sustainable design and does not account for the type of reframing of sustainability that this thesis is exploring. Despite this, their argument remains useful as it identifies the importance of familiarity and tradition in design. This chapter has largely argued for designing without aesthetic considerations, however only certain aspects of a dwelling’s design can be conceived in that way. For instance, a rooftop that collects water can have its form and material defined by qualities relating to wind, rain, and water transportation, while a living room does not engage in any meaningful way with water and must therefore look elsewhere to find a justification for design.

To ignore the expectations and needs of a building’s occupants would very likely result in a building that they dislike, ultimately leading to the outcome of modification or replacement described by McMinn and Polo. Recall the discussion from Chapter II on Terra Amata; while stick huts may technically be the most sustainable design strategy in existence, it is not a practical one in a contemporary Canadian context. A house that implements extreme measures for sustainability and incorporates features that assist in conveying the importance of sustainable behavior should also be balanced by traditional and comfortable spaces for activities that are outside the scope of environmental concern. In a house where a bathroom may be entirely reimagined to visualize consumption habits and influence behaviour, the living room and bedrooms should reflect a more traditional design to ensure the house satisfies the expectations of a typical Canadian. The question of aesthetics comes into play again, what will these auxiliary spaces look like? If a moral aesthetic approach to design results in particular material or formal outcomes that ultimately impact the appearance of the auxiliary spaces, then they should reflect those outcomes while maintaining their expected functionality. In the case that a moral aesthetic approach does not impact auxiliary spaces, then those spaces should be free to draw upon the most logical approach to design that satisfies vernacular needs.

The ideal sustainable home would be able to entirely shed itself of contemporary expectations of living, however such a building would simply not be accepted today. Aesthetics can be avoided to the greatest extent possible, allowing them to become a result of a process of designing a building that responds to ecological systems and natural conditions, however there will always be the need to design spaces that exist to respond to human expectations alone, a process necessitating a more traditional approach to design.
Aesthetics and Water

The previous section presented how ever-evolving taste and aesthetic preferences contribute to unsustainable architecture, even when the building is intended to be a sustainable design. It presented the concept of moral-aesthetics and designing architecture to be actively engaged with natural systems, revealing an otherwise hidden truth. So far, these concepts have been discussed broadly and in the context of general sustainability. Since the focus of this thesis is on the sustainability of water in particular, how can these concepts help imagine an architecture that instantiates sustainable consumption of this resource? The design exercises explored in the previous chapter reveal that simply addressing direct issues of human engagement with water fixtures are not enough to formulate an architecture that could possibly achieve that goal. Buildings facilitate human engagement with water, however what those exercises failed to recognize was that buildings likewise engage with water themselves. To ignore that fact would result in a design process whereby architectural aesthetic is preconceived and taste-driven, forgoing Hill’s warning and becoming a ‘delightful aesthetic package’. The following design exploration helps to better understand the results of such a process by inadvertently epitomizing Hill’s critique.

Consumption Feedback Neighbourhood
A Design Exploration

The design exploration in question preceded the research of this chapter and was intended to investigate design strategies for incorporating water consumption feedback systems — inspired by the consumption feedback research of Debera Lilley — into two residential environments of different densities. The premise first questioned how homeowners might react if a municipality were to begin requiring households to display their water consumption publicly [Figure 4.6]. An alternative neighbourhood was designed in response to this utilitarian outcome which exhibited a variety of distinct designs for each house, each integrating water feedback tanks into their facades [Figure 4.7].
Figure 4.7: Anticipated Homeowner Responses, Mitchell Cairns-Spicer, 2020

Figure 4.8: Architectural Interventions, Mitchell Cairns-Spicer, 2020
It is clear that these design outcomes are representative of the ‘delightful aesthetic package’ problem described by Glen Hill. While there is an element of sustainable thinking incorporated into the design, it is merely a component of a design process with a focus on aesthetic outcomes. The form of the water tanks, their volume and placement are aspects of the design all driven by an aesthetic goal, when they should instead be driven by an ecological one. To move the discourse on sustainable design forward in a meaningful way, the delightful aesthetic package must be left behind to make room for an aesthetic outcome instead driven by natural systems. The focus will be shifted from a beautiful architectural outcome to one that responds to the natural world in the most appropriate way possible, without being shackled by arbitrary design principles. It is also important to ensure the architecture does not stray too far in the opposite direction.
Architecture that aims to address a particular topic often becomes heavily imbued with symbolism, to the point that it uses formal design and ornamentation to convey ideas. The Blue Planet Aquarium by 3XN uses various instances of natural geometry to drive the formal design of the building. It is evident from the exterior alone that this building is expressing the idea of water on account of the large wave-like form emerging from the water below. Robert Venturi would likely classify this building as a Duck, suggesting that form follows function to an extreme — a building that houses large tanks of water should look like water. This approach to design may suitable to the aquarium, however in the case of a building that has a goal of changing the way people think about and engage with water, reducing it to a formal representation of water is greatly restrictive. Understanding aesthetics is therefore very important to developing a successful design. Consider a house designed with the same approach as the aquarium, perhaps a house shaped like a raindrop. The formal design is the beginning and the end of the building’s ability to convey meaning and ideas, it completely disregards how the building itself engages with water. When it rains, what does the roof do with the water? What happens when water hits the cladding? The form exists to symbolize water, the would-be-walls are curved to accomplish the formal goal, the roof comes to point because that’s what raindrops look like. Of course this imaginary building is an extreme example of designing towards an aesthetic end, however it reinforces the importance of allowing aesthetic to be a result rather than a starting point.
Returning to the image of this sustainable house, it now takes on new meaning. The house was designed to be highly sustainable, in fact designed to be net zero, however the architecture does nothing to suggest this. Without prior knowledge, it would be reasonable to assume that the solar panels were newly installed on a house built decades ago with no consideration for its environmental impact at all. As such, the architecture is unable to promote new ways of thinking about resources.

