ARCOLOGY

A Design Thesis by Jack Peterson

SIGNATURES:

The following is a design thesis submitted to the
Department of Landscape Architecture and Architecture
at North Dakota State University

Completed by Jack Peterson
May 2018

In partial fulfillment of the requirements for the degree of
Master of Architecture

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PROPOSAL

"Sustainability pertains to a balanced interaction between a population and the carrying capacity of an environment such that the population develops to express its full potential without adversely and irreversibly affecting the carrying capacity of the environment upon which it depends."

-P2P Foundation

Yosemite National Park, California USA

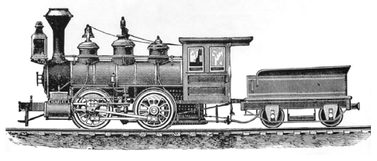
THESIS ABSTRACT:

Arcology is an approximately 30,000 square foot transit center located within the Ford Site redevelopment plan in St. Paul, MN. The core concept of the project lies in its incorporation of algae, a diverse group of water-based photosynthetic organisms, into the architectural framework. By exploring the vast potential of algae to provide energy, cleanse water, sequester CO2, and create a quilted mosaic of color, Arcology showcases a vision for the future of architecture that is both functionally, and quite literally, green.

In this future, algae along with further research into biological sciences, help develop a symbiotic relationship between architecture and nature. This relationship will allow healthy infrastructure to continually provide for the needs of an ever-changing planet and an evolving society. As the community around Arcology develops per the city plan, and the needs of its people change, the building will work together with a growing ecosystem to meet these needs and evolve with its context.

In this vision, the architecture functions self-sufficiently, remaining within the resource limit of the site, and creating a positive impact on both the human, and natural systems with which it interacts.

THESIS NARRATIVE:



Premise for Investigation
Ever since the first industrial revolution, occurring in the late 18th and early 19th centuries, we as a society have been depending on fossil fuels as our primary energy source. These fuels were formed millions of years ago by the compression of organic material that was buried in the ground and are primarily extracted in the forms of coal, natural gas and/or petroleum oil (Newman).

With the introduction of fossil fuels also came the birth of the modern profession of architecture. Thanks to the invention of the fossil fuel – powered steam engine, our material capabilities expanded exponentially allowing us to build taller, faster and more efficiently (W). These new capabilities would spur on further advancements through the second industrial revolution that occurred a century after the first resulting in the boom of the transportation industry, and later into the tech revolution brought about in the 1970's thanks to the personal computer (W).

All of the aforementioned inventions have undoubtedly played a major role in the advancement of the human race and the expansion of our infrastructure. However they have another thing in common and that is that they are, what MIT professor and architect Neri Oxman would call, ecologically indifferent. They are all simply assemblies of parts that the designers of which made without thinking of their interaction with the natural environment(Oxman). This has led to some profoundly negative side effects brought about by the evolution of our built environment.

For the last one hundred years NASA has been observing these side effects materialized in the decreasing area of global ice masses, the increase in global temperatures, the increase in sea levels and temperatures, the rise in atmospheric co2 and the increase in frequency of catastrophic weather events – the rates of which are all increasing with our global population and its inherent need for expanding infrastructure. In the United States, it was found by the Energy Information Association that buildings account for 40% of all CO2 emissions and are one of the heaviest consumers of our natural resources (2030). As population continues to rise and we continue to deplete these precious resources at exponential rates, alternatives to non-renewable, non-recyclable and harmful materials and building techniques must be explored.

There are architects who are attempting to do that and ever since the birth of the sustainability movement in the mid-20th century, they and their organizations have been working hard to make buildings that are less bad for the environment, and working hard to provide alternatives to these harmful norms.

However with technology and scientific discovery expanding every day, many architects and economists believe we are on the cusp of yet another revolution – a green revolution – that could change the landscape of the built environment. With the advancement of green building technology, design collaboration, and an expanding base of scientific possibilities, a new, revolutionized architecture is growing closer and closer to becoming a reality. An architecture that isn't just less bad for the environment, but is actually good for it. An architecture that doesn't just provide alternatives, but creates new norms.

An architecture that is truly green.

Macro Context

Minnesota is known for being one of the greenest states in the U.S. (more information in the 'thesis site' section) and is ranked in the top five in terms of environmental quality and eco-friendly behavior (Kiernan). There are numerous trend-setting green projects in The Land of 10,000 Lakes, most notably the first modern tall wood building in the United States - a mass-timber framed, seven story high-rise located in downtown Minneapolis (USGBC MN). These sustainable efforts being put forth by the Architecture community in the Twin Cities area show that the state has potential to be a leader when it comes to green design. It also suggests that clients there are willing to make sacrifices to get environmentally-conscious designs to become reality. All of these reasons make the Twin Cities area a prime location to become a sustainable design pioneer that can set the standards for the future of architecture.

The Ford Site, located in St. Paul, is the former Ford manufacturing plant site and already has a city master-plan to be redeveloped. The 135 acre site is to become "A 21st Century Community," and will be redesigned with a focus on energy & sustainability, parks & amenities, mixed-uses and smart transportation (Ford Site). All of these things are values shared with many design programs such as the 2030 Challenge, as well as this thesis project itself. Building a large scale, iconic project here could set a precedent for other cities and other developments to look towards innovative design collaboration as a way to achieve the highest levels of environmental responsibility.

The master plan for the site will provide a way to explore how cities and governments can encourage sustainable design on a large scale, and set precedents to lead the future of our built environment.

Typology

Based on the study of the surrounding area as well as the principles put forth by the master plan, the program for this thesis will primarily be a transit center designed to link the new Ford Site Redevelopment to its immediate context and its urban neighbors. This typology was chosen for these reasons:

1. Scale and availability of space on site
2. Potential for interaction with many people throughout the day
3. Traffic concerns regarding the density of the redevelopment
4. The potential expansion of the Twin Cities transit network being researched by the cities

The design will hope to stand as an example of what architecture could look like as we move into a more sustainable future. It will implement the philosophy and principles that are leading the 2030 Challenge and 2030 Commitment (2030 Challenge). The vernacular established through the fulfillment of this thesis will showcase what the underlying principles of what building design could look like as we attempt to achieve our most ambitious sustainability goals. This vernacular will include cross disciplinary collaboration, connections to nature, sustainability focused materiality and the establishment of new industry standards.

Specific consideration will be given to sustainably design spaces for each of the potential various functions. These include but are not limited to:
Waiting areas, loading zones, café space, bicycle storage, parking, locker rooms, educational space, urban agriculture, support spaces and more. The main priority for all spaces and for the design as a whole will be addressing the inherent tensions between the built and natural environments.

The finished design on the chosen site would establish the Twin Cities as a premier example for collaborative planning and design. By working through the Ford Site Master Plan provided by the City of St. Paul, this project hopes to suggest the realistic possibility of a new standard of sustainability in the future of architecture and environmental design.

TYPOLOGICAL RESEARCH:

Things to Consider

1. Sustainable strategies: 2030 challenge implementation, materiality studies, recycle/reuse, innovative technology

2. Project typology: Large scale, public projects, mixed-uses

3. Location: Urban areas, places expecting traffic

4: Socio-economic context: Urban renewal master plans, city-lead development, redevelopment plans

5. Impact: Successful project, positive reaction, lead to more sustainable projects nearby

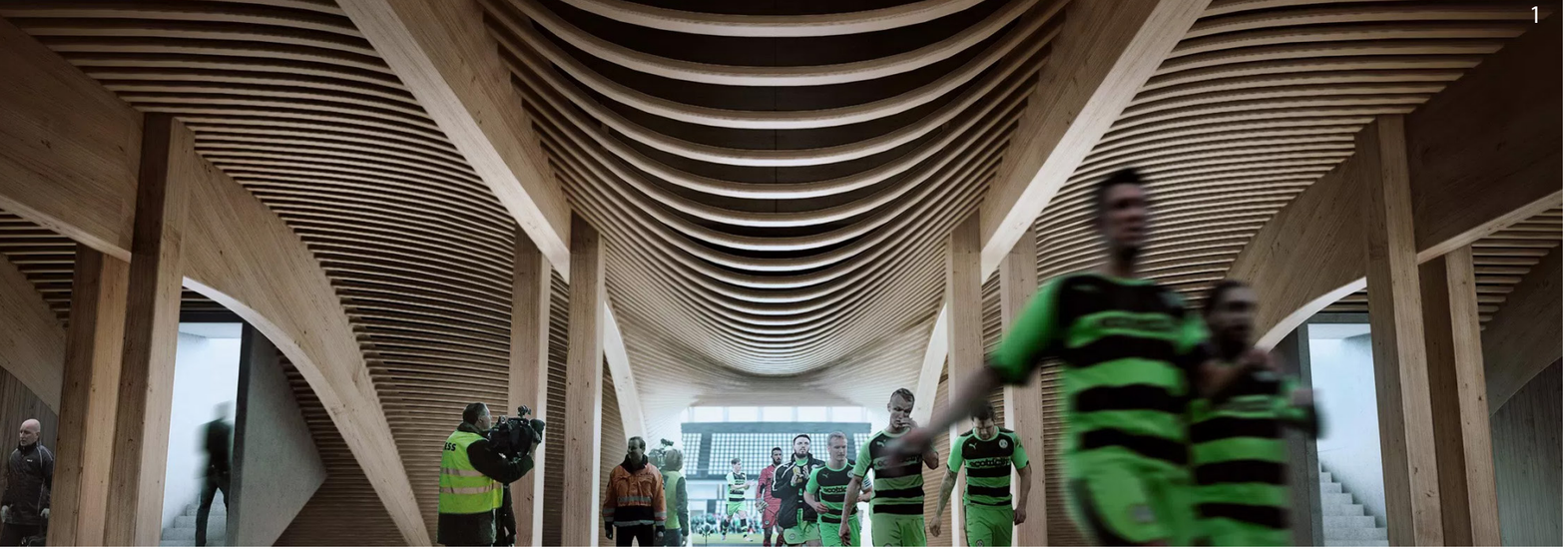
The chosen projects:

1. Eco Park Development and Stadium	Nailsworth, England
2. Packard Foundation Headquarters	Los Altos, CA
3. Miller Hull Seattle Studio	Seattle, WA

Eco Park & **Stadium**

Typology: Green development plan/athletic complex
Location: Gloucestershire, England
Size: 100 acres
Developer: Ecotricity
Architect: ZHA (stadium)
Status: Planning

Summary
On top of the athletic complex meant for the Forest Green Rovers Football Club, the project will include a $120 million nature reserve, a public transport hub, and the restoration of a canal in nearby Gloucestershire. All of this was commissioned by the renewable energy company Ecotricity and aims to operate completely carbon neutral by generating its own energy on site. Half of the Park will specifically be dedicated to sporting facilities and will include the ZHA stadium, training pitches, and a sports science hub. The other half will be a green technology business park.



Eco Park & **Stadium**

Green Emphasis
From the beginning, Zaha Hadid Architects set out to design what they called, "The world's greenest football stadium." It was this attitude that helped their design beat out the 50+ other entries and win the competition for the project (Mairs). When completed, this will be the worlds only stadium to be built entirely out of wood and would, if all goes to plan, undoubtedly have the lowest embodied carbon of any stadium (Mairs). ZHA director Jim Heverin put it like this, "...combining the latest material research and construction techniques with new design approaches to build a more ecologically sustainable and inclusive architecture." This is an 'attitude' that is echoed throughout the entirety of the Eco Park development (Mairs).

Important Takeaways
Despite the wide range of functions and broad spectrum of typologies involved, the common principle of green-driven design hopes to unify the site and lead to what could be a revolutionary and trend-setting project. The timber beams and cladding of the stadium will be mimicked in the facades of the tech-park and the louvers from the tech-park will be segued into a large fluid highway bridge connecting parts of the site across an impassible boundary. The commitment to this materiality and eco-technological elements across many site elements and phases emphasizes a truly impressive attitude. This project demonstrates the success that can be found in implementing an environmentally-conscious attitude from the very first stages of planning.

"It will be a place where green businesses and technology companies come together and share ideas: a real focal point of creativity and innovation for the area and a part of the green industrial revolution that's beginning to take off around the world."

-Ecotricity Website

Packard Foundation **Headquarters**

Typology: Commercial headquarters
Location: Los Altos California
Size: 51 thousand sq. ft.
Architect: EHDD
Completed: July, 2012

Summary
When the David and Lucile Packard Foundation set out to create their state of the art headquarters building, the main goal was not just to design a sustainable building, but to advance the Foundation's sustainability as an organization. The also hoped that their new building would be an inspiration to others and a model for sustainable design. This project is a perfect demonstration of how architecture can both improve the quality of life for its occupants while effectively limiting its carbon footprint. Upon its completion, the Packard Foundation Headquarters was the largest Net Zero Energy Certified building in the world, and achieved LEED Platinum building performance.
(Our Green Headquarters)

Packard Foundation **Headquarters**

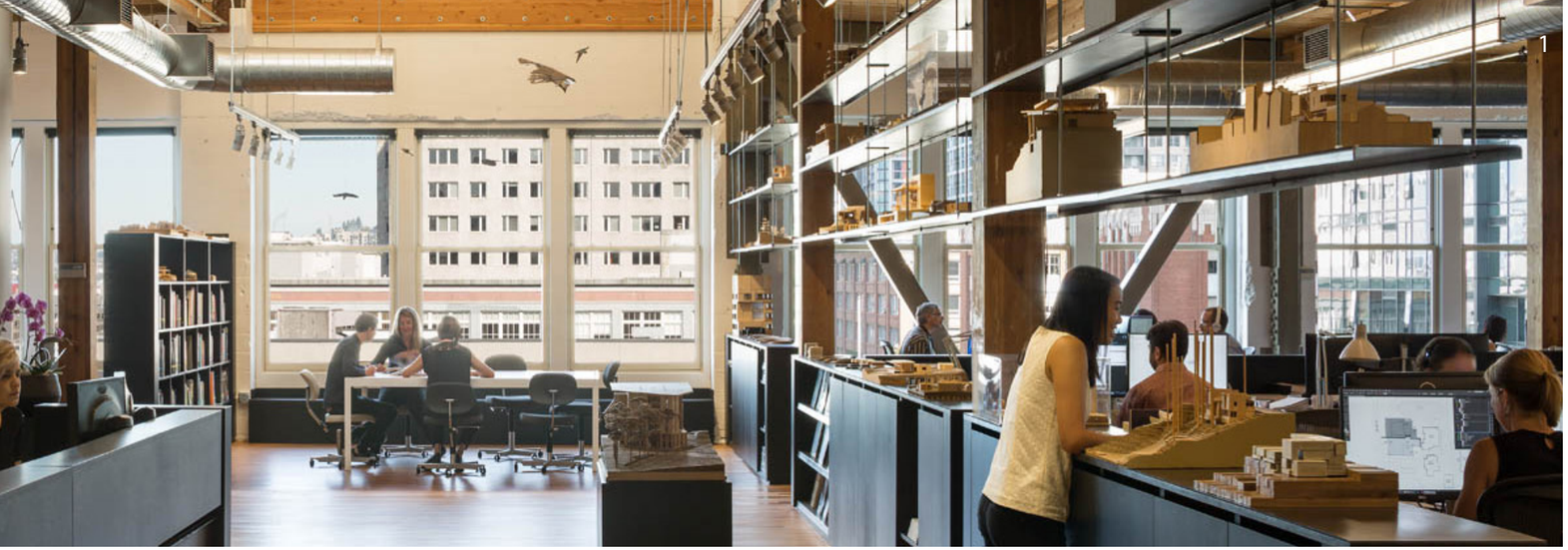
Sustainable Strategies
Once again, the focus on sustainability began long before construction of the Packard Foundation Headquarters building in California. With the overall greenhouse-gas footprint chosen as the ultimate measure for the project's success, the design team aimed for eliminating net annual gas and electricity use while aggressively addressing the process itself and its impacts throughout the project. The goal was to determine the best practices - regardless of cost - that were believed to be the building practices of the future and would transform the architectural vernacular into the coming decades. The design team sourced 95% of the building materials from recycled buildings and used many use reduction techniques such as wider stud separation. The building provides 100% of its own energy through on-site resources including 915 photovoltaic roof panels. It also has an extensive rooftop guttering system to collect and utilize some 20,000 gallons of rainwater.
(The David and Lucile Packard Foundation Headquarters)

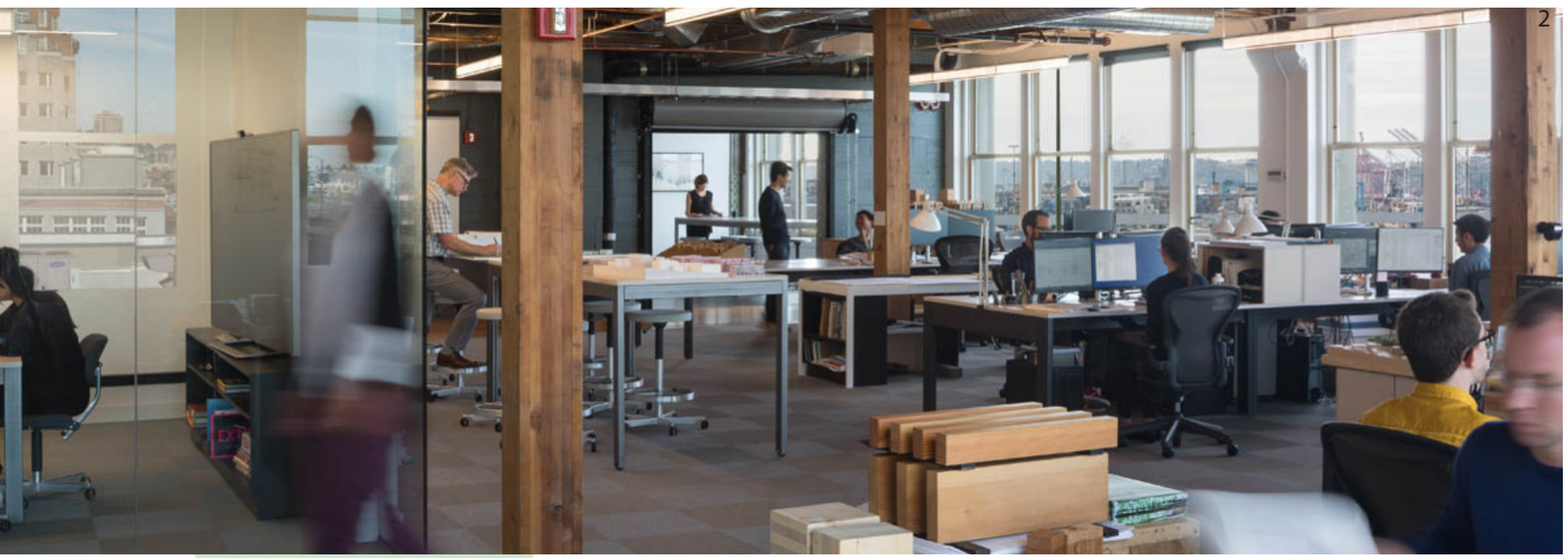
Important Takeaways
The users of this space were immediately reporting an increased sense of community and improve quality of everyday life. In this case, sustainable design was approached from an employee/occupant - first design philosophy. The building gives its users views to the outside in 90% of the building area while maximizing user customization with operable windows and smart technology. This project successfully brings occupants and the environment together in harmony to create an example of the future of sustainable architecture.
(The David and Lucile Packard Foundation Headquarters)

Miller Hull Seattle **Studio**

Typology: Architecture Firm Studio
Location: Seattle, WA
Size: 14,000 sq ft
Architect: The Miller Hull Partnership
Completed: July, 2016

Summary
This project is a renovation project taken on by the the Miller Hull Partnership of their own offices after 13 years of occupation. The firm thought it was time to rethink the space to accomodate for growth without losing the location they loved. The main goal of the project was to create a flexible open workplace that fosters collaboration and innovation while reflecting the highest environmental standards. In this case, the frim decided to seek Living Building Challenge Petal certification. In the end the team was able to acheive great energy performance and were Petal certified in Place, Materials, Equity and Beauty. The main acheivement of the project however, lies in its success in proving that reaching well beyond the 2018 code requirements is viable today.