Figure 4.12: Net Zero House, NIST, 2020
Endnotes

2 Wright, 21.
3 Wright, 22.
5 Lee, 27.
6 Lee, 34.
7 Lee, 34.
8 Lee, 36.
9 Lee, 38.
10 Lee, 39.
11 Lee, 40.
13 Ibid.
CHAPTER V
This chapter documents the design of a dwelling that attempts to reimagine how the building facilitates human engagement with water, and how it engages with water itself. The home is the most appropriate choice for such an exploration as it is the one place that provides people with a frame of reference for understanding and relating to the world. Thomas Barrie explains that of all of architecture’s varying tasks throughout time, its most consistent task has been “to assist humans in structuring their understanding of the world and their place in it”. The architecture of the home relates to the world, and to nature, and in doing so helps its occupants do the same.
Where the previous design explorations began to reimagine how people can engage with water, considering the way buildings engage with water should be subject to the same reimagining. Buildings are designed to have an exclusionary attitude towards water. Water in the context of humans generally relates to consumption; drinking, bathing, cooking etc. Buildings however play a much more significant role when it comes to water — they keep people dry. At its absolute bare state, a building is simply a shelter, walls and a roof to keep water out, among other things. From the outset, many architecture schools instill the importance of the envelope with regard to water protection and the notion that water is the most deleterious substance when it comes to buildings. ‘The four Ds’ of a building enclosure — deflection, drainage, drying and durability — are taught to architecture students early on, positioning water as their greatest enemy for the rest of their career. In Canada, it is stressed to an even greater degree that water must be excluded at all costs due to its pernicious effects on the thermal resisting properties of insulation. Architecture therefore frames water as a thing to be avoided, an unwanted substance of little regard. An outer shell (cladding for walls and typically shingles for roofs) deflect water, weather resistant barriers drain it and cavities dry it. These three components make up a building envelope’s line of defence against water along with formal decisions such as sloped roofs and overhangs. Following the thread of the discussion in the previous chapter, how might a building reframe the way it engages with water. What needs to change for the envelope to position water as a substance of desire, something to be celebrated rather than presenting it as a foe?

Figure 5.2: Managing Water, EdWójc/Ryerson University, ASC 202, 2015

a presentation slide from a construction fundamentals course taken by the author during his first year studying architectural science at Ryerson University. The slide highlights the primary methods of managing and preventing water penetration into building enclosures.
**Water Use**

As Chapter I demonstrated, a reasonably sized home does not provide significant enough catchment area to meet the water needs of an individual, and certainly not a family of four. The chapter concluded that it is impossible to subsist on collected rainwater alone unless there is a significant change to consumption patterns and behavior. Figure 5.3 presents a detailed breakdown of a such a change in consumption behavior. The allotted consumption for each activity is substantially lower than average Canadian consumption rates, however each have been carefully considered to ensure their feasibility and practicality. This is not to say that there would not be a significant amount of sacrifice for one to adopt such consumption patterns, however that is ultimately the goal of this thesis. After formulating this ideal consumption model, an additional twenty percent was added to the resulting total to accommodate for human imperfection, plumbing leaks, and other various irregularities.

This data then allows for an optimal catchment area to be sized. Multiplying out the ideal water consumption model for a family of four, and given the average rainfall in Toronto, Figure 5.4 demonstrates how a catchment area of 140m² is optimal. Where the blue horizontal bar indicates monthly water consumption for a family of four based on the ideal water consumption model, and the vertical bars indicate rainwater collection for any given month. The black portion of the bars represent excess water collection, beyond the necessity of the family and the orange indicates months of scarcity. When the catchment area is sized to 140m², these two quantities are equalized, meaning that the excess water can be stored in a reservoir tank as a ‘top-up’ for the months where additional water is required.

The catchment area of 140m² can alternatively been considered in the context of an appropriate building footprint for a typical suburban lot. The site will be addressed later in this chapter, however 140m² offers sufficient space for a compact single storey three bedroom house, or additional space with a partial or full second storey. Instead of the catchment area being based upon a set number of individuals and a static water consumption model, an alternative approach to the design process can be to begin with a house that’s appropriately sized within its context where the consumption behavior of the occupants will vary based upon the house’s current occupancy. For example, at the outset a family of four (two adults, two children) occupy the home, their consumption is based on the total collected water divided amongst four individuals. Several years later once the children have grown and leave the house, the total collected water will not change, and instead will be divided amongst only two individuals, allowing their consumption to increase.

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**design approach 1:** begin with a static water consumption model and use it along with the anticipated number of occupants to drive the catchment area. This catchment area then informs the footprint of the home. In this case, the number of occupants is anticipated to be static and the consumption model likewise remains static.

**design approach 2:** begin by determining an appropriate house footprint based on site context. The resulting catchment area then drives the consumption model. Unlike design approach 1, the consumption model is variable depending on the number of occupants within the home.

**note:** regardless of the design approach, there will always be a maximum number of occupants the house can accommodate given its catchment area and resulting water supply.
### Ideal Water Consumption Model

<table>
<thead>
<tr>
<th>Activity</th>
<th>Volume (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shower</td>
<td>76L/min @2min = 15.2L (every other day) = 230L/month</td>
</tr>
<tr>
<td>Laundry</td>
<td>50L/wash @4 washes/month = 200L/month</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>15L/wash @6 washes/month = 90L/month</td>
</tr>
<tr>
<td>Toilet</td>
<td>5L/flush @1.5 flushes/day (urine=no flush) = 225L/month</td>
</tr>
<tr>
<td>Hand Washing (Faucet)</td>
<td>3.8L/min @20 sec/wash @10 washes/day = 380L/month</td>
</tr>
<tr>
<td>Brushing Teeth (Faucet)</td>
<td>3.8L/min @20 sec/brush @2 brushes/day = 75L/month</td>
</tr>
<tr>
<td>Cooking/Cleaning</td>
<td>8L/day = 240L/month</td>
</tr>
<tr>
<td>Waste</td>
<td>@5L/day = 150L/month</td>
</tr>
</tbody>
</table>

= 1,590L/month/person
+20%
= ~1900L/month/person

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*Figure 5.3: Ideal Water Consumption Model, Mitchell Cairns-Spicer*

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#### Rainwater Collection For Catchment Area of 140m²

![Monthly Water Consumption Graph](image)

*Figure 5.4: Catchment Area Sizing Graph, Mitchell Cairns-Spicer*
**Water System**

Reframing how buildings interact with water through a design philosophy of collection addresses the front end of water use, however after water is consumed, there is still work to be done. This design project considers the water process from beginning to end, and uses a variety of methods in a systematic approach to express the various stages of this process. This system design is not prescriptive to a site, and is inherently adaptable. The first stage of this system is the catchment surfaces. As identified previously, the rooftop surface will need to be at least 140m² though this is dependent on the volume of water the vertical surface can collect which is defined by site factors and constraints.