Miller Hull Seattle **Studio**

Sustainable Strategies
Like any Living Building Challenge Project, all materials had to be vetted to ensure none are "Red List" materials. This was extremely challenging for the design team and in, fact they were not successful in avoiding certain materials in every aspect of the project (Living Future). The team, however, was able to accomplish a lot and became the first to have a successfully certify a project under the new version 3.1 of the Living Building Challenge.

In order to reduce their carbon footprint, the team was able to salvage and reuse much of the old materials in the office. Some of the recycled materials include wood flooring, existing structure, window fittings and even a majority of the ductwork. They also worked hard to eliminate superfluous materials like cable trays, ceilings, partitions and others (Miller Hull). This attitude is one of responsible industry which is a main idea of the Living Building Challenge. Whenever possible materials were sourced from the surrounding region, decreasing the projects overall embodied carbon footprint.

In the end, the projects list of successes include (Miller Hull):

- 88% savings in lighting electricity use
- 22% savings in plug load electricity use
- 19% overall energy use savings
- An Energy Use Index of 45
- 37.5% savings over the 2030 Challenge

Important Takeaways
I think that the most important takeaway from this project is the adversity that was faced and overcome by the design team. While the industry progresses, there are going to be difficulties achieving all the sustainability goals that are set, but with focus and priorities remaining unchanged, the end result can still be successful. LBC certification is seems to be one of the most difficult sustainability standards to achieve and with Miller Hull achieving just that it shows that with the right mindset any goal can be reached - even on renovation projects.

TYPOLOGICAL RESEARCH TAKEAWAYS

Sustainability pertains to a balanced interaction between a population and the carrying capacity of an environment such that the population develops to express its full potential without adversely and irreversibly affecting the carrying capacity of the environment upon which it depends (Ben-Eli).

Through the research and analysis of each project specified in this document, certain key principles can be found in common that link these different buildings through their sustainable emphasis. By using these commonalities, we can begin to establish the vernacular required to create a successful solution to the problem posed by the 2030 challenge. This vernacular will become the basic principles guiding this thesis through the design process.

Common Principles:

1. It all starts with planning:
One of the most important things about sustainable design is the commitment required from the very beginning, to the very end. Successful sustainable design is not something that happens accidentally and is not something that can simply be added into a design late in the process if time or budget allow. All of the projects researched made a commitment to designing with an environmental and sustainable focus and stuck to that commitment through the entire process. It is a commitment to progress and it is the future of architecture and our planet alike.

2. Details are important
Sometimes the smallest details can make the biggest impact on a project. This is especially true when you are working towards a goal as lofty as net-zero building design. Although not all of the studied buildings were intending for net-neutrality, they all shared a precision and a focus on their target that helped carry the project through to the end. As previously stated, true sustainability does not happen easily. It involves carefully planning and carefully designing spaces and systems that maximize the potential of the resources available.

3. Sustainable design is sustainable living
Another thing that stands out when studying sustainable architecture and building design, is the link between green design and green living. All of the buildings studied cited healthy living somewhere within their concepts. Whether as an inspiration, design goal, or driving principle, there is no question that design for a healthy user goes hand in hand with design for a healthy planet.

4. Possibilities are endless
Whether it is 8 foot deep timber beams, or buildings that can control their systems like our brains control our bodies, it is safe to say that the possibilities are endless. When it comes to the future of our profession and the future of our planet, we do not have to wait for some new and futuristic groundbreaking technology to revitalize and redefine the world as we know it. We don't have to wait because that technology is here. Building modeling software has evolved by leaps and bounds in the last decade alone and it has given architects and builders the tools we need to permanently solve the sustainability problem. We just need to have the right mindset.

5. Materiality: The past is the future
Sometimes in order to move forward, you have to look back. That has become more and more evident as the profession of architecture moves towards creating sustainable buildings of the future. As demonstrated by all of the buildings studied for this project, simplifying and utilizing materials and inspiration from the natural world will play a huge part in 21st century architecture. Humans have been building out of wood for thousands of years and wood just might be what leads us into the next thousand.

MAJOR PROJECT ELEMENTS

Arrival / Access
Determining how the users and their various modes of transportation arrive at the site will be an important design consideration. With the hope of setting a sustainable-architecture example, it will also be important to look into the future of human transportation and how that fits into this vision for the future.

Waiting areas
Developing the waiting areas for transit users will be important because it would be the most frequently used program element. Having nice places for people to gather comfortably at various times of the day is absolutely necessary to the project's success.

Circulation Spaces
Considering the movement and flow of day-to-day users is important in any project, but especially so in one that involves large amount of people coming and going at various times. Interior and exterior circulation patterns will be designed to frame important uses.

Green Space and the River
The location on the Mississippi River will play a huge role in determining the sense of place or identity for this project. Designing to incorporate the views and natural site elements will be a huge priority.

Restaurant/cafe
A place for the users to sit and have a meal is essential to attract people who would potentially experience long wait times. It can also be a place for community members to come and experience the building outside of its primary use.

Locker/changing rooms
Incorporating user well-being into the design priorities makes it essential to focus on human-powered transit. By providing a place for people to change and freshen up on their way to or from work will encourage biking, walking, and other alternative transportation.

Education
What kind of greater impact can this design have? By including educational space into the design program we can give the general public a glimpse into the technology and decision making that went into designing the building they are participating in.

THESIS SITE

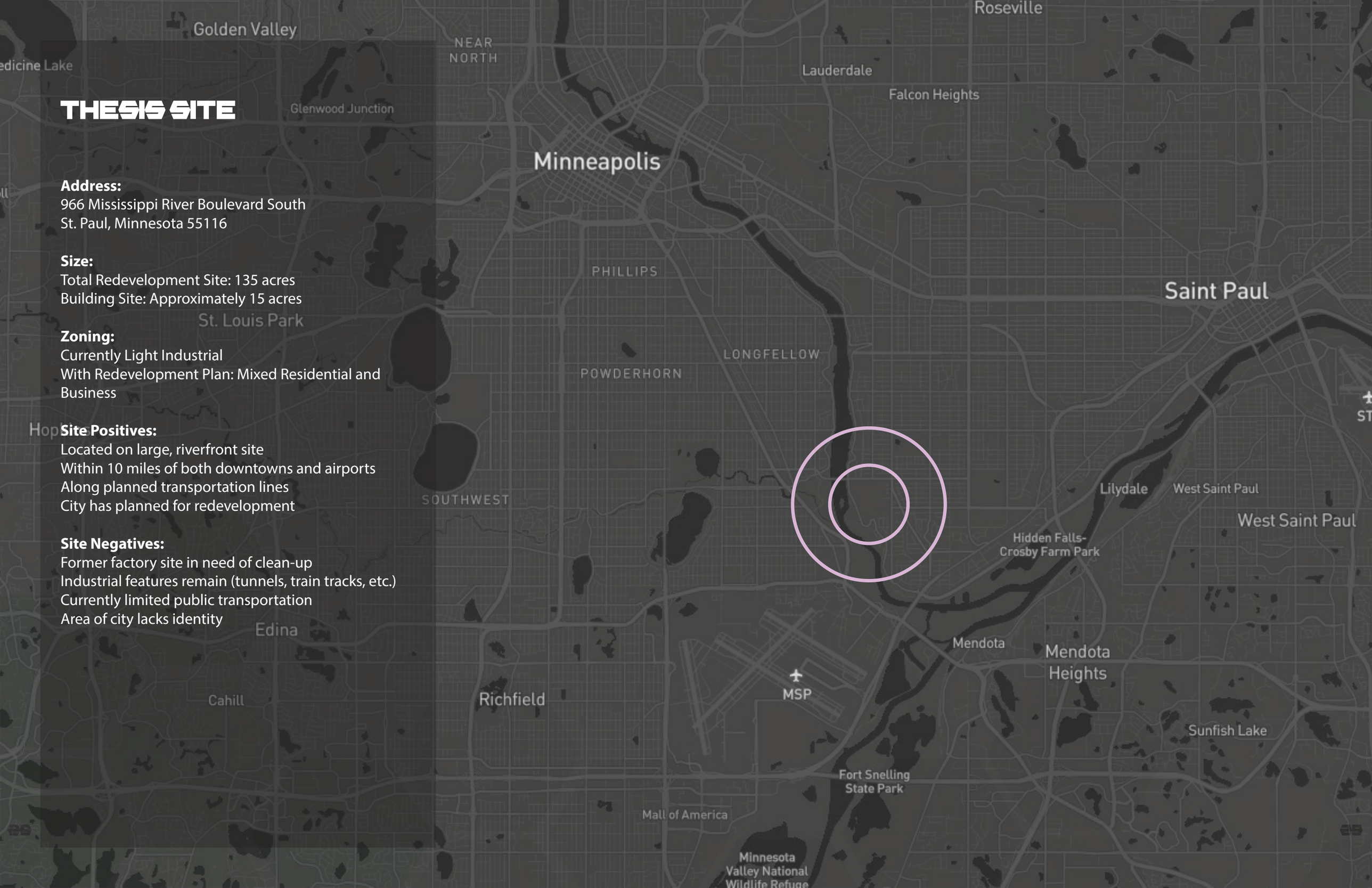
Address:
966 Mississippi River Boulevard South
St. Paul, Minnesota 55116

Size:
Total Redevelopment Site: 135 acres
Building Site: Approximately 15 acres

Zoning:
Currently Light Industrial
With Redevelopment Plan: Mixed Residential and Business

Site Positives:
Located on large, riverfront site
Within 10 miles of both downtowns and airports
Along planned transportation lines
City has planned for redevelopment

Site Negatives:
Former factory site in need of clean-up
Industrial features remain (tunnels, train tracks, etc.)
Currently limited public transportation
Area of city lacks identity



Site Selection
As I discussed in the narrative portion of this thesis, the choice to pick a site in Minnesota and in the Twin Cities area was made fairly early in the brainstorming portion of the projects development. There is a strong precedent for sustainable design here in the Midwest and I wanted to build on that while pushing the envelope even further.

Another important aspect of site selection was simply access and familiarity. Growing up in the Twin Cities area, and living there my whole life before coming to NDSU, has made me familiar with much of the data confirmed in climate and site analysis. It also meant that it would be reasonable to visit multiple times throughout the year which would allow me to capture important seasonal information.

The Ford Site, eventually selected as the final site of this thesis exploration, jumped out because of its location, potential and plan.

1. Location
It is extremely rare to find such a large site directly adjacent to one of the largest and most famous rivers in the world. This offers an inherent sense of place that cannot be overstated.

2. Potential
The site is virtually a blank slate. Having removed most of the existing infrastructure, the entire area has been primed for redevelopment by the city of St. Paul.

3. The Plan
The Master Redevelopment Plan already in place will serve as the skeleton of the design thesis. St. Paul did a very thorough job with their vision for the new development here, and that is something I will be able to build upon and incorporate into my decision making. The Plan was adopted by city council on September, 27 2017 and is expected to be a 15-20 year development (Ford Site).

THE CLIENT:

The client for this project will be the city of St Paul and the Ford Site Redevelopment team. This means working through the city issued plan and the research behind it would be their utmost priority. However the user for any building functioning primarily as a transit center is really the entire community for which it serves. This means using that master plan to develop a design that would positively affect as many community members as possible because each is a potential user. It will also be important to consider the variety of destination that each user will have, whether it's a weekday commuter or a weekend socialite. The main user demographics and potential daily traffic will be attained from case studies and through studying the current transit behaviors of the existing community members.

PROJECT EMPHASIS:

1. Defining sustainability for a future context
This is an important first step to establishing overall goals for the project. Not only am I trying to define sustainability in terms of this specific site and project, but am trying to define it for myself as the standard I hope to use to measure all my future work.

2. A commitment to inter-discipline collaboration
Considering the technological advancements being made across different fields, specifically biological science related fields, we can start to see where architecture might be headed in the coming years. This mentality of designing for the future through collaboration and by building relationships over apparent dichotomies is something that I hope to carry throughout the design process.

3. Living Building Challenge, Architecture 2030, LEED and more…
Exploring and learning about the latest green technologies and design initiatives will help me better understand both our current and future potential in terms of sustainable building. Comparing and contrasting standards between different initiatives will help develop an understanding of the design methods being developed by our industries leaders.

4. Inspiration from nature and science
Drawing inspiration from nature has long been a source of innovation in the profession of architecture. With today's technological advancements and scientific study, the profession of architecture has the potential to go beyond just mimicking nature and its processes, but to actually become a part of the ecological framework in which it exists. I hope to explore how science and architecture can work together to create a built environment that is less assembled and more grown, less construction and more organism.

THESIS GOALS:

1 **Learn more about sustainable design, biodesign and how they will shape the future of architecture:** Sustainable architecture and green-design have always been a passion of mine. Throughout this year I hope to develop a more comprehensive understanding of what that means in the professional world of architecture, and develop design skills that will allow me to contribute valuable knowledge to the profession.

2 **Explore and learn about the latest in green design software options and implement them into my design:** By researching and practicing with the latest building design technology and design standards, I can better understand where the future of design is headed for the field of Architecture and for the global built environment.

3 **Successfully communicate an exploration of a more sustainable future:** I hope to effectively and coherently bring together my ideas on this broad topic and communicate a project that represents them.

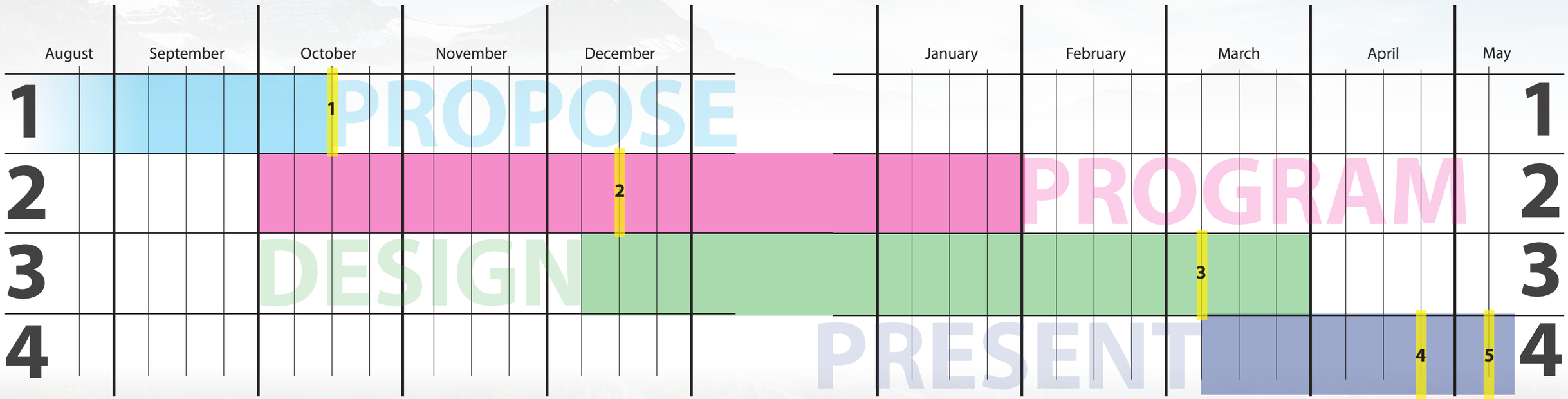
4 **Increase my architectural design abilities through practice and study:** By practicing my current design skills and learning some new ones.

5 **Create a final product that I can be proud of and that showcases all the skills I have acquired as a student of architecture:** This is the climax of a very long road and I want it to be something I can keep for years to come.

6 **Obtain a Master of Architecture Degree:** The same goal since day one. This means continuing to meet the requirements for this project as well as those for my other studies.

7 **Have some fun while doing it:** This means time managing, making efficient decisions and getting enough sleep!

PROJECT SCHEDULE:



1. Proposal
This phase began back in May when we were charged with brainstorming our thesis topics, and it will conclude with this document submission.

2. Programming
Programming began after the final typology and site were set. For me that was right at about the end of September. It will conclude when the design phase enters its third sub-phase (see following page).
*The finalized program will be submitted March 9th as the presentation phase begins.

Key Dates: **1** Thesis Proposal Due 10/12 **2** Thesis Program Due 12/11

3. Design
The design phase will begin near the end of November after data collection and analysis have progressed and will end when "production month" begins. This phase contains the bulk of the work, see the following page for details.

4. Presentation
This is the final phase and involves communicating the developed solution. This will begin in the early spring and conclude with the final project submission.

Key Dates: **3** Final Program Due 3/9 **4** Digital Exhibit Due 4/20 **5** Thesis Book Due 5/11

PRESENTATION INTENTION:

The final documentation and presentation of this thesis study will implement a variety of media to convey and summarize the design and the processes used to complete it. There will be a mix of required and non-required material including:

- The Project book: In addition to or in conjunction with this thesis proposal document, the project book will include the full report of the designs process, solution and final project takeaways. The book will be turned in prior to its due date on May 11th 2018.

- Project Boards: A printed graphic display accurately depicting the design thesis and the design solution. This will be used during the thesis display and in conjunction with the presentation (see below). Boards to be completed prior to the digital-copy due date of April 20th 2018.

- Physical Model: A physical, scale model depicting the design solution and surrounding site. The model will be constructed with a high level of care and detail to accurately represent the built environment suggested by the final design. Model to be completed prior to the opening of the thesis exhibit on April 23rd 2018.

- Thesis Presentation: An oral and digital presentation put together per the requirements and presented at the end of the spring semester. The project boards and model will be showcased during the presentation and this will mark the conclusion of the Master of Architecture Program. Presentation to be given during designated time-slot between April 30th and May 3rd 2018.

- Supplemental Models: Manifested in the form of detail models and/or research results.

A digital copy of the complete project will be published to the North Dakota State University Institutional Repository and will be available for viewing world-wide.

PLAN FOR PROCEEDING:

As stated previously in the project goals section, the most important part of my plan will be sticking to a schedule. I hope to maintain a planned and manageable pace to ensure all phases are thorough and complete to the project standards. The first step of this schedule is the completion of the proposal document.

Moving forward, per the schedule, work continues to research and develop a comprehensive program to meet the requirements of the fall semester's Thesis Preparation Seminar. After a critique of both the proposal and program, all necessary modifications will be made before stepping into Phase three: Design.

In the design phase, I will begin the application of the tools and methods developed in the prior phases of this thesis. The design phase will be the most extensive of the 4 phases and can be broken into sub-phases as follows:

1. Preliminary planning and analysis
2. Solution development and approval
3. Technical details and modeling
4. Solution administration and presentation execution

These phases are planned to mirror the typical phases of the professional architectural process; Research, Conceptual & Schematic Design, Design Development, Construction Documentation and Construction Administration.

The final design solution will be completed by March 30th 2018 to allow for plenty of time to review critiques, update changes and put together the presentation materials. All of this will conclude with the final thesis presentation described in detail in the Presentation Intention section.

A list of the design software that will be used can be found in the important resources section of the appendix.

RESEARCH

"Rethinking the design, construction, operation, and dismantling of buildings in order to mitigate climate change and increase resilience toward its effects is the most important, and exciting, undertaking that architects of this era will likely experience in their careers."

-Architect Magazine

PRELIMINARY FINDINGS:

In order to perform an efficient and effective design process, a groundwork of research and knowledge is the first step. That means identifying resources, case studies, design tools and scientific evidence that will assist in the design process as the project moves into its future phases of production. For this particular project, the goals of the preliminary research phase included:

1. **Identify the latest sustainable design standards and determine how they are used, and how they benefit the design process.** This is important to understand how other projects were able to reach their sustainability goals and produce their own versions of green design, as well as bring this project closer to finding the means to the end product of a completed thesis project.
2. **A look into the history of "green" design, fossil fuel usage, and the study of the impact of the building industry on climate change.** Not only will this provide a knowledge base and starting point for the design phases of this project, but it will also provide insight into the trajectory of the profession and perhaps shed more light onto the next steps in the world of architecture.
3. **Case studies of biomimicry and biodesign implementations.** How are architects using these principles as alternatives to harmful fossil fuels and how could this effect the future of the profession? This project hopes to explore how inspiration from nature and the principles of biomimicry and biodesign could be the future of "green" design and the future of the profession as a whole. Identifying scientific evidence and research into this idea will become the backbone of the hypothesis that this thesis hopes to produce, and the driving idea behind a final design solution.