The collected water is then conveyed through a first-flush diverter which extracts large debris items and contaminants before being drained into the rainwater storage tanks. The combined volume of these tanks is capable of holding a month’s worth of harvested rainwater during peak rainfall. Once a month water from these tanks is pumped through an ultraviolet carbon filter to render it potable, before being pumped into a large 7,600L tank. This tank houses the allotted monthly water for a family of four based on the ideal water consumption model. This tank is the only available source of fresh water for a month, before it is then refilled using the water collected and stored in the rainwater storage tanks. The sinks and shower draw water from this tank, and then drain their grey-water into the secondary grey-water tank. Fixtures that produce black-water such as the kitchen sink and dishwasher will bypass this grey-water tank. The grey-water tank provides water for the toilet and any other fixtures that don’t require fresh water.

Once flushed from the toilet, the water is considered black-water and is no longer usable without treatment. Typically this water would be carried into a sewage system for treatment at a municipal plant. Since this project maintains a closed-loop system, the water must be treated on site. The next stage of the system is a reed bed which accomplishes this task. On its way to the reed bed, the black water from the toilet passes through a composting septic tank which allows the larger debris to settle before continuing on. Once in the reed bed, oxygen is travels to the base of the reeds which allows aerobic bacteria to consume the contaminants in the water. Clean water eventually emerges from the other side of the bed. Reed beds vary in efficiency seasonally, however a significant amount of treated water is produced.

The final stage of the system, a natural pond, provides both a bookend to the water system the house engages with, as well as a reset button for the water. Each week roughly 25mm of water will evaporate from the pond. Considering how much water the pond will receive from both the treated water as well as rainwater, it can be appropriately sized to accommodate the influx of treated water [see Appendix A].
**Figure 5.5: System Diagram, Mitchell Cairns-Spicer**

- **Catchment Surface**: 140m² (Dependant upon wall collection volume)
- **Vertical Catchment Surface**: Size determined by site
- **Harvested water passes through first-flush filter**
  - **Rainwater Storage Tanks**: 3 x 3000L *
- **Stored water passes through UV + Carbon filter**
  - **Monthly Allotted Water Tank**: 7800L *
- **Primary Water Fixtures**: Shower + Sink
- **Greywater Storage Tank**: 3900L
- **Toilet**
  - **Waste black water passes through composting filter**
- **Reed Bed Water Treatment System**: 26m² ***
  - **Water treated by reed bed trickles down to pond**
- **Natural Pond**: 85m² ***

*Figures indicate approximate capacities and sizes. Actual measurements may vary depending on site conditions and design specifications.
An initial exploration into the design of a home that attempts to reframe the way its occupants interact with water made some positive strides, however ultimately fell into the trap of taste-driven aesthetic design and traditional architectural conceptual thinking. It is included here as a preface to the final design exploration as it was a catalyst for several avenues of design thinking that were carried into that final design.

The massing (Figure 5.6) identifies the stepped elevations of each program’s volume with the sleeping area at the bottom, followed by the living area above it, and the kitchen and washroom area on top. The intention was to ascribe a sense of importance to the program areas of water consumption by placing it atop an ascending mass. The notion of the highest level being of greater value is repeated consistently throughout various aspects of many cultures and was the driver for this massing. This design approach while perhaps appropriate in a conventional architectural context, remains rooted in theory and ideas unrelated to issues of sustainability, which ultimately result in formal outcomes. Asking why the building is angled in this particular way, and why this one program is placed above another can not be answered from a standpoint of sustainable thinking, natural processes or responses to ecological systems. It therefore remains firmly rooted in the realm of taste-built thinking.

The roof begins to consider its relationship with water by sloping to allow the building to collect it, yet again, the angle and orientation of the roofs can not be justified or explained outside of an aesthetic and taste-based mode of thinking.

The selected site for the house is a large lot located along a hillside in the neighborhood of Rosedale, Toronto. The intention of choosing this site was to allow the design to easily explore and implement the components of the system study (Figure 5.5). The sizeable allowed plenty of room for the reed bed and evaporation pond to fit, in addition to minimal constraints in terms of the architectural design. The site, while plentiful in its opportunities, is not a realistic representation of a typical Canadian’s home — more on this later — and therefore can only provide a testing ground for a variety of design tools, rather than support a cohesive model for a new form of sustainable design.

Despite this clear limitation, there are several elements of the architectural design of this home that are relevant to this thesis’ discussion and will help to set the stage for the final design exploration.
axis-driven: another portion of the design is the implementation of three distinct axes. The primary set are perpendicular to each other — defining the sleeping and living spaces — while the third axis defines the spaces of water consumption and disrupts the order of the otherwise orthogonal plan. This type of planning design stems from ancient periods of architecture and imposes an anthropic concept onto a building design which was intended to be driven by sustainable thinking and natural systems.
wall vignette (cladding): an early exploration into the implementation of using a trough-like cladding to collect wind-driven rain water. This iteration over-emphasizes the required slope and does not use meteorological data for the design of the profile (something is addressed in later design work).

wall vignette (woven polymer mesh): due to the angle of the cladding, portions of the wall are left exposed to the elements. This design exploration uses a woven polymer mesh similar to those used to collect water particles from the air as a durable material which can additionally act as a water collection device.

entry bridge: to further explore how aspects beyond the building itself could be used to collect rainwater, an entry bridge was designed where the guard rail uses a similar trough-like profile to collect rainwater. The bridge surface itself is composed of spaced wood slats which are placed above a sloped steel surface that drains into a trough leading into the home.
The primary design development that came about through this design exercise was the idea that function of an envelope can be changed such that it frames water in an entirely different way. This will be further explained in the final design exploration, however the basic concept is that typical cladding deflects and drains water away from the building, so the logical alternative is to use the cladding to collect water and bring it into the building. Within this exploration, this is achieved by modifying the cladding profile to be a trough that slopes lengthwise along the wall so that wind-driven rain can collect and drain into an internal reservoir. This initial iteration is very limited however as it does not take into account meteorological data and therefore is unable to maximize its efficacy when engaging with rainwater. The profile design, trough slope and wall orientation do not respond to natural systems within the context of the site, but rather accommodate an aesthetic goal. As a result, they are a representation of a sustainable idea, but not a proper implementation of one.
Timed Shower Dial
Spaced wood for drainage
Sloped surface below
Sloped 'sink' surface
Sloped trough
Grey water storage tank for toilet flushing