Green-Design Programs

Sefaira architecture is a program that promises to be the next phase of performance design. Its main points of emphasis include its seed, difficulty level, credibility, collaborative ability, and communicative ability. Being cloud based, it is extremely easy and efficient to download the plug in and upload to the Sefaira data cloud. This means it can be viewed and modified by anyone who is given access to the online model – creating quick and efficient inter disciplinary communication. One thing that makes Sefaira different is its validation analysis. It can quickly recalculate data after the simplest of design modifications and can be use with the most basic of a schematic design. The program itself analyzes the building based on energy, carbon, thermal comfort and renewables with a simple click of the mouse.
(Source: Sefaira)

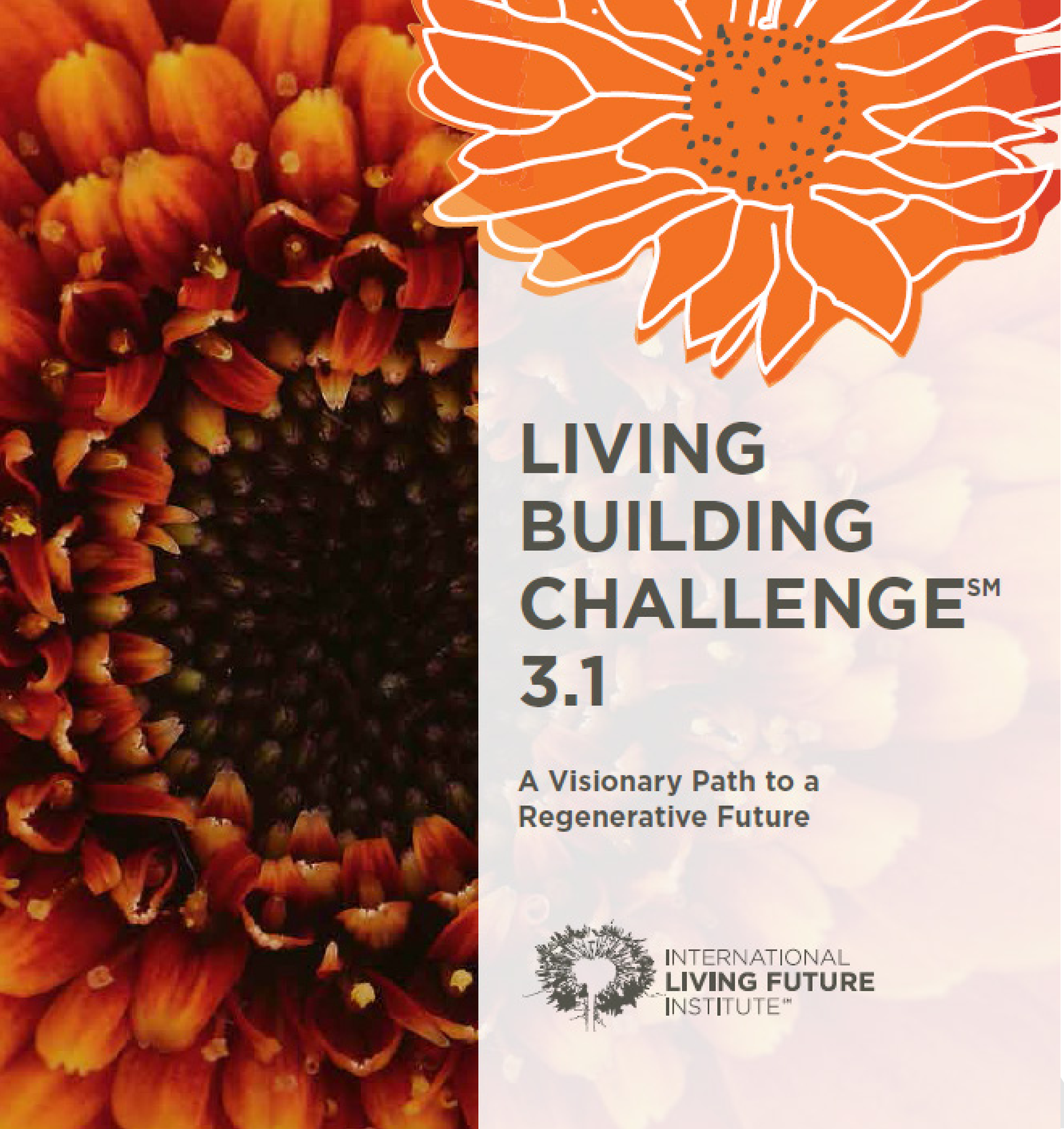
Green Building Studio(GBS) is an Autodesk product design to run building performance simulations to optimize energy efficiency and work toward a carbon neutrality in the early design process. This is another cloud-based program that is focused on simplifying the task of conducting building performance analysis. One of the best features of GBS is its seamless Revit integration. Being an Autodesk product means it can very easily communicate with a Revit model directly. Unlike sefaira, even the most complete and detailed models can be analyzed.
Another key feature is the ENERGYSTAR score that the program gives, allowing you to compare your design's energy efficiency to similar buildings across the country. GBS can also provide LEED point estimates and shows detailed ways you can improve the daylight and water use in the design.
(Source: Kilkelly)

Insight is another Autodesk product that promises to empower architects and integrated design teams with centralized access to building performance analysis data and advanced simulation engines. This program is one of the few that offers a free 3 year membership to students. The main features of Insight include real-time feedback, BIM integration, Daylight simulation, and simple visualization tools. One cool thing that can be found on the Insight website (https://www.autodesk.com/products/insight) is a collection of case studies on buildings that used the software in the real world. I think this really helps with learning how you can apply this technology to your specific project. (Source: Insight)

OpenStudio is a cross-platform collection of energy modeling software tools. The main ideas of OpenStudio are facilitating community development, extension and private sector adoption. This program was developed by the National Renewable Energy Laboratory and the US Department of Energy. This program is a little different from the rest because it encourages use by not only those designing and building the buildings, but those who run and manage them as well. Open Studio is really made up of two programs, the application suite and the software development platform. The development platform is actually geared to researches and hopes to help with the development of even better energy software in the future. In fact it can help anyone develop and code specific software to help in their building design. (Source: Open Studio)

Integrated Environmental Solutions (IESVE) is another program hoping to help build better buildings and smarter cities by reducing energy costs with building performance analysis. This is a UK based company that claims to be the
recognized world leader in 3D performance analysis software. It is used to design tens of thousands of energy efficient buildings around the world. The main goals of this program and software is to uncover the hidden costs in energy and carbon to save on investment and create better buildings. This software is endorsed by many of the worlds largest international firms and integrates easily with SetchUp specifically. They offer a specific packages for architects that is considered the most comprehensive performance analysis suite. A cool thing that this software emphasizes is its application in every phase of a project beginning from the opening charrette. It's capabilities include water reduction, building form optimization, "Right-To-Light," material characteristics and advanced solar orientation. (Source: IES)

Vabi apps are an integration of productivity tools for building performance specifically within Revit. The apps include a financial simulator, spatial requirements assistant, thermal comfort optimizer, energy assessor, daylight ratio evaluator, lighting organizer, ventilation optimizer and accessibility evaluator. Approaching green design from a financial, spatial and accessible viewpoint is something that is unique about Vabi Apps. (Source: Kilkelly)



LIVING BUILDING CHALLENGE℠ 3.1

A Visionary Path to a Regenerative Future

INTERNATIONAL LIVING FUTURE INSTITUTE™

THE LIVING BUILDING CHALLENGE

The Living Building Challenge is known as the most rigorous proven performance standard for buildings. It consists of seven categories or "Petals" that are broken down into a total of twenty rules or "imperatives" that must be followed in order to achieve certification. The Petals are as follows:

PETALS

Imagine a building that is as efficient as a flower; a simple symbol for the ideal built environment. The Living Building Challenge is organized into seven performance areas.

PLACE

Restoring a healthy interrelationship with nature.

WATER

Creating developments that operate within the water balance of a given place and climate.

ENERGY

Relying only on current solar income.

HEALTH & HAPPINESS

Creating environments that optimize physical and psychological health and well being.

MATERIALS

Endorsing products that are safe for all species through time.

EQUITY

Supporting a just and equitable world.

BEAUTY

Celebrating design the uplifts the human spirit.

The Living Building Challenge(LBC) became the first major factor in the design process and influenced many of the design decisions, especially early on in the process. By providing a framework of a high design standard and an easy to follow standard guide (pictured left) the LBC can be introduced into any design process.

Alternative Research

Nature was and will always be man's first teacher. From learning simple lessons such as which foods to eat and which to avoid, to more profound lessons such as the transformative metaphor that a caterpillar goes through to become a butterfly. Lessons and inspiration can be taken from almost everywhere in nature and applied to not only an academic or metaphorical context, but an architectural one as well.

From the tree-trunk like pillars of the Sagrada Familia, to the Beijing national stadium's resemblance to a birds nest, nature has been inspiring architects for as long as there have been architects. Other fantastic examples of nature inspired architecture include Santiago Caltrava's great white wings of the Milwaukee Art Museum, the sea sponge – like system and structure of The Gherkin by Norman Foster in London, the former tallest building in the world Taipei 101 and it's resemblance to slender bamboo, the Lotus (flower) Temple in New Delhi, India, and so much more (Douglass).

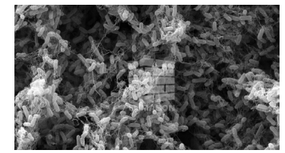
In recent years however, with new technology and scientific advancements, nature has begun to inspire architecture in a whole new way. Researchers and innovators have begun to use nature and "natural materials" to not only inspire form and function, but to literally develop new materials and building techniques. In this context, "natural materials" does not mean market typical real wood flooring or "natural" siding; but instead refers to truly raw and unaltered material produced entirely by the natural ecosystems of the planet. Today we are digging deeper and deeper into the natural world - even to microscopic levels – to seek answers that have been there all along. This concept is called biodesign (Bender).

Silkworms and Robots work Together
Mediated Matter group, a part of MIT Media Labs, have researched how silk, woven in real time by live silkworms, can be used to create actual building form. In 2013 they created a dome from silk fibers woven by a robotic arm and is the result of an exploration into how digital and biological fabrication techniques can combine to produce architectural structures. The arm was specifically programed to imitate the way a silkworm would deposit silk to build it's cocoon and created a 26 panel structure that was suspended from the ceiling. Next, some 6 and a half thousand silkworms were placed on the structure and allowed to roam around, depositing a silk skin as they moved.

The program was lead by Neri Oxman who believes that by studying this and other natural processes, we can develop a way of "printing" structures and pieces of architecture more efficiently.
(Source: Howarth)

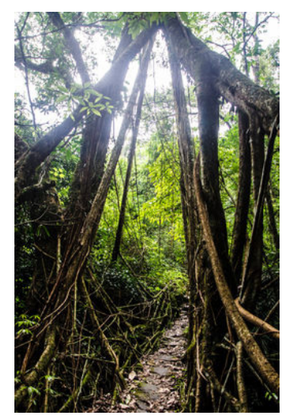
Bricks formed by Cornstalks and Mushroom Roots
In a project called Hy-Fi by The Living, a New York based design studio led by David Benjamin, a design team, led by Dani Nagy, developed a pavilion design out of a self-assembling mixture of crop waste and mycelium, a mushroom root material. They were able to pack the mixture into 10,000 brick forms and build a 40 foot tall pavilion out of them which they then used to host public and cultural events for a few months time, before disassembling the structure, composting the bricks, and returning the resulting soil to local community gardens.

The studio's website sums up the process perfectly; "This successful experiment offers many possibilities for future construction." These organic bricks are a material that can grow in just five days and contains no waste, no energy input and no carbon emissions.
(Source: Hy-Fi)



Cement that Grows
The cement industry alone accounts for 5% of the global carbon dioxide emissions. This is something bioMASON, a biotechnology manufacturing company, hopes to change as it attempts to revolutionize the construction industry. Instead of through firing and traditional curing/hardening, bioMASON grows their cement blocks by feeding units mixed with a microorganism a specific aqueous solution.

This process promises no CO2 emission, minimal dependency on natural fossil fuels, no waste manufacturing, renewable sources for materials and even industrial waste stream recycling.
(Source: bioMASON)



Tree-Shaping Bridges
Tree shaping is the use of living trees and/or plants as the medium to create structures and art. The concept can be seen as early as the 18th century where ornamental, woven tree-lined pathways and avenues were common. However the present day bridges built in present day northeastern India perhaps showcase the most perfected implementation of the idea.

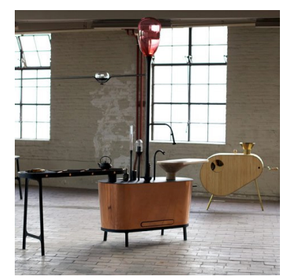
Needless to say, these bridges do not come quickly and can take 5, 10 or even 20 years to complete, but they are said to have life spans of well over 500 years. These living bridges are self-renewing and self-strengthening, as their root components continue to grow over time. The bridges located in this region come in a variety of shapes and sizes but can be found as big as 170 feet long, and 80 feet high above the rivers below!
(Source: Bose)

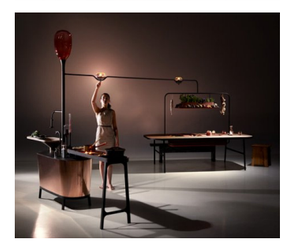
Mushroom Root Structure
An architect – Engineer duo, Dirk Hebel and Philippe Block respectively, have been developing a self-supporting structure made from fungi! Mushroom mycelium has been discovered to be one of the most valuable biodesign materials, but this pair have gone one step further.

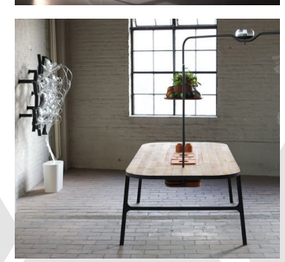
They believe their designed structure could be an alternative to construction materials that, "…get us in trouble with the world." By itself, mycelium is not necessarily very strong, however Hebel and Block conducted this experiment to show how something like this can actually be very stable through its form. Their blocks are a mix of mushroom spores and a mix that includes sawdust and sugarcane. This mixture acts as food for the fungi which is then transformed into a spongy mass, and transferred into molds where it can continue to solidify. This form-growing process takes just two weeks only requires, "a little bit of biological residue and a little bit of knowhow," to grow into any shape anywhere.
(Source: Frearson)

Fab Tree Hab
At the Massachusetts Institute of Technology, a team called Human Ecology Design (H.E.D.) led by Mitchell Joachim developed a concept intended to revolutionize the way Habitat for Humanity provides homes to those in need. The idea was to grow homes out of native trees using simple and reusable scaffolding that would be removed once the home was able to support itself. This means the home would be fully grown from and integrated to the native ecological community. The plan involved growing the small dwellings based on five growth periods with a habitable space available in about 5 years. A key concept that drove the team can be found on the archinode website listed below: "By rejecting the tendency towards immediacy and, likewise, first cost dependency, a true representation of sustainable value can be achieved by explicitly recognizing the adaptive, renewal, cooperative, evolutionary, and longevity characteristics of home."
(Source: Joachim)

Dune
This architect, Magnus Larsson, envisions using bacteria and sand to develop barriers that could stop desert spread. The particular bacteria that would be used has the ability to naturally convert sand into sandstone. The transforming sand dunes could be shaped to collect moisture, protect trees or shelter people (Myers, 62). The problem of desert spread is one of great concern in Africa, and this idea could be used to form a 3,728 mile barrier protecting land and people. According to a United Nations study, 'Desertification has emerged as an environmental crisis of global proportions, currently affecting an estimated 100 to 200 million people, and threatening the lives and livelihoods of an even larger number' (Myers, 62). This is an example of how the study of biodesign and the integration of biology into architecture could help to solve some of earth's most important crisis. (Image Source: Hudson)





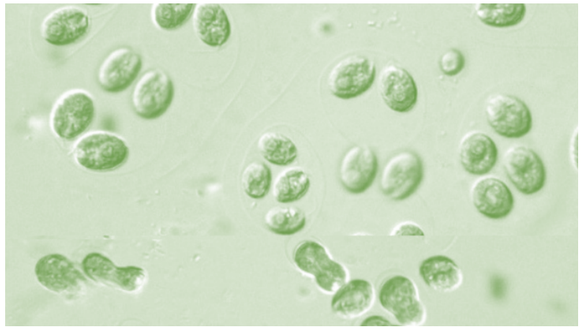


Microbial Home
This concept is not necessarily architecture but it could still be an important innovation to be integrated into future architectural design. The Microbial Home is comprised of several integrated appliances that can heat, refrigerate, and even generate food while also digesting waste products (Myers, 97). The idea that the designers had was to view the home as a biological machine for filtering, processing, and recycling what we conventionally view as waste. The Microbial Home is a proposal for an integrated cyclical ecosystem where each function's output is another's input. (Image Source: Myers)

ALGAE FOR ENERGY PRODUCTION

As the design research progressed, algae became the second major factor in the process. This is the most influential result of the research into biological sciences.

"Algae," is actually a very broad term used to describe a diverse group of (mostly) aquatic photosynthetic organisms, ranging from single-cellular micro-algae to giant kelp and seaweed. In the context of this project and the context of energy production, we will be dealing with Microalgae (Algal).



To put it simply, micro algae are able to convert sunlight into fuel in the form of natural oils. Under the right conditions this oil can be produced in massive quantities and converted into biofuel. Algae could potentially produce up to 60 times more oil per acre than land-based sources and this is largely due to the fact that micro algae have an extremely high growth rate and can grow up to 100% in size in 24 hours (Algal).

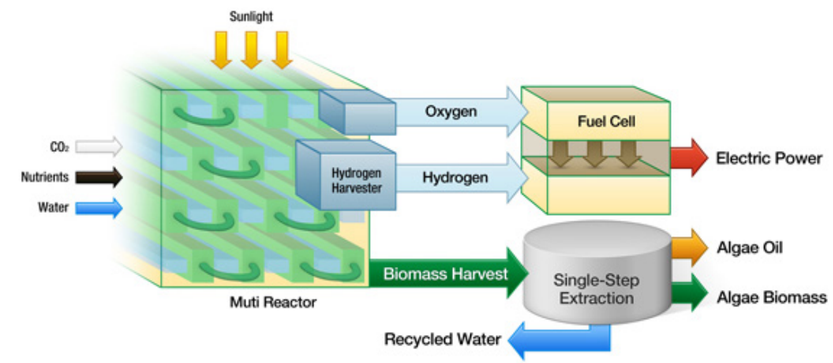
Researchers have been studying this algae to energy process since about the 1940's and in the 1970's the us department of energy determined algae to be the only viable method to produce enough fuel to replace current world diesel usage (Algae Basics).

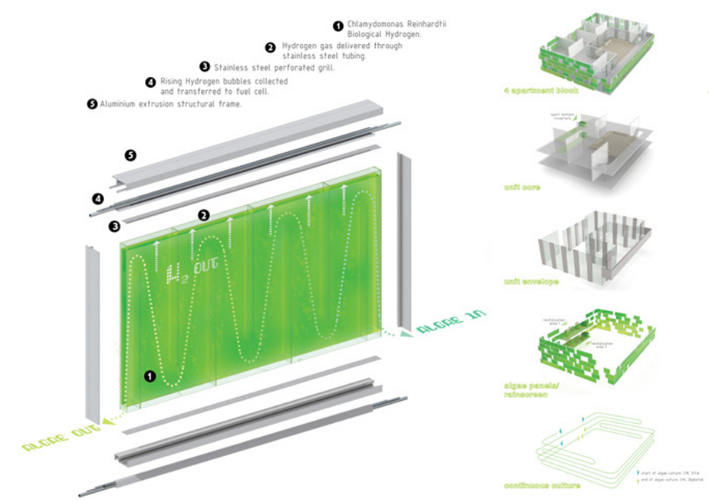
Unfortunately, because of the complex process necessary for producing bio-deisel from algae, the only current method of profiting on cost is in large scale algae farms. While there are many fuel companies investing in such farms, the small scale production of this kind of biodiesel remains unattainable for the time being (Wesoff).

More recently however, researchers have discovered another way. In the year 2000 researchers discovered that a certain type of algae, Chlamydamonas Reinhardtii, could be modified to produce hydrogen instead of oxygen during photosynthesis. This meant that the process of harvesting biomass could be skipped, and the hydrogen being produced could be moved directly to a fuel cell for combustion (Grow Energy).

This system can then be modularized and operated as a closed loop system with water, some nutrients and sunlight going in, hydrogen and eventually recycled algal biomass coming out. The process of combustion of hydrogen is also a closed loop in this system, operating on the hydrogen from the algae panels and producing only power, heat and water as a byproduct.

The image on the lower right is a concept for modular algae panels developed by a company called Grow Energy. They envision these hydrogen producing panels to be able to integrate into architecture similar to todays photovoltaic and could one day provide a cost-comparable, more efficient and more sustainable option for modular energy production. This panel system was the inspiration for the one found in the design solution.

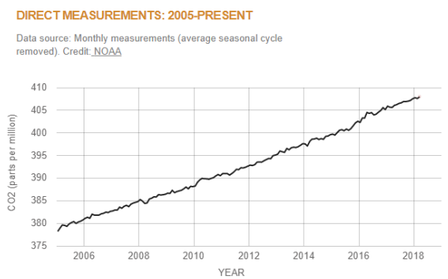


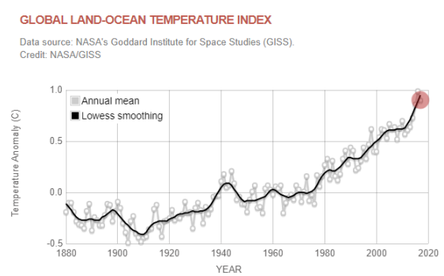


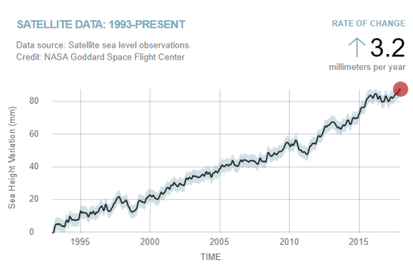
PROJECT JUSTIFICATION:

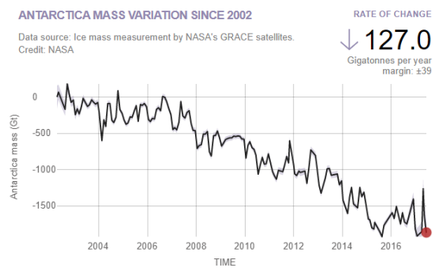
There are many reasons that I believe this to be a valid and important topic of study for my thesis. Most of them have to do with climate change and the impact that human construction and buildings have on our planet. Here are the facts:

1. The Earth's climate is changing.
16 of the 17 warmest years on record have occurred since 2001. This has led to an increase in Earth's surface temperature of about 2 degrees Fahrenheit (Global Climate). This temperature increase is then largely absorbed by the oceans which has led to massive glacial retreat, shrinking ice sheets, decreased snow cover, increased sea level, increase in frequency and intensity of extreme weather events, and an increase in ocean acidity. The evidence reveals that the earth is currently warming at a rate of roughly ten times that of the last ice-age-recovery warming. This warming is largely attributed to the burning of fossil fuels which leads to an increase in atmospheric carbon dioxide.

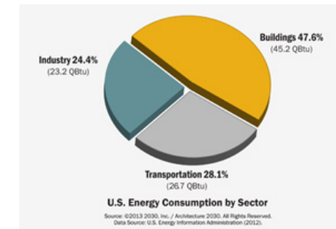


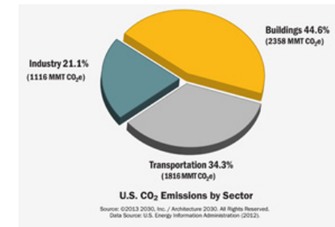






2. Buildings are responsible for nearly half of the energy consumed, and gasses emitted in this country.





4. A change must be made!
This is an excerpt from architecture2030.org:

The latest International Panel on Climate Change (IPCC) Fifth Assessment Report confirms the necessity for immediate and sustained action on climate change, detailing how close we are to a turning point in the earth's climate system. The underlying conclusion of the report is that the time has arrived for taking the necessary steps to preserve livable conditions on earth: as quickly as possible, we must stop burning fossil fuels, aiming for a complete phase-out by around 2050. One key way to do that is to reduce and ultimately phase out the CO2 emissions produced by the building sector by transforming the way buildings are designed, built, and operated.

The process of phasing out CO2 emissions in the building sector and "changing the way buildings are designed" is obviously a long and complicated road. There are many organizations and initiatives trying to tackle the world's most massive problem and we have made great strides towards our goals; but we need to do more. As new designers about to enter the professional world, we need to be the change. The vernacular of architecture, engineering and construction needs to continue to become more conscious of the impact our buildings are having on our planet. We are now at a turning point and need to take the necessary steps to preserve our way of life here on Earth and ensure a long, sustainable future. Today we have the research, technology and ability to make that happen – we just need to learn to apply it. That is what I hope to explore with this thesis.

THESIS CONTEXT:

History of Climate Change Science
The scientific discovery of climate change began during the early 1800's when the natural greenhouse effect was first identified, and the ice ages were first suspected. It wasn't until the 1960's however that the warming effect of carbon dioxide theory became widely accepted. By the 1990's the result of increased technological capabilities such as computers was in depth study and data analysis of our climate and humanities impact on it. Since then, research on climate change has expanded to include multiple disciplines and the theory of human-lead global warming is endorsed by some 97% of climate scientists (Climate Change).

History of Fossil Fuels
The use of some fossil fuels, such as coal, predates recorded history. However it wasn't until the latter half of the 18th century that their use became widespread and industrial. Around this time, the use of fossil fuels in steam engines began to build us into the Industrial Revolution (1820). The invention of the internal combustion engine greatly increased the demand for gasoline and oil. At the same time, gas lights, electrical generators and new forms of transportation began significantly increasing the global fossil fuel use (Wiki).

To put it simply, fossil fuels create energy through burning million + year old organic material. This process of combustion produces carbon dioxide and water typically in the form of vapor. These two resultants are the main components of what make up the earth's layer of greenhouse gasses (along with methane and nitrous oxide). This layer is like a thermal blanket for the planet, absorbing heat that would otherwise escape, and radiating it back towards the earth's surface (Cimate Change).

The role of the greenhouse effect is vital to life as we know it and is what makes earth the only habitable planet in our solar system. As an example, the planet Mars has a thinner atmosphere made up of nearly all carbon dioxide. Because of this, Mars' surface is mostly frozen and there is no evidence of life. On the other hand, Venus has too strong of a greenhouse effect, one that contains about 154,000 thousand times as much CO_2 as earth. This leads to a surface temperature hot enough to melt lead (Climate Change).

The industrial activities depended upon by our civilizations around the world have raised CO_2 levels by almost 50% in the last 150 years alone (Climate Change).

History of "Green" Architecture

Though not a radically new concept, green architecture is a philosophy that simply supports sustainable energy, sustainable materials, reuse/recycling, and an approach that is conscious of environmental impact. Buildings in the 21st century consume half of the world's resources and green architecture hopes to change that pattern.

There are varying accounts as to the true beginning of green architecture but the modern and mainstream view of this concept can be attributed to the rise of eco-awareness that developed in the 1960's. Ian McHarg, a british landscape architect and founder of the LA department at the University of Pennsylvania, published a book called "Design with Nature" in 1969 (Honeyager). This is considered as the first step-by-step guide to designing with a region and use the natural aspects appropriately. The pioneers of green design however, came well before that, with architects like Frank Lloyd Wright stressing a cooperation with nature and letting architecture rise out of a natural area.

As the profession progressed into the 1980's, the concepts of green design had taken root and the number of environmental advocacy societies expanded greatly. With membership in these societies soaring, the trend made its most significant milestone in 1994 - the formation of the U.S. Green Building Council (USGBC) (Honeyager). With the USGBC came the first list of measurable standards and criteria for the design, construction and function of environmentally responsible architecture. This list is known as the Leadership in Energy and Environmental Design (LEED) standards and included guidelines for all of the following:

1. Sustainable Site Development
2. Conservation of Water
3. Energy Efficient Operation
4. Materiality Choices
5. Indoor Environmental Quality

Since the formation of the USGBC and LEED, more significant strides have been made in terms of availability of materials, technological capabilities, and acceptance of standards. Unfortunately the practice of building to meet the standards of LEED is not as widespread as it could be, and there is still a lot of room for improvement.

GREEN DESIGN TIMELINE:

1775 - 1820 The Widespread Use of Fossil Fuels

Leading up to the industrial revolution, the use of fossil fuels as a primary energy source fuels industy.

1859 The First Oil Rig is Tapped

With a growing demand for oil after the invention of the kerosene lamp, oil wells can now be used to succesfully produce petroleum.

1896 Fossil Fuels Linked to Global Warming

Swedish scientist Svante Arrhenius is the first claim that fossil fuel combustion may lead to an increase in the greenhouse effect.

1935 The Father of Green Architecture

The influential project *Fallingwater* is completed by renown architect Frank Lloyd Wright whom many consider the father of green and sustainable architecture. Wright was on of the earliest advocates for design *with* nature, not on top of it.

1969 The Book is Written on Green Design

Landscape architect Ian McHarg writes, "Design With Nature," a step-by-step guide to eco-aware design.

1970's The Environmental Movement Continues

Increasing environmental awareness combined with spiking oil prices leads to the earliest experiments with contemporary green building and significant research into improving resource efficiency is spurred.

1989 AIA Forms Environmental Committee

The Committee on the Environment is formed by the American Institute of Architects.

1994 USGBC & LEED

The United States Green Building Council and Leadership in Energy and Environmental Design are formed. Marked as the turning point for Green Design.

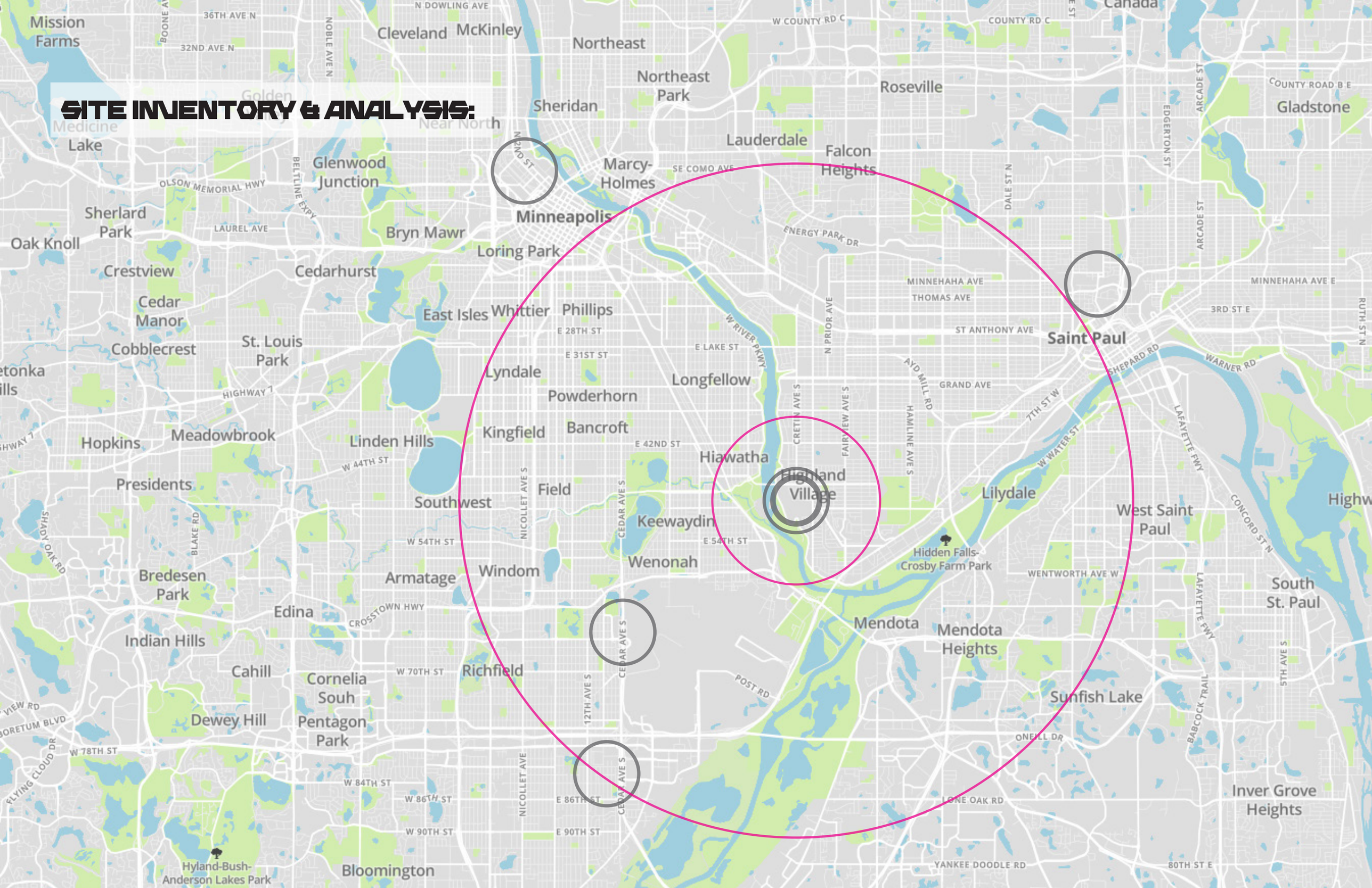
2004 2030 Challenge Commitment

The 2030 Commitment is addopted by the AIA vowing to have all new buildings and significant renovations be carbon neutral by 2030.

2005 + Green Legislation

A growing number of government agencies continue to enact green building standards and codes, furthering the principles of eco-consious and green design.

SITE INVENTORY & ANALYSIS:



SITE INTRODUCTION:

As previously stated in this document, the site for this thesis will be the located within the Ford Site in St. Paul, Mn. It is situated off of Ford Pkwy between Mississippi River Blvd and Cleveland Ave S. This thesis will occupy a part of the 135 acre site and will fit into, and slightly modify, the cities master plan for its redevelopment.

The Ford Site Zoning and Public Realm Master Plan was adopted by the Saint Paul City Council in September of 2017 and promises to be a "21st Century Community." From the Saint Paul City Website;

"The vision for the site is a connected, livable, mixed-use neighborhood that looks to the future with clean technologies and high quality design for energy, buildings and infrastructure."

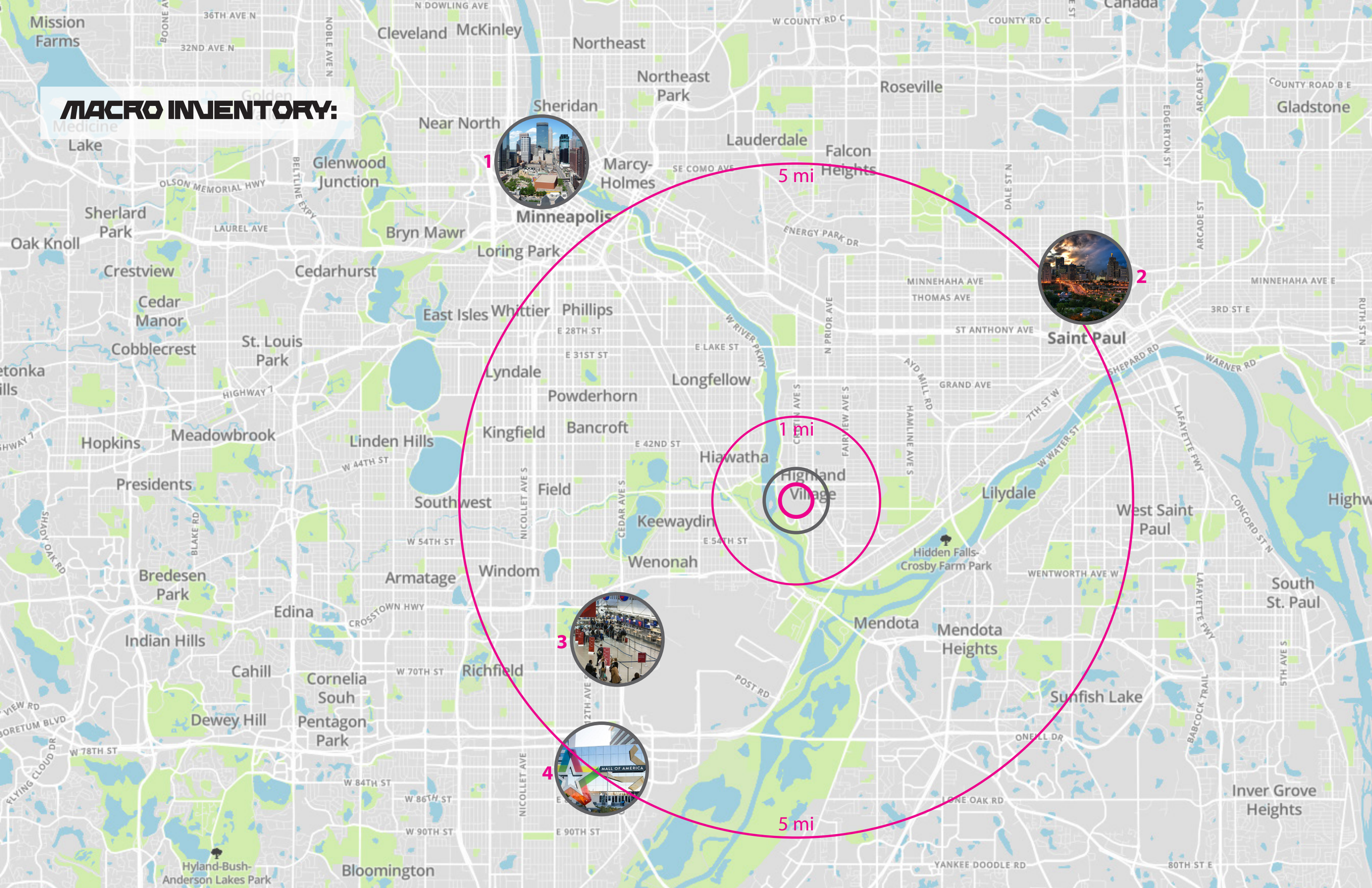
This site was chosen for multiple reasons. The first is simply the scale and possibilities of this development opportunity. It is very rare in a modern city that a vacant site of this size is primed for redevelopment – especially one so close to two separate downtowns, an international airport, and located on the banks of a major river. All of that adds up to an exciting and intriguing development opportunity – one I would love to be a part of.

The second reason is access to, and attitude of the City of St. Paul's Master Plan. This plan sites sustainability and looking to the future with clean technology as major factors in its proposal. These are values that directly align with the underlying idea behind this Architectural Thesis.

The master plan will also add a sense of realism to the project. I will hope to work closely with the documents provided online, as well as the ongoing discussion for the future of the site to see how my design would fit into this real world situation. With any city plan of this scale, there is also plenty of opposition. Many residents of the area complain that the cities plan with create an area far too dense for the surrounding neighborhoods to handle and the traffic would simply be too much. By paying attention to the community's thoughts and emotions, I will be able to cater my design to their concerns while still only slightly modifying the council approved master plan. This is an issue that can arise very often in the professional world of architecture and development and I will enjoy working through that process.

Finally, I chose this site to host my thesis design because I believe that the Twin Cities area is the perfect place for a project that hopes to push the boundaries of sustainability. This project would further the reputation of the twin cities area as a leader of sustainable design, and will set an example leading us into the future of architecture and development. By working through the problems that arise when designing for this climate while keeping the principles and priorities set in the introduction of this thesis at the forefront, we can show that if it can happen here it can happen anywhere.