Figure 5.10: Level 2 Plan, Mitchell Cairns-Spicer

Figure 5.11: Bathroom Diagram, Mitchell Cairns-Spicer
The design of the building plan places all of the programing related to water consumption on the topmost level with the intention of highlighting its importance. Conceptually this is perhaps reasonable, however in practice it creates a very cumbersome experience for its occupants. The central feature of this top floor is a large 7800L tank that stores the monthly amount of water a family of four can drink under the ideal water consumption model and is located between the kitchen and washroom. The placement of this tank is meant to act as a clear and constant reminder of the occupants’ consumption habits. The washroom is designed to transfer all waste water from the shower and sink to a small grey water storage tank adjacent to the toilet. The flow of this water is visualized through exposed troughs to clarify this process.

These various design strategies draw from much of the research in Chapter III and begin to demonstrate how the concept of consumption feedback can manifest in an architectural project. Though this project does not describe a new model for sustainable design, it provides a starting point for new avenues of conceptualizing aspects of design and highlights the areas that need greater focus moving forward.
The Site

According to Statistics Canada’s 2016 census, the majority of Canadians live in a single-detached house, with 20,748,070 people occupying 7,541,495 houses. The next most common housing type is apartments with fewer than five storeys which house 4,608,960 people. Looking at dense cities such as Toronto and Vancouver, these statistics are surprising, however many smaller Canadian cities are mostly composed of suburban streets lined with single-detached houses. Older cities such as Kingston have historical suburbs dating back to the 19th century which are not so dissimilar to the contemporary suburb, demonstrating Canada’s long-term love affair with this type of housing.

The term single-detached house is quite broad however and does not describe a single type of house or site. It can be used to equally describe a small bungalow sandwiched between adjacent houses on a ten meter lot, or a 1500m² mansion along the Bridle Path with a two acre lot. House and lot sizes are also very subjective relative to their locality. What might be considered a large house and large lot in a Toronto suburb, might be considered quite typical in a smaller town such as Belleville or Kingston.

The site for this project is representative of the common narrow, long lots found in many Toronto neighbourhoods, as well as neighbourhoods across Ontario and the rest of Canada. The lot size of 15m by 35m is based on property data for several Toronto neighbourhoods, and though not determined objectively, approximates the appearance of a typical lot in many other Canadian cities. The site is bounded by houses on either side, and a neighbouring yard to the rear, and trees of varying species and size are located across the site.

Municipal water infrastructure serves the site, however unlike the neighbouring houses, this lot will not be connected to those services as it will be a self-contained water system, performing all of the tasks from water collection to treatment on-site.
Figure 5.13: Site Plan & Axo, Mitchell Cairns-Spicer
The Envelope

The function of a building’s envelope is to deflect water, and so reversing this frames the dwelling as a collector of water rather than a protector from water—a powerful conceptual change, simple as it may be. The visible portion of the building envelope is composed of the roof and the walls, both of which typically act to deflect water, and both of which are capable of collecting it. When discussing deflecting and collecting water, the water in question refers to rain water. Understanding local rain and wind patterns is essential to designing a house that is intended to respond to this natural resource in a meaningful manner.

Though site specific data would be ideal, there are only certain points of measurement for meteorological data in Toronto dependant on weather station locations. The data used in this design project [Figure 5.14] was measured in the Upper Beaches, a mid-density suburban area of the city which more accurately reflects the selected site than the city’s other weather stations. This data demonstrates the variety of rain and wind conditions throughout the year. Figure 5.15 uses data from a University of Waterloo research paper by John Straube to represent the average yearly quantity of wind-driven rain on a vertical surface relative to its orientation. Observing the two sets of data reveals that the west-wind is the most dominant throughout the year, and particularly during months of significant rainfall.

Since roof-collected rain is less influenced by the direction of wind-driven rain (more on this later), the data in Figures 5.14 & 5.15 is used to drive building orientation and general massing to ensure the most exposed wall surface is receiving as much wind-driven rain exposure as possible. There has been significant research on wind-driven rain and buildings, and Appendix A goes into great detail on this topic where this chapter will gloss over some of the finer details for the sake of clarity.
MONTHLY RAINFALL (mm)
DOMINANT WIND DIRECTION & SPEED (km/h)

Figure 5.14: Wind Data, Wind Finder, 2020

Figure 5.15: Driving Rain Rose For Toronto (inches/year), John Straube, 2010
In nearly every city and town along the 401 in southern Ontario, the orientation of the streets are off-axis relative to true north. Typically the north-south streets are perpendicular to the waterfront, and are therefore several degrees off of true north. This means that it is very difficult to find a suburban lot similar to this project’s site with its street-face oriented towards the west. By orienting a building’s façade orthogonal to an off-axis site, it will not be facing west and will therefore not experience the maximum wind-driven rain exposure. Trees and other large site elements will impact a wall’s rain exposure as well.

The wall pictured in Figure 5.17 is as described above, oriented orthogonally to an off-axis site. It will be exposed to a significant amount of wind-driven rain — substantially more than an east-facing site — however a house following the design parameters set-out earlier in this chapter is not a house that settles for ‘good enough’. The design needs to adapt to the site’s conditions, and in this case, that means a rotation away from the natural orthogonal orientation of the neighbouring homes.
Figure 5.17: Orthogonal Oriented Wall Diagrams, Mitchell Cairns-Spicer
Figure 5.18: True-East Oriented Wall Diagrams, Mitchell Cairns-Spicer
This next iteration positions the wall such that it is facing directly west, and is therefore fully exposed to the west-wind and its accompanying wind-driven rain. Additionally, this iteration of the wall accounts for the tree at the front of the lot by becoming more narrow, but extending up to be taller, taking advantage of more wind exposure. As discussed in Appendix A, one of the factors of determining wind-driven rain exposure is the building’s height. Higher buildings, even at the small scale of residential homes, will experience exponentially greater wind at very small increases in height. While the wall’s height is not necessarily restrained by anything, it should respect the average height datum defined by the rest of the neighbourhood. In the case of this particular site that datum allows this wall to extend up to seven meters. The wall’s footprint is defined by the property to the right, which has a two storey home along the property line (Figure 5.17). Due to the shelter factors also discussed in Appendix A, the wind would be reduced to a minimal speed as the wall approaches the property line and so the way it is pictured in Figure 5.18 ensures the entire surface is exposed to a consistent maximum wind-driven rain load.