MACRO INVENTORY:



1

2

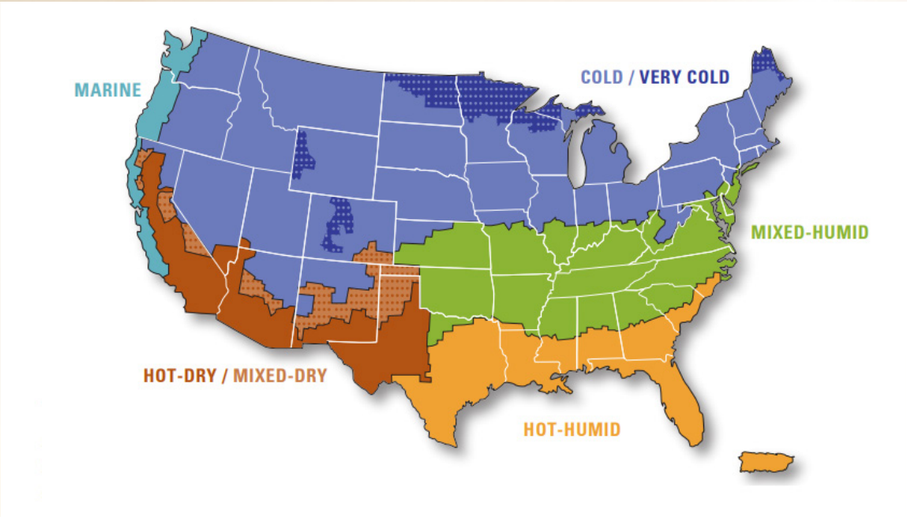
Downtowns of the Twin Cities
The hearts of both downtown Minneapolis, and downtown St. Paul are located just 15 minutes away from the site and will undoubtedly be major influences on any design in this area. Being located right on the bank of the Mississippi River also means the site is located right on the border of these major cities. This creates great opportunities, such as being able to draw in people from all sides, however it also creates challenges in dealing with the traffic and different spheres of influence. While Minneapolis is known as the go to for entertainment, food and drink, Saint Paul is widely accepted as being more livable, spacious and romantic. All of this will be important when creating an identity for this new development.

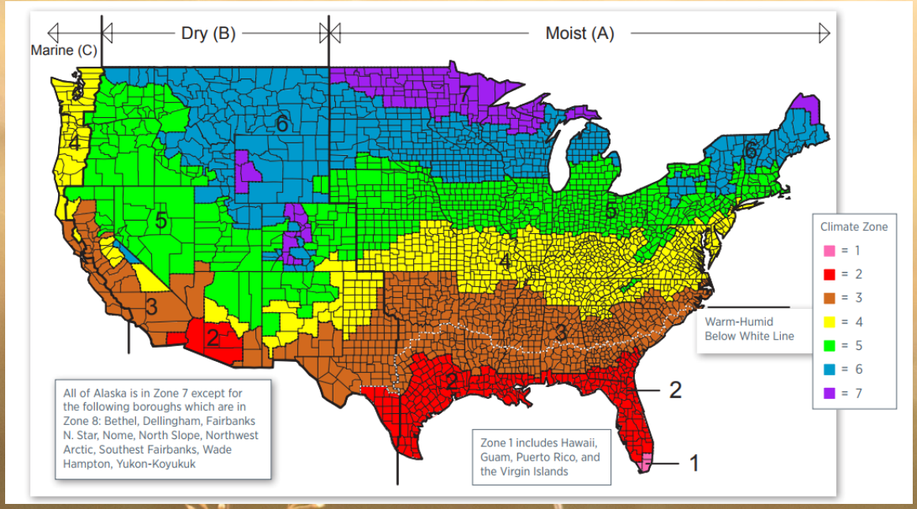
3

MSP International Airport
Located less than 4 miles from such a major airport creates great opportunity for easy access for visitors or business people coming from all over the world. However this also comes with its own set of challenges. For one, airports (obviously) need to control quite a bit of airspace in the areas surrounding their terminals. This will greatly affect the height restrictions for any on-site development that is to take place now or in the future. Another challenge is going to be traffic. According to the Airport's Council International, the Minneapolis – Saint Paul International Airport ranks 49th in the world in terms of traffic. Being this close to a top 50 airport, and right in the triangle between MSP, Minneapolis and St. Paul will create the need for special consideration to be given to the typology and design of the spaces to be created in this thesis.

4

Mall of America
The fourth major point of influence will be the Mall of America. Including Nickelodeon Universe, the large indoor amusement park located at the mall's center, MOA is by far the largest mall in the United States and the 12 largest in the world. Being less than 8 miles away from the biggest attraction in the state and one of the biggest in the country will, again, come with some challenges. The mall is going to be a major draw for the people in the sites surrounding areas – especially on weekends. This is important to know when determining the type of businesses and demographics of people that will occupy the site at different times of the day, week and year.





CLIMATE DATA:

Climate Zone Introduction

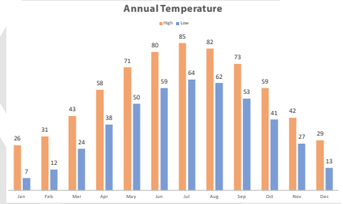
The dictionary definition of climate is, "the weather conditions prevailing in an area in general over a long period of time." This is a very simple explanation of a complex thing however, one that should be broken down into macro-climate and micro-climate in order to better understand its effects on the world of architecture. In this context, "macro-climate" refers to the general conditions pertaining to a region or country and accounts for the major phenomena of the region. "Micro- climate" then denotes the meteorological conditions and a local level, relevant only to a particular place (Ghadiali). For architecture, it is the micro-climate that needs to be mastered in order for a design to successfully perform in its given location.

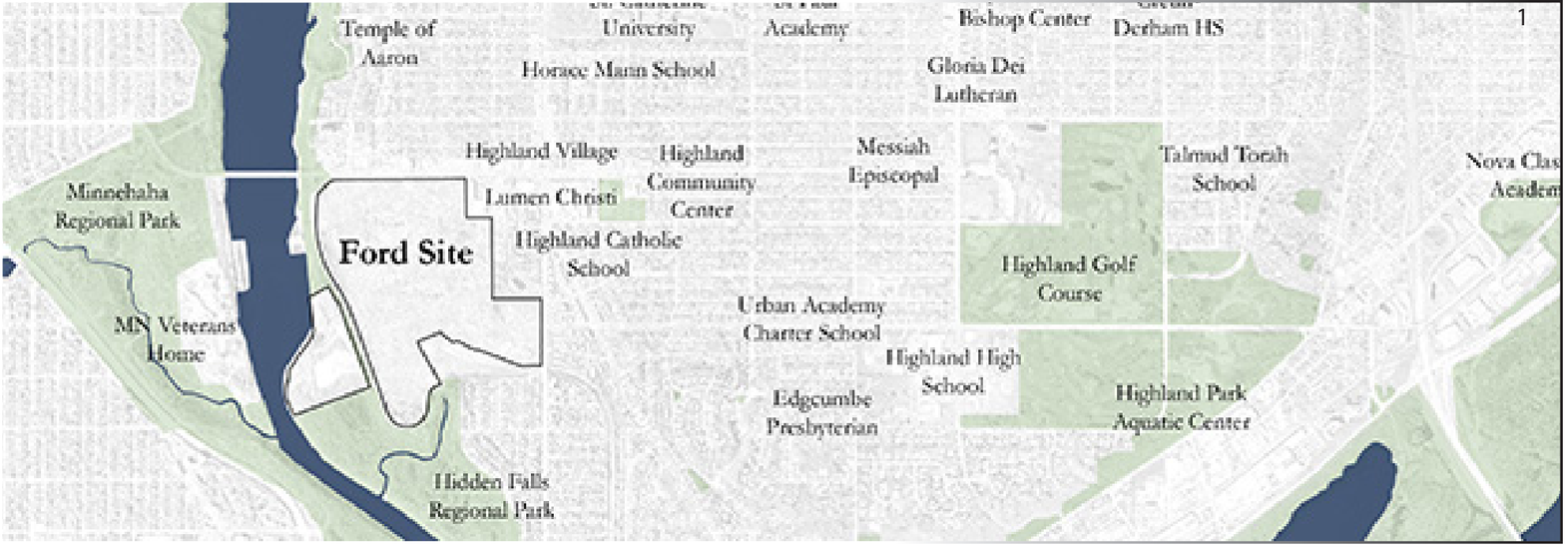
Being located in central Minnesota means a variety of weather conditions over the course of the year ranging from extreme cold (-60 F) to extreme heat (114 F). This creates a seasonal considerations that need to be addressed in order to ensure the design performs all year round.

According to the International Energy Conservation Code (IECC), the twin cities are in climate zone 6 and is simply classified as the "Cold" region. This means there are roughly 5,400 and 9,000 heating degree days.


Summer Solstice


Winter Solstice

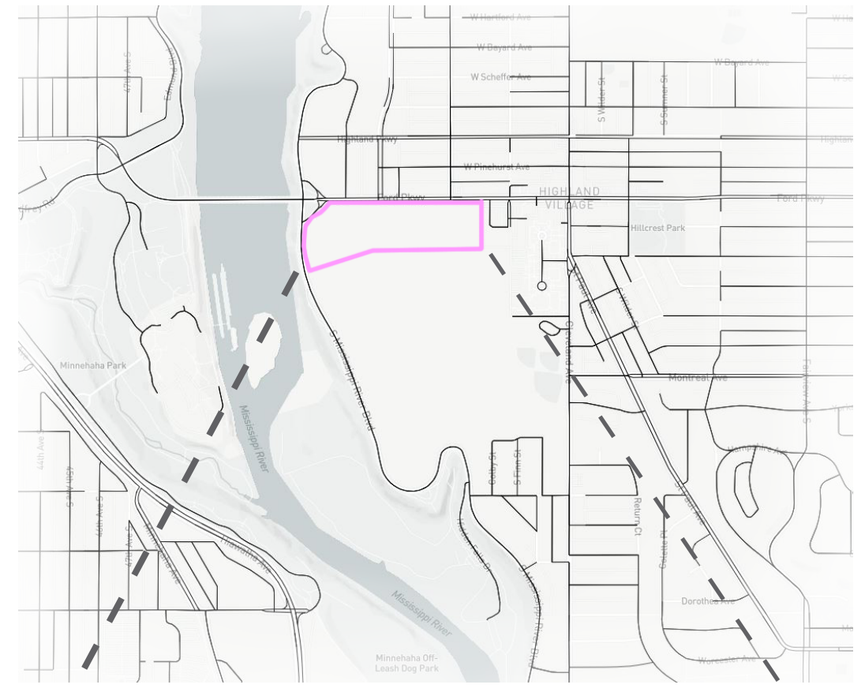


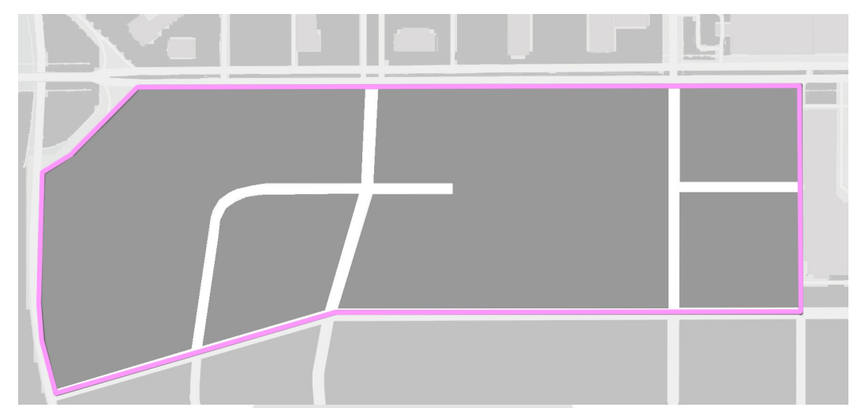

1
Temple of Aaron
University
Academy
Bishop Center
Derham HS
Horace Mann School
Gloria Dei Lutheran
Highland Village
Highland Community Center
Messiah Episcopal
Talmud Torah School
Minnehaha Regional Park
Lumen Christi
Ford Site
Highland Catholic School
Highland Golf Course
Urban Academy Charter School
MN Veterans Home
Highland High School
Edgcumbe Presbyterian
Highland Park Aquatic Center
Hidden Falls Regional Park


2


3

Thesis Site:


Minnehaha Park
Mississippi River
Minnehaha Off-Leash Dog Park
Hillcrest Park
HIGHLAND VILLAGE



MICRO INVENTORY:

1

Minnehaha Falls and Park
As one of Minneapolis' oldest and most popular parks, Minnehaha Regional Park attracts more than 850,000 visitors annually and showcases Mississippi River overlooks, limestone bluffs and a 53-foot waterfall. This site offers a fantastic contrast to the city surrounding it – something the design of the Ford Site Project will hope to compliment and build on. Direct views of the sites development will be available from the parks river-overlooks so it will be important to capture attention but not distract from the year-round users of the park.
https://www.minneapolisparks.org

2

Hidden Falls Regional Park
Much like Minnehaha, Hidden Falls Regional Park offers a pleasant recluse from the dense city surrounding it and gives direct Mississippi River access to its visitors. However unlike Minnehaha Regional Park, Hidden Falls will have a direct connection to this thesis site and the rest of the Ford Redevelopment Site. This will allow for a link down Mississippi River Blvd from the thesis development to the miles of trails, scenic overlooks and summer amenities. This link is something that will be very important to enhance with the design of this project. If done correctly, the Ford site could connect the neighboring parks completing a network of greenspace that spans for miles along both banks of the mighty Mississippi. https://www.stpaul.gov

3

Cleveland and Ford
As the nearest major intersection, the junction of Cleveland Ave S and Ford Parkway is a major focal point for the area. It creates the Highland Village Center of Highland Park neighborhood in St. Paul and boasts the Highland Shopping Center containing countless shops and amenities. Creating spaces for businesses to build on the success of this area will help with a smooth transition into and out of the site from the surrounding community.

4

Lock and Dam No. 1
Lock and Dam number 1 is one of the steps on the "Stairway of Water" which is a series of locks and dams on the Mississippi River that makes travel possible from St. Anthony Falls all the way to the gulf of Mexico. This particular spot is popular with local residents and visitors who can watch watercrafts pass through from an observation deck off of Mississippi River Blvd, the Ford Parkway Bridge, or from lookouts within Minnehaha Regional Park. Views towards and from the river and this dam will be something to capitalize on with the development of any site in the surrounding area. https://www.nps.gov/miss/planyourvisit/lockdam1.htm

5

Canadian Pacific Railway Land
The Ford Site Redevelopment plan includes a large 12.75 acre portion of land currently owned by the Canadian Pacific Railway. This was what used to be the start of the old Ford Plant's rail route which extends East through St. Paul, then connects to an even greater network. Though none of these rails or this land intersects with the specific thesis site, having rails like this in such proximity offers potential for future developments that should be considered such as reusing the rails in the growing public transit network or redeveloping their routes into walking or bike paths.
http://www.twincities.com/2017/04/03/st-paul-to-study-use-of-ford-plant-rail-spur-into-highland-park/

6

7

Surrounding neighborhoods
The site for this project is situated at the intersection of three vibrant Twin Cities neighborhoods; Hiawatha and Minnehaha of Minneapolis to the West, and Highland Park of St. Paul to the East and North. Technically the site will be located completely within the City of St. Paul and its Highland Park neighborhood, so the majority of influence will come from the people there, with a secondary effect from the Minneapolis neighbors across the River. Both Minnehaha and Hiawatha are typically associated with Lake Nokomis and Lake Hiawatha as well as Minnehaha falls and the Hiawatha mural. Highland Park is an older, orderly neighborhood of Saint Paul, with typical residents being wealthier and less diverse than the rest of the city. The area boasts a population of about 25,000 spread out over an area of about 6 square miles for a density of a little over 4,000/sq mi. For years its defining feature has been the now vacant Ford Plant which means the redevelopment of the site is a source of many opinions and concerns from residents of the area. The design of such a large scale area will define the Highland Park neighborhood for decades and therefore there is a great deal of potential in any project constructed here. The thesis that will occupy the northern edge of the Ford development will not only welcome those crossing the bridge from Minneapolis, but could provide the residents of Highland Park with a new identity and a source of pride.
https://www.visitsaintpaul.com/discover-saint-paul/neighborhoods/highland-park/

who is **St. Paul?**

Population:	300,840
Median Age:	31.5
Poverty Rate:	21.2%
Median Household Income:	$50,267
Number of Employees:	154,951
Median Property Value:	$186,800

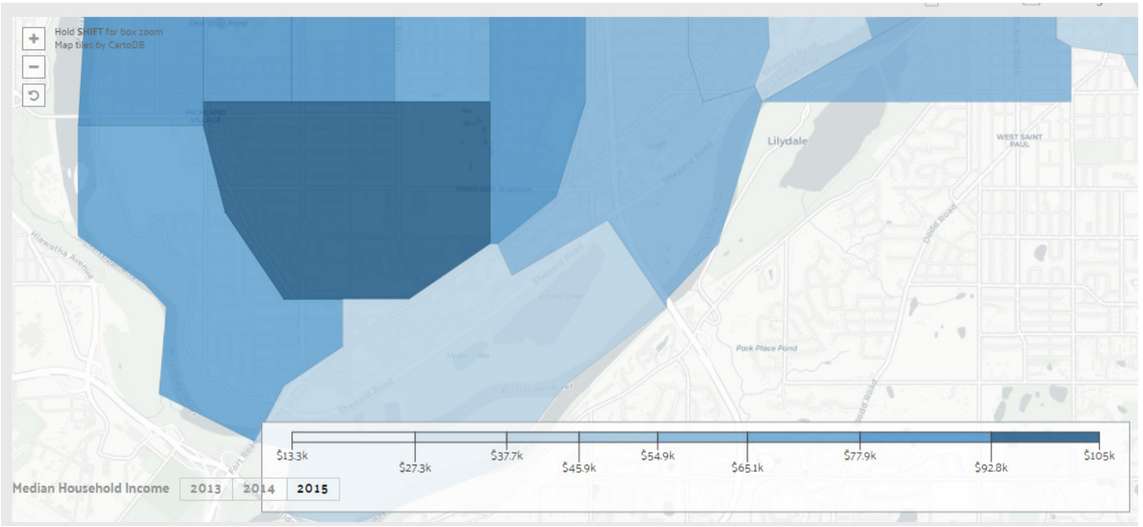
8

Ford Site Sitescape and Master Plan
As discussed previously, the master plan for the devel opment of the entire Ford site will be a major influence upon any design happening in the thesis portion of the site. The zoning plans and recommendations for the larger site will be taken into account and it will be assumed that the build out will proceed per the designs in the Master plan document.

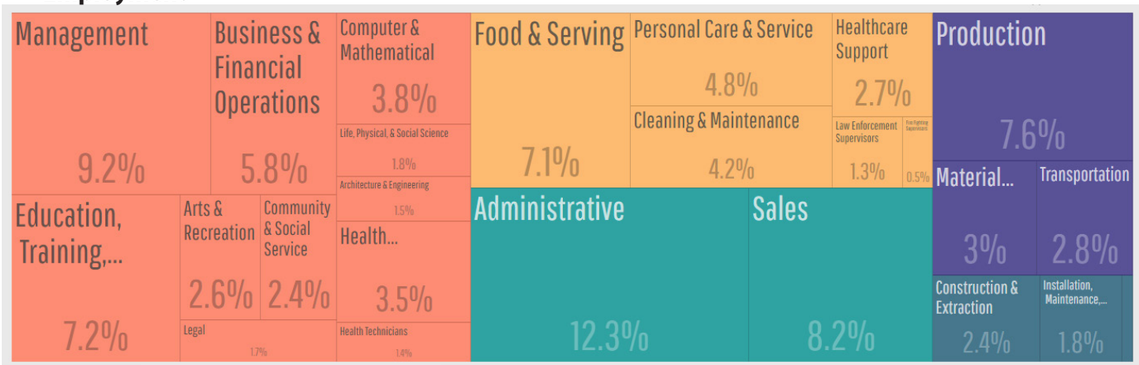
9

Primary Approach
This will be the first thing anyone coming across the Ford Ave Bridge or down Mississippi River Blvd. will see and it will be their first impression of the thesis design, as well as of the Ford Site as a whole. The zoning documents classify this spot as a "Gateway" area which means aesthetics and impression should be important design factors to any development here.

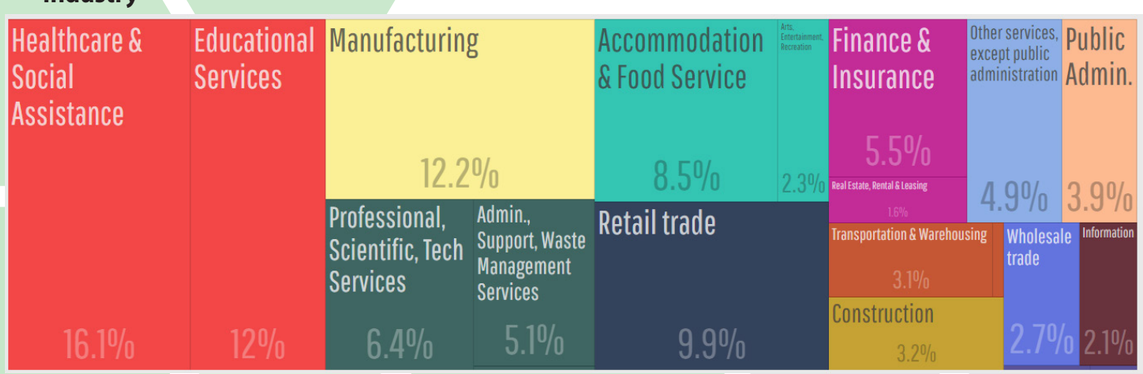
Household Income



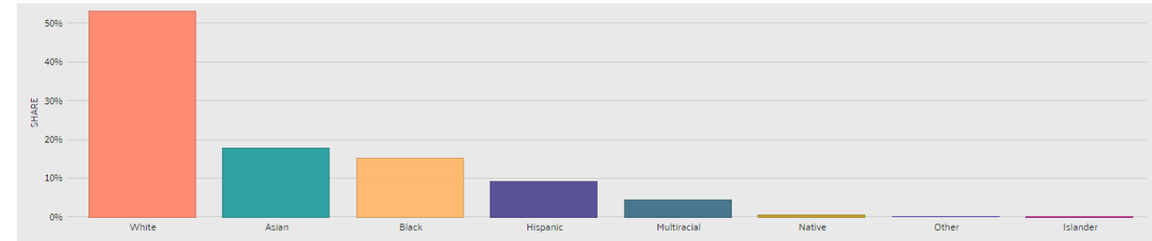
Employment



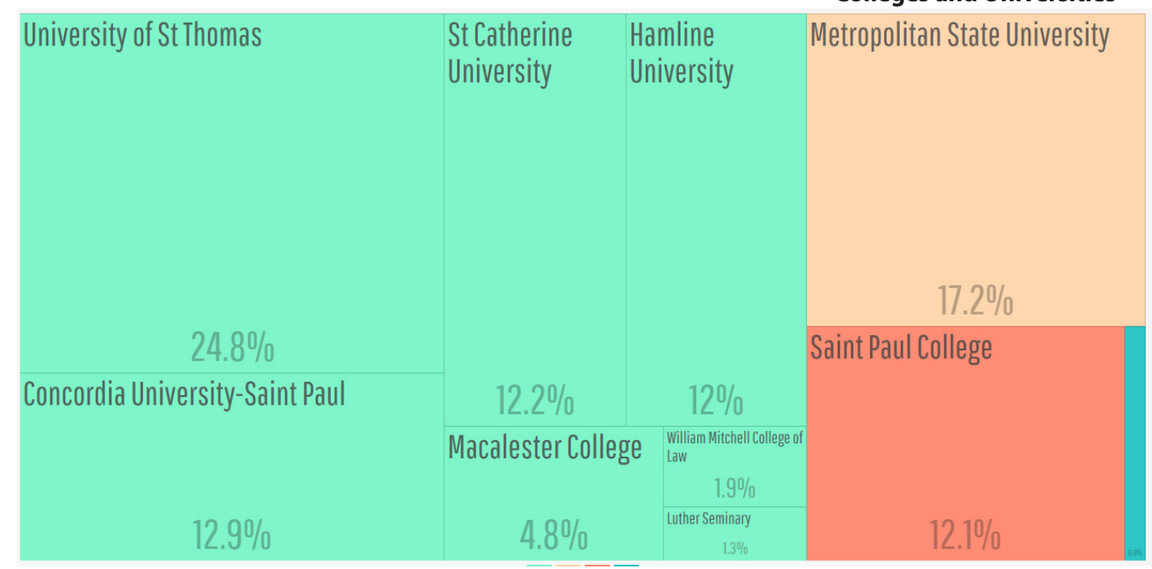
Industry



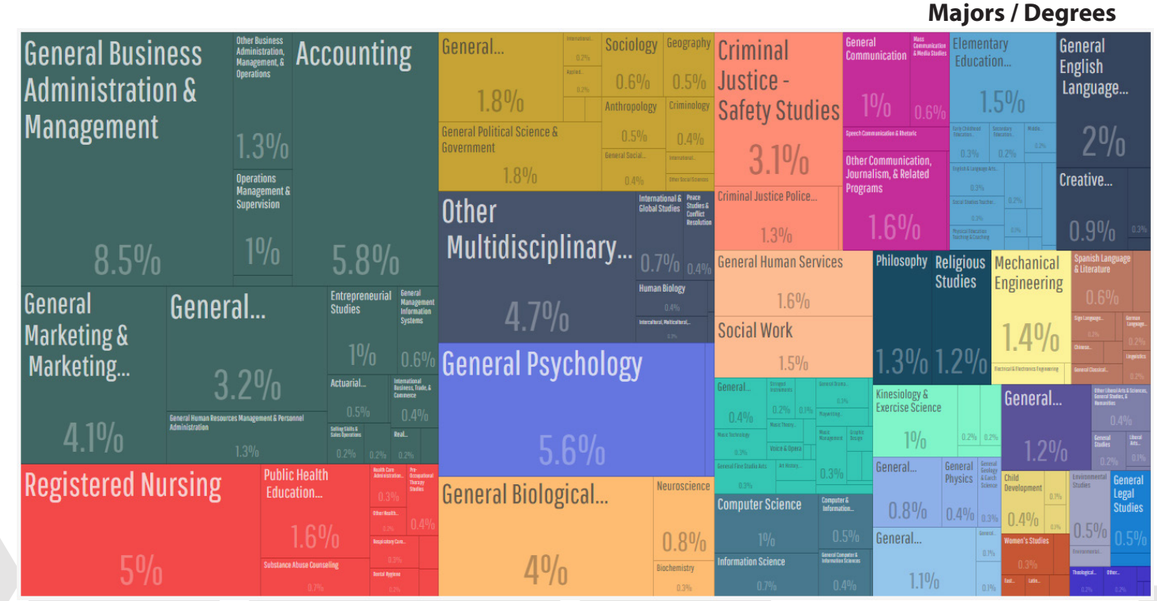
Race / Ethnicity



Colleges and Universities



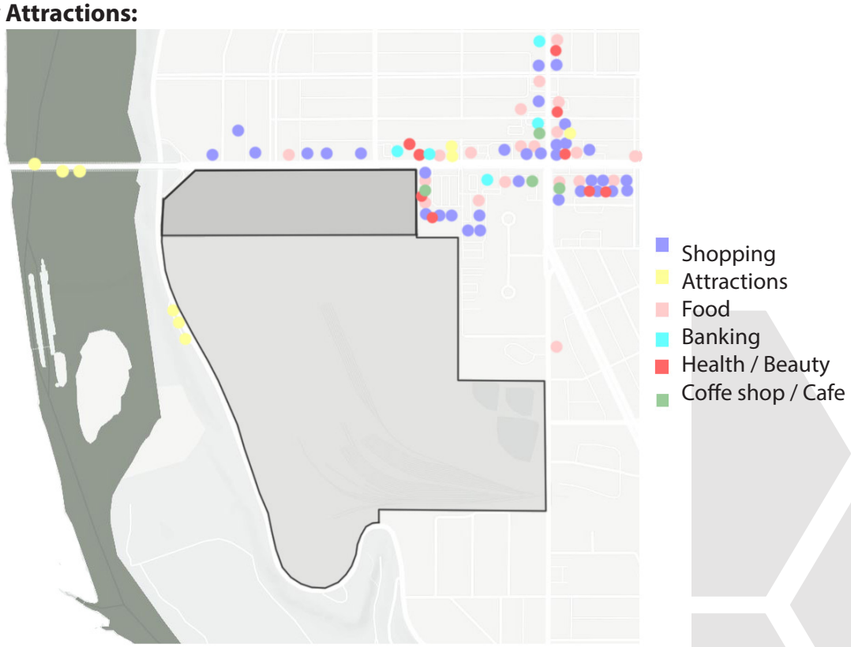
Majors / Degrees



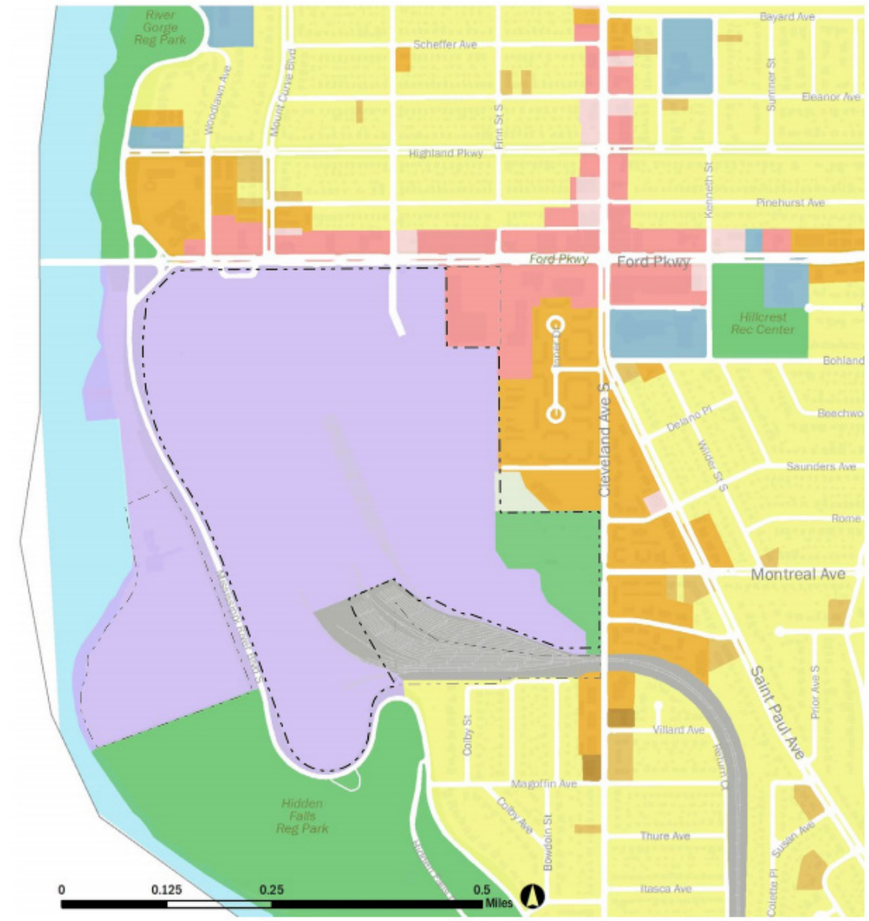
ANALYSIS MAPS:

Road Network

Nearby Attractions:

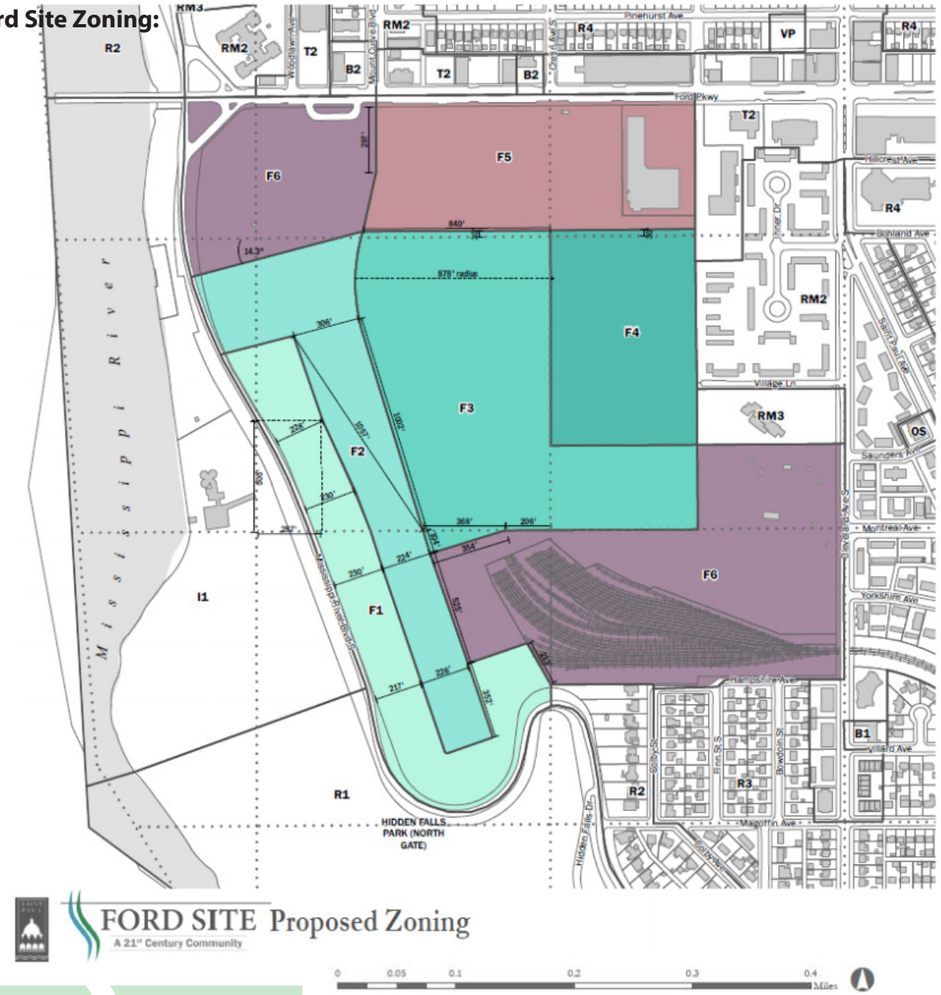


Surrounding Zoning:

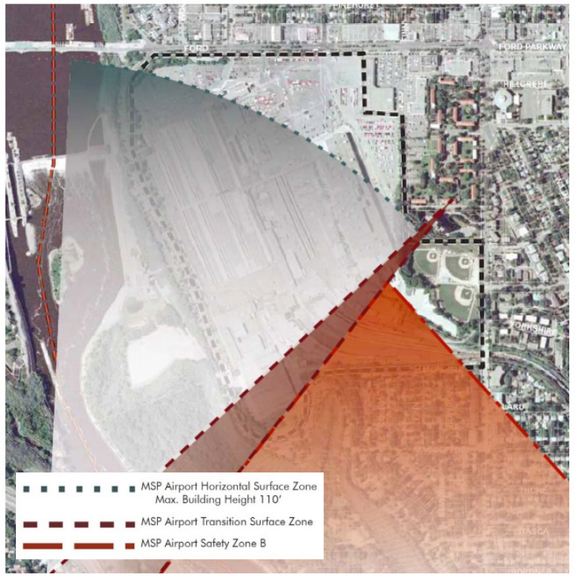


- Single Family Detached
- Single Family Attached
- Multifamily
- Retail and Other Commercial
- Office
- Mixed Use Residential
- Industrial and Utility
- Institutional
- Park, Recreation or Preserve
- Major Highway
- Railway
- Undeveloped
- Water

Ford Site Zoning:

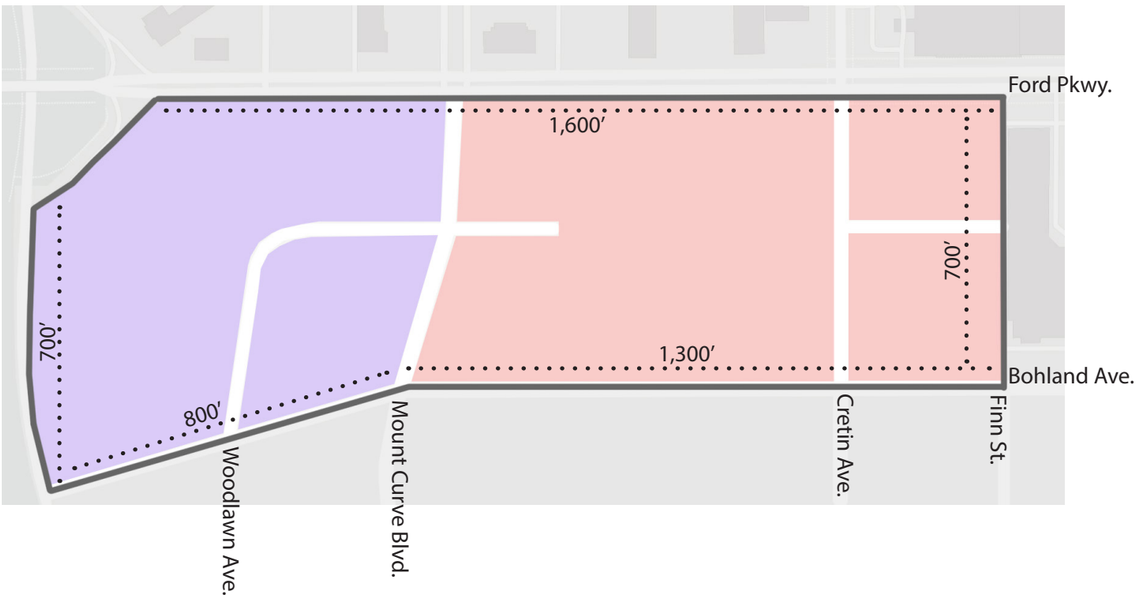


Airport zone
Because the thesis site is so close to MSP Airport, some of the buildable site may fall into an airport restriction zone dictating land use and building height.
Horizontal Surface Zone: The grey cone on the map, sets a maximum building height of 110'
Safety Zoning B: Though not directly effecting the portion of the Ford Site that will be occupied by this thesis design, this zone, pictured as the red triangle, dictates certain land use restrictions. The land uses not allowed include. Churches, hospitals, schools, theaters, stadiums, hotels, motels, trailer courts, campgrounds, and other places of frequent public or semi-public assembly, and ponds (Ford Site).



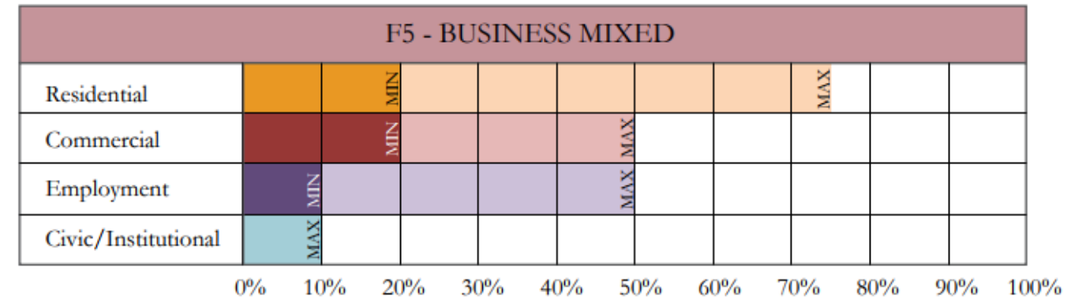
Mississippi River zone
Because the thesis site is on an important waterway such as the Mississippi River, the Minnesota Department of Natural Resources has some rules of their own. The area surrounding the river is known as the Mississippi River Corridor Critical Area (MRCCA). The MRCCA covers some 72 miles of river and 54,000 acres of surrounding land in the Twin Cities Metropolitan Area. This region has special land development regulations to protect and preserve the unique features and natural characteristics of the Mississippi River (Ford Site).