Another iteration of the wall that was considered was a curved wall (Figure 5.19). Typically concave surfaces introduce erratic wind patterns which may or may not affect the amount of water impacting the wall surface. It is not possible to calculate this using the equations provided by John Straube (Appendix A), and so this design is not used moving forward.

Figure 5.19: Curved Wall Diagram, Mitchell Cairns-Spicer
With the wall’s position defined, it can be used as a starting point to generate a building massing. The other constraint on building massing is the catchment area. Earlier in this chapter it was concluded that at least 140m$^2$ of catchment area will be required to accommodate the water consumption model. With the wall acting as an additional catchment surface, the rooftop catchment area can be reduced to 135m$^2$ — see Appendix A for details on how this was calculated. Figure 5.20 (i) simply extrudes the wall to accommodate the 135m$^2$ catchment area. The result is an awkward mass with a corner sitting on the property line. The next figure [ii] explores a second mass perpendicular to the main one. To accommodate the required catchment area, this mass would extend beyond the lot. Additionally, there is no reason to match the rotation of the main mass since the west facing wall of this new mass would be far too sheltered to receive any significant amount of wind-driven rain. This reasoning leads to the next figure [iii] which simply rotates the second mass to be orthogonal with the site and neighbouring buildings. The final figure [iv] articulates the mass more by lowering the roof height of the rear mass to more clearly define the two and adding an entryway which is also orthogonal to the site. This creates two strong axes through the site which are used to define the layout and function of the interior spaces.

**The Roof**

The roof is perhaps the element synonymous with water protection. In the case of a house which operates on collected rainwater however, it serves a far more important purpose than shelter. Rainfall data provides a quantity of rain passing through a horizontal plane. As already discussed, rain does not always fall in a perfect vertical line, as wind often adds a horizontal vector, causing it to fall at an incline. Abstractly, more rain will impact a surface inclined towards the windward side which matches the inclination of the falling rain. The additional amount of rain may only be marginal, however as stated before, the design of this project is not satisfied with ‘good enough’.

The first step of designing a roof to maximize rainwater collection is to determine the optimal slope. Because wind patterns are inconsistent and rain falls at various inclines each year, the most frequent incline has been used. There are many factors that must be accounted for in the case of calculating the incline of rain. Ghent University in Belgium performed an experiment in a wind tunnel to generate data that can be used to approximate rain incline based on wind speed [Figure 5.22]. Using a wind-rose composed of weather station data for Toronto, the most frequent wind speed was able to be determined, and subsequently the incline of the rain in the various directions the roof was facing [Figure 5.21]. Figure 5.23 illustrates the resulting roof geometry from the rain inclines. The ratio of one angled surface to its opposing one was simply determined by the ratio of the two directions of rainfall at their respective inclines throughout the year.
Figure 5.20, Massing Development, Mitchell Cairns-Spicer
Figure 5.21: Wind Rose For Roof Orientation, Mitchell Cairns-Spicer

Figure 5.22: Rain Inclination Relative to Wind Speed, Gabriels, 1997
Figure 5.23: Roof Slope Diagrams, Mitchell Cairns-Spicer
Collected water drains to storage tanks below.

Corrugated Steel Catchment Surface

Wood Frame Support & Steel Standoffs

Steel Catchment Channels

Environmental Control Layers

Figure 5.24 Roof Massing Diagrams, Mitchell Cairns-Spicer

Figure 5.25: Roof Assembly
Mitchell Cairns-Spicer
When determining the best way for these roof slopes to materialize through massing, the most direct method is to simply extrude the inclines as solid forms [Figure 5.24 (i)], similar to a traditional pitched roof house. The problem with this approach is that due to the steep incline, the roof would extend well beyond the height datum set by the adjacent houses. A possible solution would be to drop the roof down to an appropriate height (ii) however in doing so, the rain collection wall is greatly reduced in surface area. In order to maintain the wall’s height, and adhere to the determined optimal roof slope, the large single sloped mass was broken into smaller pieces (iii). Rain falling perpendicular to this surface is unaffected by this change, each individual surface remains perpendicular, however it acts to reduce the overall height of the roof. Another interesting result of this design approach is that it allows the roof and catchment surface to be considered as two discreet objects.

Typically a roof is composed of various layers which perform the necessary functions of maintaining a conditioned indoor space. Since the topmost layer of the roof — in this case steel panels — simply serves to prevent the majority of rainwater from reaching the subsequent layers, it is free to be detached from those layers. The remaining roof below performs as any well-built ‘inverted roof’ would with the ability to manage any water that finds its way onto it. This means that the roof does not need to follow the profile of the catchment surface, an overly complex geometry that would serve no real purpose. This separation and stratification of roof and catchment surface also offers a unique architectural expression which clarifies the function of the two layers [Figure 5.25]. The remainder of this chapter will refer to this detached layer as the catchment surface, independently from the roof which constitutes the composite assembly providing environmental protection to the interior spaces.

roof profile: the selected building massing (i) employs a simple flat roof and affixes the angled catchment surfaces atop a properly enclosed roof system. This is preferable to the alternative (ii) of allowing the roof system to follow the ‘sawtooth’ catchment angles. Overly complex roof geometry is more difficult to construct and therefore more likely to fail.

Figure 5.26: Roof Profile, Mitchell Cairns-Spicer
The Wall

A typical rainscreen assembly is designed to engage with water, however this engagement is defensive. The cladding is the primary barrier, serving to deflect, and drain wind-driven rain. Behind the cladding is an air gap and a weather membrane. The weather membrane is the wall's last line of defense, it drains any water than manages to find its way behind the cladding, and the air gap allows airflow to dry away any remaining water. This type of wall assembly is very well suited to a Canadian climate and it would be unwise to alter its overall function in any way. What can be altered however is the attitude the cladding has towards water. Instead of being designed to shed water, it can instead be designed to collect it.

The profile of the cladding has been changed to resemble a gutter, providing a volume for water to collect and be transported. A simple extruded rectangular profile [Figure 5.28 (i)] is insufficient for this task as it would deflect a significant portion of wind-driven rain. The blue dashed line indicates the vertical plane which wind-driven rain intersects. The rectangular profile overlaps with much of that plane, therefore acting as a barrier to rain that would otherwise have passed through it and been collected by the wall. Based on what was learned from this, a more effective profile was designed (ii). The main component of this profile is the angled wall which matches the most frequent incline of west wind-driven rain — 30 degrees, as identified earlier in this chapter — maximizing the exposure of the vertical plane compared to the rectangular profile. In the case of faster wind gusts where the rain's incline is greater than 30 degrees, the angled profile allows the rain to impact it and fall into the trough below. The sizing of the troughs is based on typical gutter dimensions as there is no minimum size that they can be based on due to the low amount of water volume during a single rainfall. The vertical spacing is based on typical wood cladding with a dimension of 150mm.
Figure 5.28: Wall Cladding (Trough) Design. Mitchell Cairns-Spicer

Drains to interior storage tanks

WIND

50mm

150mm

100mm

Furring Strip

Furring Strip

5%
**Site Design**

Beyond the building itself, the site plays an important role in this design project. It is used to perform two necessary functions of completing the full cycle of water use; treatment and restitution. Following the use of water in a toilet or other fixture that produces black-water, the waste travels into a composting filter before entering the reed bed. The reed bed is a lined basin that is simply filled with gravel and reeds or other macrophytes such as rushes. The water is passed through the gravel and plant roots which cause a variety of “physical, chemical and biological interactions between wastewater, plants, micro-organisms, gravel and atmosphere”.

Appendix A describes the function of reed beds in greater depth. The design of the bed ensures the water remains near the bottom to prevent any health risks and odours. Determining the size of a reed bed relies on two factors; the depth, and the number of occupants. Based on a minimum depth of 300mm, the reed bed must be at least 6.5m² per person. Given the size of the land, the reed bed’s surface area has been increased by a factor of fifty percent to further aid in ensuring there are no odours given the fairly dense suburban site. Additionally, increasing the size of the reed bed beyond the minimum extends the ‘residency time’ of the water. Typically reed beds are sized to maintain a residency time of 5 – 7 days. The water will remain in the bed until it is full and forced out by new water. Extending this time frame by providing more volume for the water to inhabit simply means it will be treated to a greater extent.

Once the water has passed through the reed bed, it needs somewhere to go. On larger sites in less urban areas, the water can simply drain off into the water table, however water management on a suburban site is important so a pond was created to allow the water a controlled place to terminate. The pond sizing is based on several factors; the amount of water exiting the reed bed, and the amount of rainfall the pond will receive, and the rate of evaporation. It has been sized to accommodate peak rainfall months, and the level will change throughout the year. The process of evaporation means that the water returns to the natural water cycle, being returned to its original state of exergy.

In addition to the specific site features that are involved in water management process, the remainder of the site itself is also engaged directly within the natural water system. Typical grass lawns can drain some rainwater into the water table, but are not efficient at dealing with heavy rain loads, leading to significant runoff into municipal storm water systems. A natural design strategy to mitigate this is the implementation of a ‘rain garden’. Rain gardens are typically depressed into the site, and filled with various vegetation which traps excess rainwater and slowly drains it back to the water table.
**Feedback Tanks**

The heart of the home is the water feedback tanks. Throughout the various stages of design research in this thesis, the concept of visualizing water consumption has remained consistent. With this design, the additional element of a grey-water feedback tank is introduced. Together, these tanks act as meters to inform the occupants of how much water they’re using, how much remains, as well as clearly expressing the idea of exergy, or rather, water quality transformation. These tanks can either be placed in sequence vertically or horizontally [Figure 5.30]. The practical outcomes of these two design approaches is explored in Figure 5.31.

By orienting the tanks in vertical sequence, the fixtures that use freshwater (shower and toilet) are located above the toilet which uses the grey water. This vertical stacking would require the occupant to ascend to the upper level simply to wash their hands after using the toilet. A sink could be placed on the lower level with the toilet, but then the clarity of the design is lost and the separation of the two qualities of water is rendered meaningless.

The alternative option is to orient the tanks in horizontal sequence. This approach allows all of the fixtures to be situated on a single level, with visual separation occurring thanks to the tanks themselves. The freshwater tank defines the space for use of its fixtures, and the grey-water tank defines the space for use of its fixtures. Additionally, this allows for vertical stacking of program uses. While the diagram only depicts the bathroom, there are other areas of the house such as the kitchen which will need to be placed within the defined spaces.

*Figure 5.30, Feedback Tank Massing, Mitchell Cairns-Spicer*
Figure 5.31: Feedback Tank Design (Horizontal Top, Vertical Bottom), Mitchell Cairns-Spicer
Figure 5.33: Interior Rendering, Mitchell Cairns-Spicer
Figure 5.34: Second Floor Plan, Mitchell Cairns Spicer
Figure 5.35: Second Floor Washroom Rendering, Mitchell Cairns Spicer
north elevation: the northern elevation is the most complex formally as the two building masses intersect here. The primary feature is the large window which is defined by the internal water tank with a mullion separating two glazing units, representative of the spacer between the fresh and grey waters. This window allows reflected and diffused light to illuminate the water tanks.

longitudinal section: this section visualizes the central water tanks, adjacent stairs, double height kitchen and dining area, living room, bedroom, and water management room.
**West elevation:** the primary elevation facing the street is clad with the rain-collecting trough panels. These panels are constructed from stainless steel to minimize water loss and avoid contaminating the collected water. A portion of the troughs reveal a strip of ceiling-height glazing to allow western light to penetrate the building.