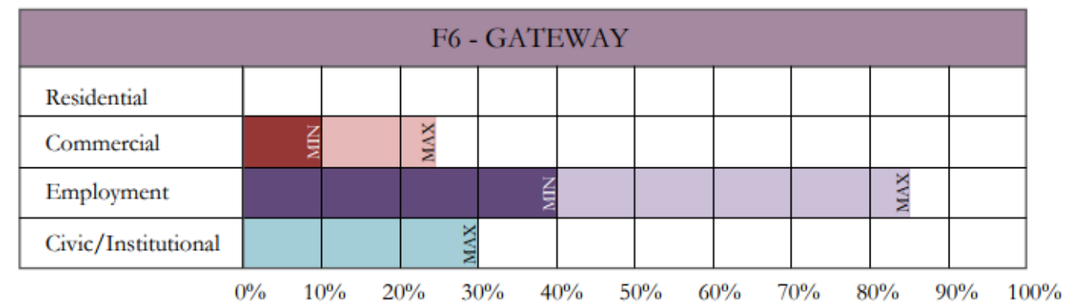
SITE ZONING:



Gateway
The Gateway District hopes to become the main entrance onto the site. This area will provide a variety of business and office uses as well as the potential for educational or civic uses. It is meant to be an attractive gateway that greets vehicles and pedestrians coming over the Ford Pkwy Bridge or down Mississippi River Blvd.
General Character: Attractive and welcoming site entrance
Heights: Min 30 ft Max 65 ft
FAR 1.0 - 3.0

Business Mixed District
This area is meant to provide space for a potential variety of retail stores, dining, office buildings and service establishments. It is important that this area respect and enhance the public realm both along Ford Street, and through the site.
General Character: Primarily retail and office
Heights: Min 40 ft Max 75 ft (with 10 foot setback above 25 ft)
FAR 2.0 - 4.0





Ford Plan Typology Examples:

PERFORMANCE CRITERIA:

1. Space Allocation
The main criteria I will use for the allocation of spaces will come from research of similar projects within my building typology. I hope to study both the design and post-occupancy findings of these projects to develop an appropriate and effective program. I will judge my own project on how closely I can replicate the ideal spatial distribution based on findings from research.

2. Energy Consumption
Being a primary focus of my thesis design, developing energy consumption criteria is very important. I will primarily be utilizing the 2030 challenge and the standards for energy consumption it sets. I will judge my project as a success if it is completed as a 2030 challenge compliant building to at least the goals set for the year 2018 if not 2030.

3. Environmental Performance
Similar to Energy Consumption, this will be a primary focus of my thesis. For me, I will focus on materials and their embodied energy to judge my designs environmental performance. This will require research of materials and strategies used by other designers, and an analysis of my findings to determine how to achieve the best performance without compromising on embodied energy.

4. Behavioral Performance
Usage pattern criteria for my thesis design will be largely based on spatial allocation and predicted activity that will come from the research portion of the thesis. I will consider it a success if I and my classmates can realistically see the building as a logical design and layout for its intended use.

5. Psychological Impact
This part of my performance criteria will be considered the cultural impact of my design. I hope to establish a vernacular and set a precedent that would theoretically influence and lead other architects to create similar designs. I hope to address the sustainable building issue – the most important challenge facing our generation of architects – and establish a solution that could inspire and be built upon as we go into the future of architectural design.

6. Environmental Impact
As stated above, the primary focus of my thesis is on the environmental impact of typical architecture and construction methods. Needless to say, a small impact and environmental footprint is of the upmost priority. I will judge my design using the latest green design technology and software, while comparing my findings to the standards set by the 2030 challenge and other green design prerogatives.

7. Code Compliance
I will hope to demonstrate an understanding and skill with code compliance and ADA standards that meets the expectation expected of a candidate for a Master of Architecture degree. This category will mostly be judged on a pass / fail basis for me, and will be considered throughout the entire design process.

8. Cost
This will be a tricky category to judge because our designs are not going to actually be constructed or bid out. However cost is an important part of architecture and must be considered at all phases of design. It is also important to me to keep my perceived costs as low as possible to show that a design that meets the standards I hope to set is financially plausible in the real world.

Summary of Main Performance Criteria

1. Environmental, Sustainability & Energy Use Criteria
2. Functionality, Efficiency & Work-flow Criteria
3. Social, Cultural & Historical Criteria

The primary performance criteria that this building will be judged against is the list of goals laid out in the 2030 challenge. For this particular design I will judge the project against the 2025 goals set by the Challenge. This means a 90% reduction in fossil fuel consumption from the national average of similar building types. The 2030 challenge provides a list of targets that can be found on-line. These targets, separated by building typology, state the 60-90% Energy Use Index reduction goals that are meant to keep the building sector on pace to meet the ultimate, carbon neutral goal.

A second criteria would involve the functionality of the designed space. I hope to study the spatial program of similar designs to determine an ideal layout and flow. This will undoubtedly be incorporated into the energy use criteria as well because studying where people will be and when will determine where the building needs to be using its energy.

The final criteria I will use to judge this project involves it's social and cultural impact. Hopefully this design showcases something that would set a precedent for future designs and future architects. This means judging the final solution on its aesthetic appeal and clarity of message. I want it to be educational and informative as well as inspiring and iconic. Does this thesis further the progress of architecture towards a more sustainable future?

Spatial Allocation Research

Spatial Allocation Research

Another important point of research is into the physical spaces this design hopes to create, and how they will interact with each other and effect the users moving through them. Being primarily a transit center, determining efficient flow and spatial relationships can make all the difference when it comes to user experience. According to the Metro Council, transit centers or "transitway" design should focus on these primary provisions:

1. Facilities that support access for customers of all ages and abilities
2. Facilities that support access for pedestrians and people using wheel-chairs or bicycles, including providing bicycle parking
3. Station Platforms
4. Waiting shelters for all public transit routes serving the station
5. Provisions for short-term pick-up/drop-off of transit patrons by shuttle, taxi, etc.

Through further research it was determined that spaces will be allocated based on four categories. They are waiting/circulation, arrival/departure, café/restaurant and educational space. These categories can be broken down further into main components as follows.

Waiting/Circulation

This is any space designed for pedestrians to gather and or move about while waiting for or moving to their required mode of transportation. This area includes lounge space, information desk, the main circulation paths and access to restrooms.

Arrival/Departure

This space directly deals with how people and transportation methods enter and exit the site. These spaces include lockers/changing areas, bicycle storage and exterior arrival points.

Café/Restaurant

This space should maintain a connection to the waiting areas while remaining out of the way of the spatial flow of the site. This is a space that could be used by community members who are not using the transitways and should therefore have its own access separate from the building's other functions.

Education

For this design, the education category includes the mechanical areas and any other indications of the building's function. It will be important for users to be in contact with the biological sciences implemented into the architecture in order to learn about their function and contribution. This will also require gathering space for students or community members to congregate outside the travel lanes of the transit users.

SOLUTION

Primary Design Factors

After the completion of the project research portion of this thesis, a couple of primary inspirations emerged as the key factors to the design. The first, the Living Building Challenge, served as a resource throughout decision making because of its emphasis on the highest level of possible sustainability we have today. The design Standard that can be found on living-future.org/lbc/ was vital in providing a realistic process for a 100% closed loop building. This "closed-loop" ideal was perhaps the biggest takeaway from the Living Building Challenge as well as their list of design goals that include operation within the resource limit of the site, regenerative design that connect occupants to light, air, food, nature, and community, and positive impacts on the human and natural systems that interact with them. These are project themes that were carried throughout this design.

The second key, and perhaps most influential, factor was the biological science of algae growth. Not only did research into biological science inspire the buildings form and structural layout, but the process of algae growth is something that inspired the overall attitude of the project that a building could be grown and fit into its natural ecology as seamlessly and efficiently as algae grow in nature. This emphasis on the relationships between the built and natural environments, between construction and organism, between assembly and growth, are what drove the design process from start to finish and ultimately resulted in the projects title:

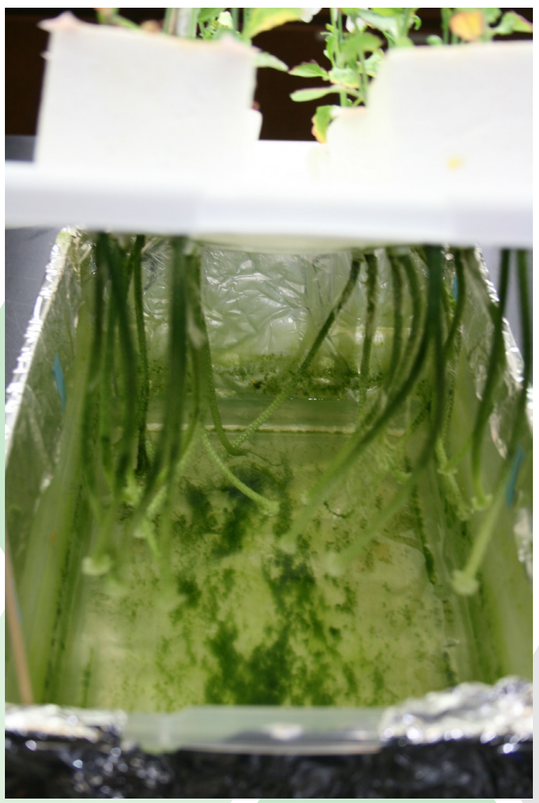
ARCOLOGY

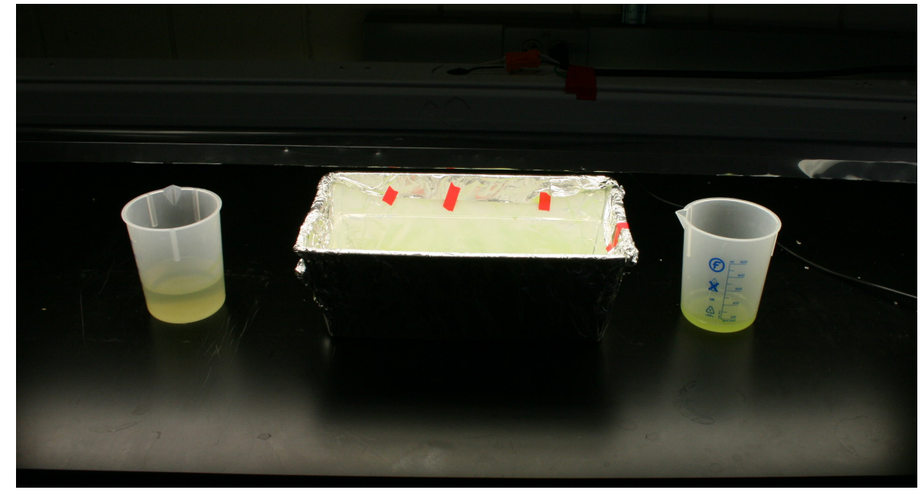
ARCHITECTURE + ECOLOGY

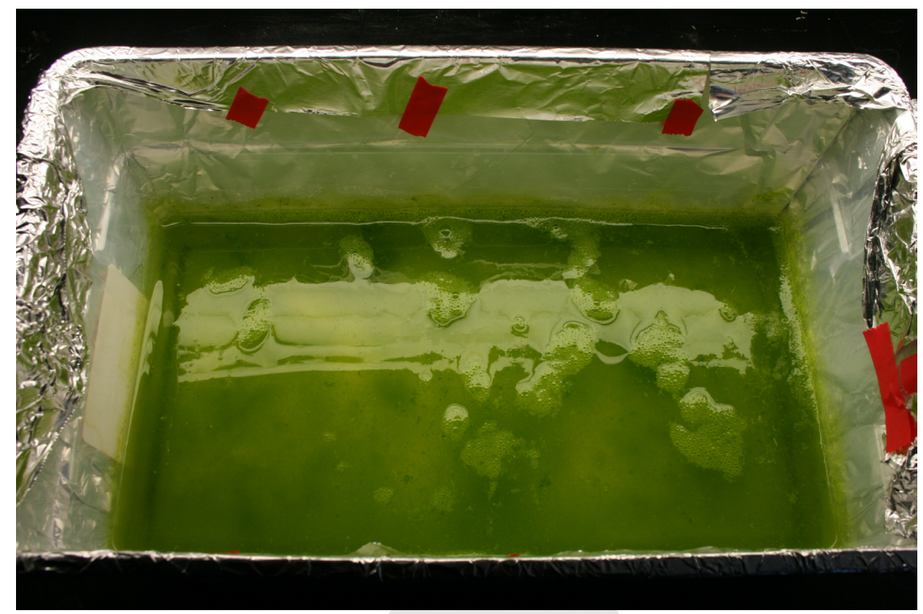
FUN WITH ALGAE

After getting in touch with a friend who is a graduate student in the biological science department at North Dakota State University, we were able to set up a small, algae-growth experiment to further study the process. Although we did not have the resources to test the algae for energy production, the very act of this collaboration became a huge inspiration for the projects ultimate design.

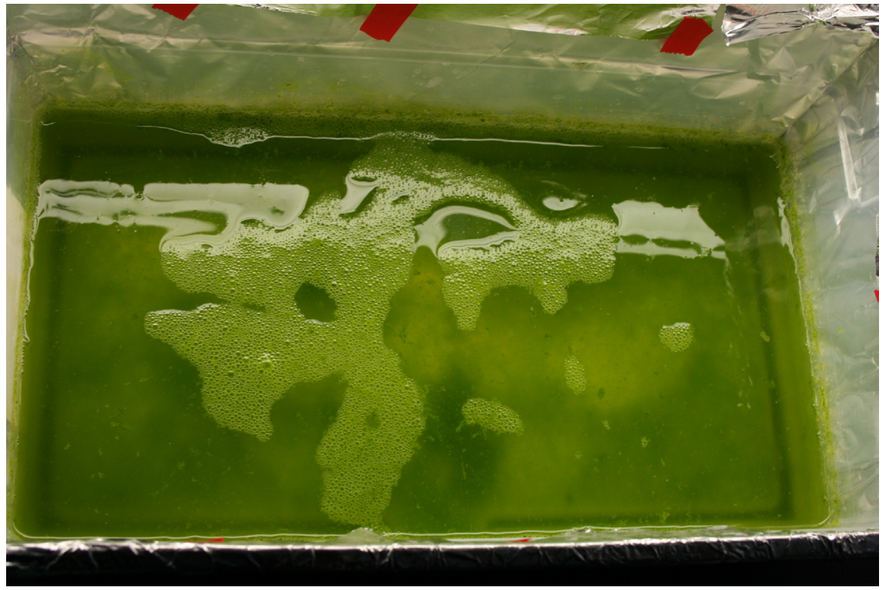
The algae cultures we started our experiment come as an unintended byproduct of many experiments going on in the NDSU science labs. This made it fairly simple for us to capture and begin our observations. The image below shows some of that algae growing underneath some small plants in the lab. Then, to the right, you can see the set up for our intentional growth medium.

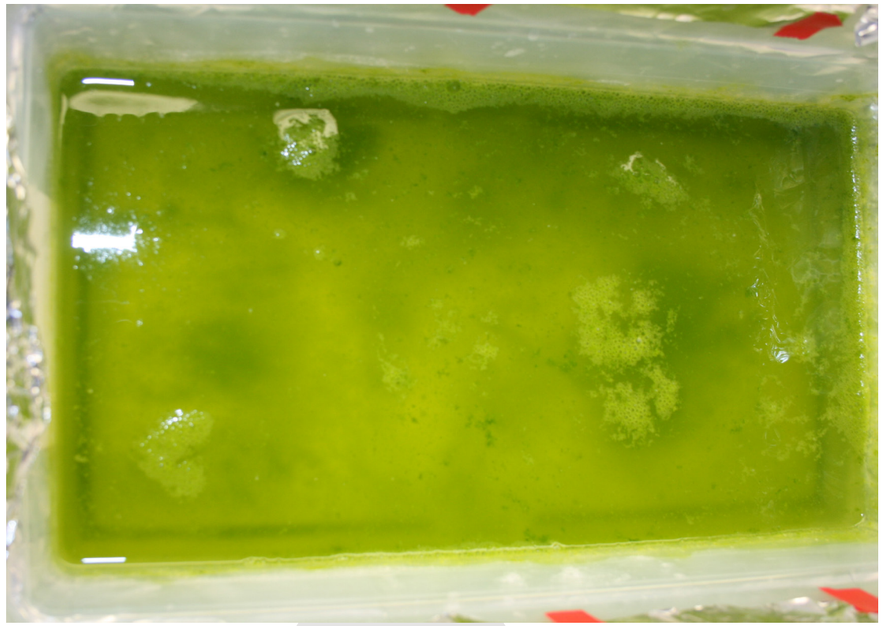






The images on the following pages show some of the results we were able to acheive in just a few weeks of growing.





Study conducted in collaboration with Tyler Stadel, NDSU Biological Science Graduate Student.

Thanks for all your help Tyler!

"The biggest innovations of the twenty-first century will be the intersection of biology and technology. A new era is beginning."

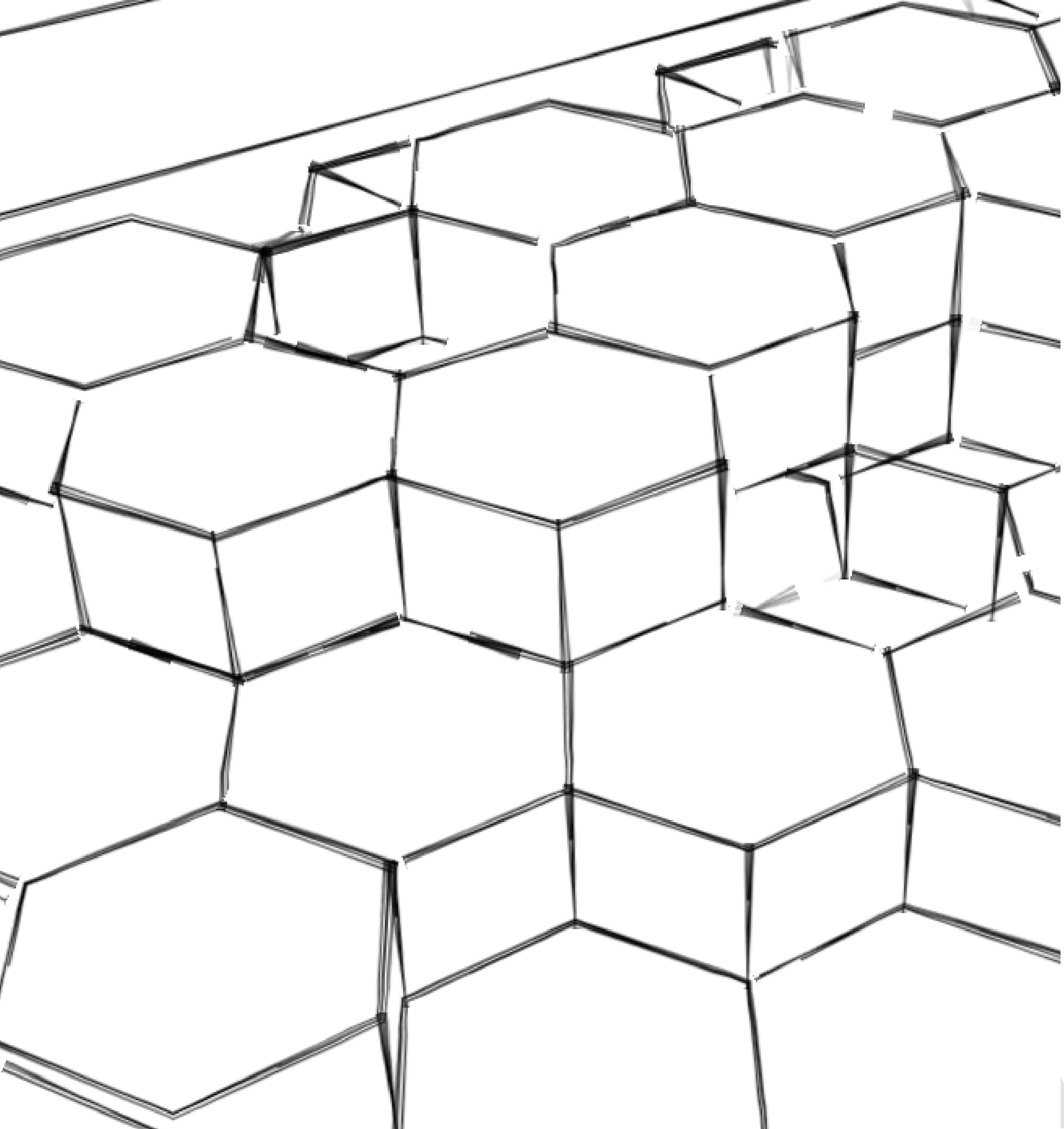
-Steve Jobs

As a further experiment, and as a way to showcase the recyclability of the algal biomass, an online recipe was used to create algae chips! These were created using store bought spirulina supplements and served at the projects' mid-term presentation.