**South elevation:** the southern elevation is clad in vertical white anodized aluminum panels and features the downspouts which drain the collected rainwater from the roof. Between the first and second downspout is a full-height strip of glazing.
Figure 5.40: East Elevation (top) & Transverse Section (bottom), Mitchell Cairns-Spicer
Figure 5.41: Backyard Rendering, Mitchell Cairns-Spicer
Summary

The Water House represents an approach to sustainable design which acknowledges both the human component of sustainability as well as the technological one. It recognizes that architecture has a communicative ability and harnesses it by reframing the building’s function and attitude towards water, bringing legibility to systems and processes that are otherwise obfuscated. In doing so, the building presents its occupant with a new perspective on their relationship with water, providing them an insight into their place within a larger natural system, as well as a measure of their impact on it.

The building presented in this chapter is a manifestation of a design process developed over the course of this thesis. The resulting design is not intended to be a one-size-fits-all solution to sustainable living, instead it should be seen as an outcome of an alternative way of thinking about sustainability within the context of an architectural design process. Another home designed in the spirit of The Water House would appear drastically different — even one across the street — a testament to the reliance on natural systems as drivers for formal and material decisions.

Much of the design for this project came about as a result of shedding the desire for an aesthetic outcome, but this can not be absolute. Architecture is a visual medium and necessitates decisions that manifest in visual outcomes. The design of this project demonstrates how massing, orientation, cladding, and site design can be defined by natural weather systems, however other aspects of the building such as certain interior design elements, finishes and aspects of planning inevitably require aesthetic decisions to be made. Future design projects might consider how systems and resources beyond water influence the design of a home and perhaps these systems would define further aspects of the design. An example could be a home that only uses materials sourced from within a specified radius, thus heavily limiting the architect’s choices, and impacting the aesthetic outcome.

Beyond the design of the building, this approach to sustainable architecture reframes the way its occupants directly engage with their resources. No longer do they consume blindly from a never-ending supply, the architecture guides their understanding by visualizing the source of their resources, their consumption rate, and their remaining capacity. All of this while avoiding an overly oppressive design, affording the occupant a comfortable and enjoyable space to occupy.

This project addresses issues of water use, consumption, conservation, and treatment, though it is possible other projects may want to tackle further issues of sustainability with the same approach. The driving principle behind this project — bringing legibility to a hidden system — is not limited to water or any other single resource. It is an attitude towards sustainable design that is highly flexible and can be adapted to a variety of outcomes.
Endnotes


5 Lismore City Council, “The Use of Reed Beds for the Treatment of Sewage & Wastewater from Domestic Households” (Southern Cross University, 2005), 2.

6 Lismore City Council, 4.
Designing Sustainability for Humans

The title of this thesis, Designing Sustainability for Humans, is intended to highlight the lack of human oriented design thinking when it comes to sustainability in architecture. Many green-buildings suggest that architects are afraid to involve the occupant in the processes of becoming sustainable. These buildings, which masquerade as everyday architecture, are actually complex technological systems that exist to maintain normalcy for the occupant, all the while attempting to minimize their environmental footprint at every turn of the faucet and flick of the light switch. The primary question this thesis aimed to address was; how can architecture take the concept of sustainability which often resides in a more technical realm and bring it to the forefront of people’s awareness?

This thesis identified two primary methods of bringing legibility to these otherwise hidden systems and processes; allowing the building to clearly express its place within a larger system through form and materials, and secondly by designing feedback systems into the home that reveal to the occupant the outcomes of their consumption behavior.

This alternative sustainable design process steps outside of the conventional green-design paradigm and reframes the way it engages with surrounding natural systems and likewise reframes its occupants understanding of the resources they interact with every day. Despite this, the work of this thesis does not exist within a vacuum and only occupies a small place within the much larger context of architecture and sustainability. It is not intended to discount the importance of conventional sustainable initiatives which are improving every day. Many of the infrastructure systems used in Toronto and much of Canada are highly sustainable in their current state. Toronto specifically employs a very low impact water treatment system which alleviates many of the issues discussed in Chapter I. The work of this thesis and improvements to building technologies can exist in a symbiotic, mutually beneficial, relationship. The act of exposing and clarifying systems and processes of resource consumption to a building occupant is not driven by an agenda of demonizing sustainable technologies, it is instead aiming to provide humans with the knowledge required to make informed decisions and behavioural changes that can work in tandem with high efficiency technologies to result in an even more sustainable future.

The innovations and advancements within sustainable design are contributing to a better future, but should not be seen as the only tool to addresses environmental concerns. Through careful and thoughtful design, architecture can step beyond its current role of shelter and beauty, and begin to provide humans with the understanding required to make meaningful changes to their relationship with resources.
Post-Script

The cover photo of this thesis was taken in the summer of 2018 at the waterfront of the Bay of Quinte in Belleville Ontario. At the time of the photograph, the water was over thirty meters inland of its typical shoreline and is entirely covering a waterfront trail which can be identified by the bench towards the right of the photo. I spent my childhood riding my bike, walking and rollerblading along this trail. This was the first time in my lifetime that the water had risen anywhere near the trail.

This problem was not localized to the Bay of Quinte, the rising water levels could be seen across all of Lake Ontario, especially in Toronto. The two main contributing factors are general climate change which causes more frequent and intense storms, and anthropogenic activity. The latter is a result of large scale development of natural landscapes into urban paved areas and agricultural land. Both of these land uses result in significantly more runoff into rivers and the great lakes as they are poor at absorbing rainwater into the water table.

Seeing the effects of our actions so blatantly evident in my own hometown inspired the direction for this thesis. Our homes keep us protected from worrying about our impact on the environment by attempting to reduce the severity of our behaviors, however they do not attempt to improve or change those behaviours, nor do they make us aware of our impact. We tend to become aware of our environmental impact only when it is too late. Architecture that guides change and carefully demonstrates the outcome of our decisions might be able to help us avoid losing more than our childhood trail to the effects of climate change.
APPENDICES
Appendix A
Driving Rain Research

Driving rain is rain that travels at an angle incident to a true vertical plane. The cause of driving rain is attributed to high wind speeds that introduce a horizontal vector to the otherwise vertical motion of a raindrop falling at terminal velocity.\(^1\)

To determine the quantity of driving rain that will impact a building’s facade, there are several factors to take into consideration. The first is the driving rain load which is determined by climate region. This factor relies on the Driving Rain Factor (DRF). This factor is a ratio of rain crossing a vertical plane to rain crossing only a horizontal plane (normal falling rain). This can be calculated using a simple equation however this factor can change dynamically over the course of a rain-fall event adding unnecessary complexity for the purposes of this thesis. Instead, a driving rain rose for the site’s particular climate region based on historical meteorological data will be used to determine the quantity and direction of driven rain for the site location. This however only accounts for the quantity of driven rain in an empty field, other factors need to be considered to properly determine the quantity of rain impacting the building’s walls.\(^2\)

The first is the Rain Deposition Factor (RDF) which is based on the general shape and size of the building and describes the ratio of the driving rain load that will impact the building. A building’s RDF ranges from less than 0.5 to 1.0. Generally upper corners of buildings will have higher RDF values while lower, central areas will have lower values. A building with a sloped roof and overhang will also have a significantly lower RDF value.\(^3\)

The next consideration is the Exposure and Height Factor (EHF) which is based on the building’s surrounding context, and the height of the exposed wall. Wind increases in speed exponentially at higher elevations which has an impact on the driven rain load. Each of these aspects can be calculated independently, however in his paper *Simplified Prediction of Driving Rain on Buildings*, John Straube provides a graph [Figure A1] which allows the EHF to be easily determined.

For sites with significant topographical features, the Topography Factor (TOF) would need to be determined, however such features would need to be of notable size, nothing that would be found in the suburban area of the selected site.\(^4\)
With these considerations and factors, Straube provides the following equation to determine *Design Driving Rain Load* — the amount of rain impacting the building’s wall:

$$\text{Design Driving Rain Load} = r_{vb} \cdot \text{RDF} \cdot \text{EHF}$$

Where $r_{vb}$ is the ‘open field’ driven rain load found in the driven rain rose [Figure A2]. Multiplying it by the two factors provides a realistic assumption of the actual rain load impacting the building.

*Figure A1: Exposure Height Factor, John Straube, 2010*
Figure A2: Driving Rain Rose For Toronto (inches/year), John Straube, 2010
### Pond Sizing Data

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<th>Size</th>
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<th>Evaporated Water</th>
<th>Treated Water</th>
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*Figure A3: Pond Sizing Chart and Graph, Mitchell Cairns-Spicer, 2020*
Rainwater storage tanks | 3 x 3000L

140m² catchment area | 140m² max. footprint

Reed bed waste water treatment | 26m²

Composting septic tank

Treated grey water storage tank

Rainwater storage tanks | 3 x 3000L

Independant of municipal water infrastructure

Figure A4: Water System Design Concept, Mitchell Cairns-Spicer, 2020
Inlet Pipe

Outlet Pipe

Reeds

100mm Rocks

Gravel Surface

10-20mm Gravel

See Table

1:1 - 4:1 Length : Width Ratio

Figure A5: Reed Bed Design, Mitchell Cairns-Spicer, 2020

(Based on "The Use of Reed Beds for the Treatment of Sewage & Wastewater" by Lismore City Council)

Figure A6: Reed Bed Sizing Chart, Lismore City Council, 2005

<table>
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<th>Surface Area/Person (m²) (Combined black and greywater)*</th>
<th>Surface Area/Person (m²) (Greywater only) #</th>
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* Based on a wastewater generation rate of 115 L/person/day

# Based on a greywater generation rate of 90 L/person/day

Table 1: Rule-of-thumb Sizing of a Reed Bed to achieve a Residence Time of 7 Days.
Figure A7: Water System Concept II, Mitchell Cairns-Spicer, 2020
Figure A8: Envelope Relationship With Rainwater Exploration, Mitchell Cairns-Spicer, 2020
Endnotes


2 Straube, 4.

3 Straube, 5.

4 Straube, 7.
The purpose of this design exercise was to first imagine what a neighborhood might look like should a municipality require households to begin using rainwater collection as their primary source of water. In addition, each household would be required to display their collection tanks so as to visualize their level of water consumption. The base-case neighbourhood employs a rather functional array of simple plastic containers that could be found at a hardware store. The aim of the design project was to imagine how the architecture could subsume the act of rainwater collection, displaying it in a clearly understandable manner. In taking this approach however, the design process becomes hindered due to a preconceived aesthetic outcome. Each house was designed to reflect a taste-driven architectural aesthetic which simply integrates the water tanks. Water as an ecological system is not the driver for the design and therefore the designs are no different than any other contemporary house that composes the aesthetic economy discussed in chapter iv.

Figure B.1: Low Density Suburb Neighbourhood Intervention, Mitchell Cairns-Spicer

Figure B.2: Low Density Suburb Neighbourhood Design, Mitchell Cairns-Spicer
Figure B3: Various Suburb Design Elevations, Mitchell Cairns-Spicer
Figure B.4: Suburb Home
Elevation (top) and Plan (bottom)
Mitchell Cairns-Spicer
Figure B5: Feedback Tank Design in Kitchen, Mitchell Cairns-Spicer
Figure B6: Section Through Home With Feedback Tanks, Mitchell Cairns-Spicer
Figure B7: Townhouse Neighbourhood Intervention, Mitchell Cairns-Spicer
Figure B8: Townhouse Neighbourhood Design, Mitchell Cairns-Spicer
Figure B9: Various Townhouse Elevations, Mitchell Cairns-Spicer
Figure B12: Townhouse Interior, Mitchell Cairns- Spicer
Figure B13: Section Through Home Showing Feedback Tank,
Mitchell Cairns-Spicer
Water Consumption Retreat
A Design Exploration

Figure B14: Retreat Perspective, Mitchell Cairns-Spicer, 2020
Figure B15: Retreat Axonometrics, Mitchell Cairns-Spicer, 2020
Figure B16: Retreat Plan, Mitchell Cairns-Spicer, 2020

Figure B17: Retreat Auxiliary Space, Mitchell Cairns-Spicer, 2020
Figure B.18: Sink Water Engagement, Mitchell Cairns-Spicer, 2020

Figure B.19: Retreat Bathroom Design, Mitchell Cairns-Spicer, 2020


Lismore City Council. “The Use of Reed Beds for the Treatment of Sewage & Wastewater from Domestic Households.” Southern Cross University, 2005.