Algae as a food source is actually being studied for its potential role in fighting malnutrition around the world and it is widely considered a super-food because of its extremely high nutritional benefits including:

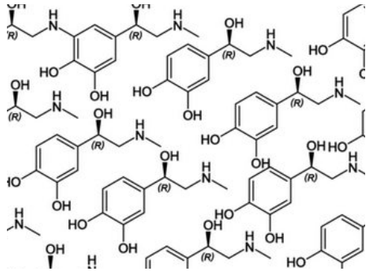
6x more protein than eggs
10x more potassium than most fruits and vegies
6x richer in iron than raw beef liver
50x more iron than spinach
7x more calcium than milk
(Food Friday)

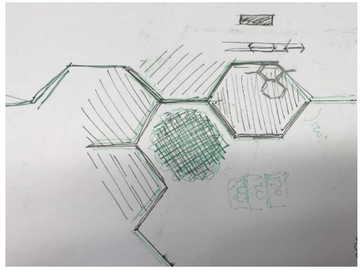
This all makes it one of the most nutritious foods on the planet! However, if eating (very) earthy algae is not your thing, the raw biomass could be recycled as animal feed, as fertilizer or processed for biodiesel instead.

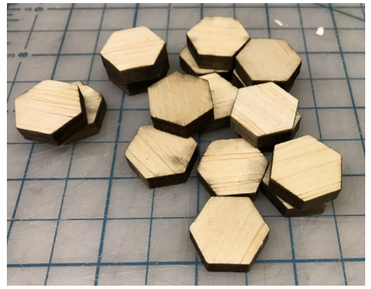


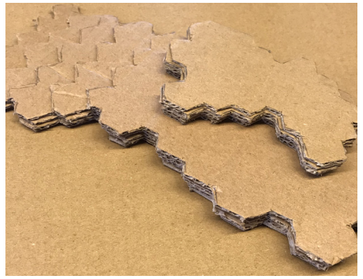
FINDING FORM

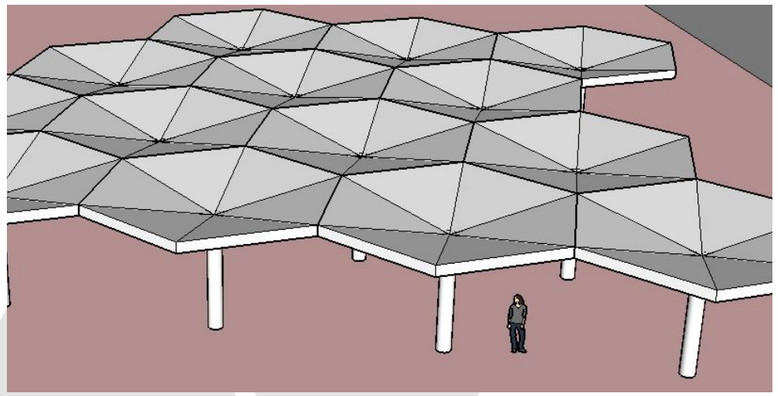
The primary form of the building evolved from the earliest phases of scientific research. After pouring over chemical equations and formulas while studying algae and energy production, this modular hexagonal shape stood out. By drawing inspiration directly from this growth experiment, it allowed the design's focus to remain on the relationship between architecture and ecology. In this case, a relationship of symbiotic influence.



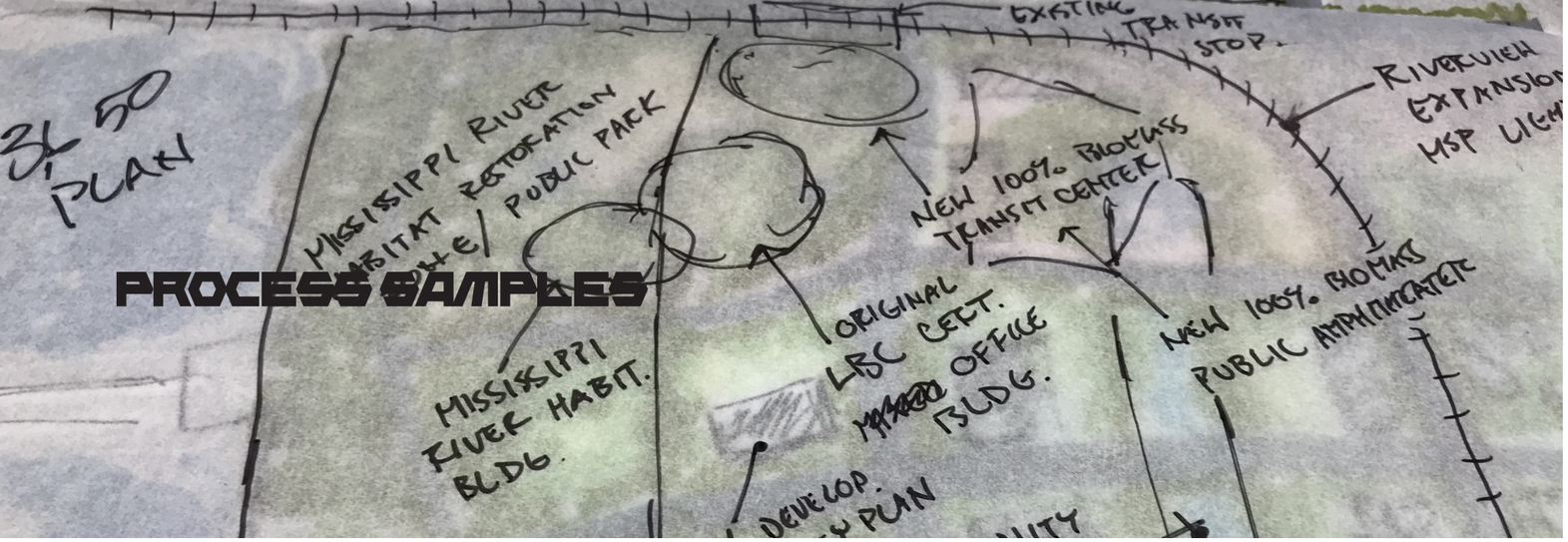


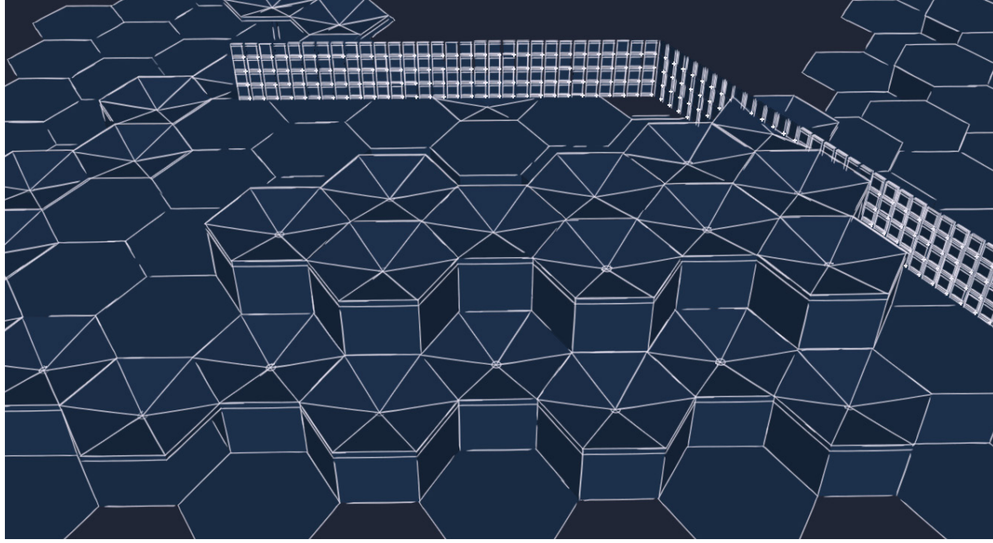


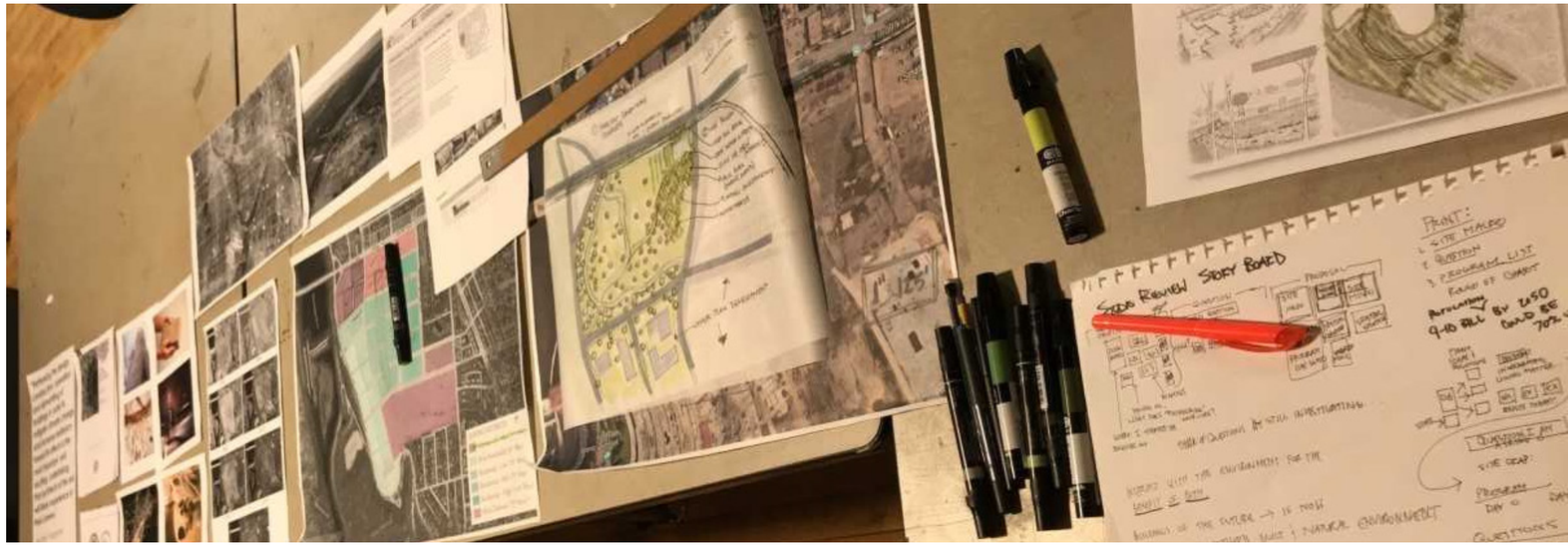


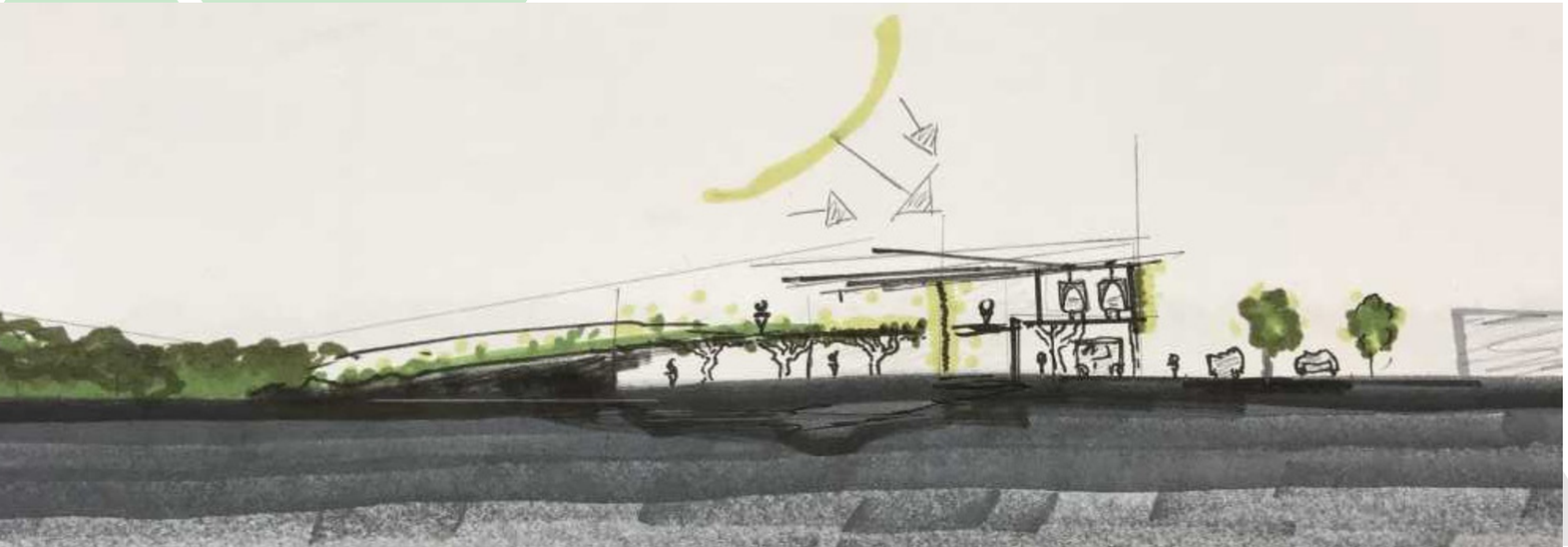


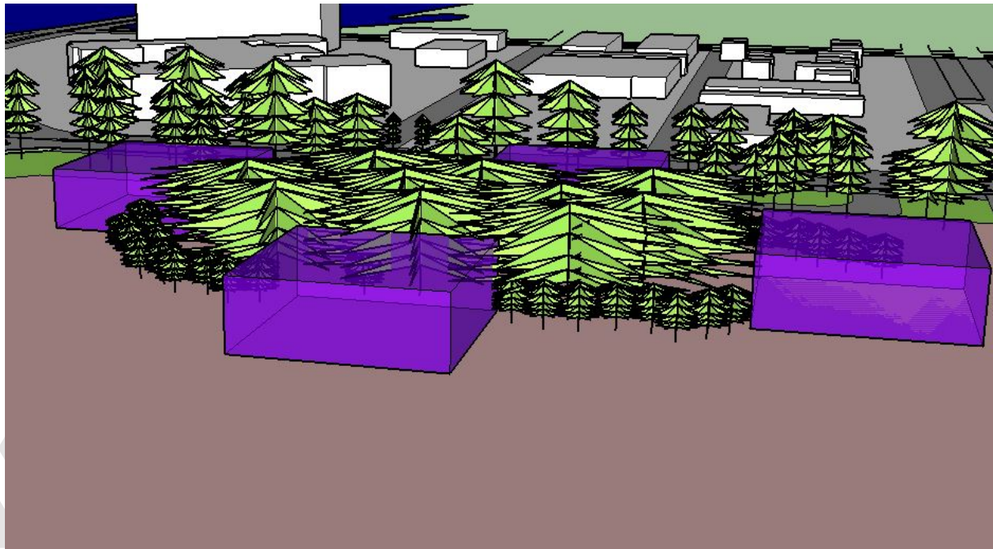
PROCESS SAMPLES



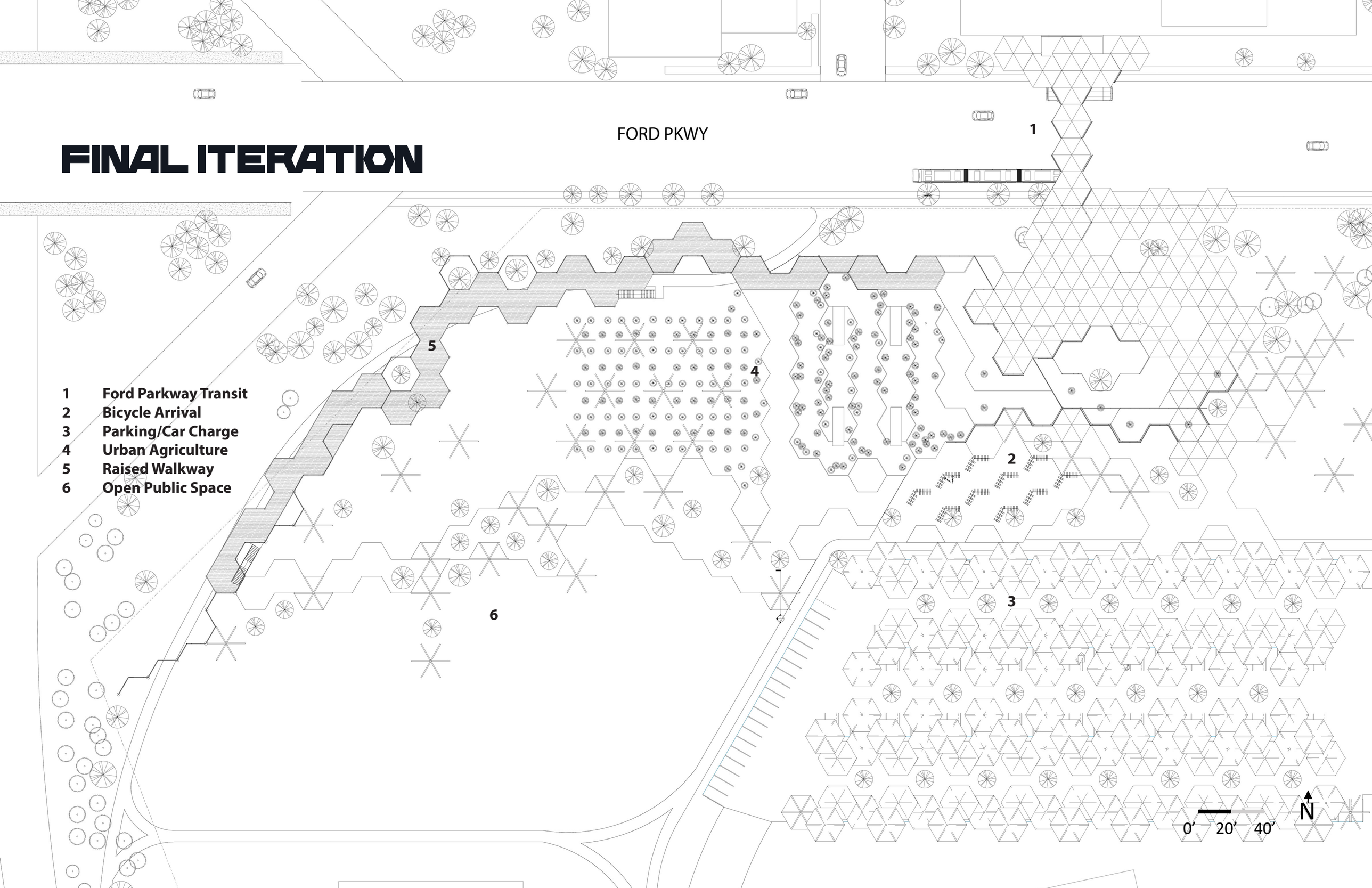






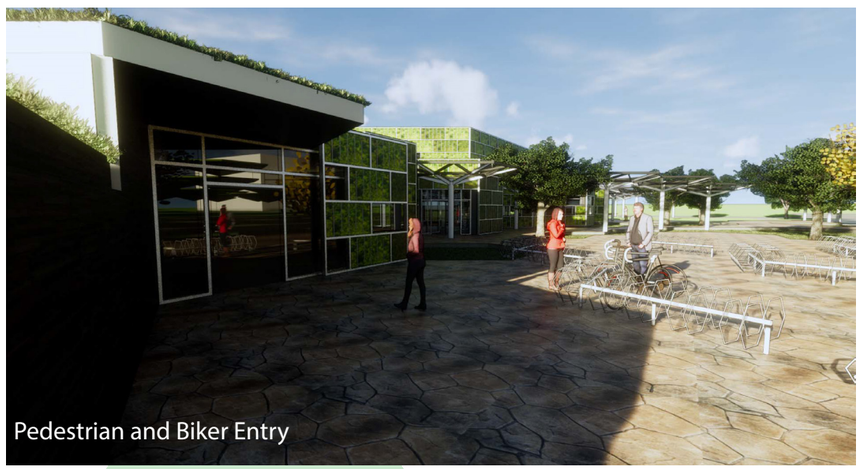


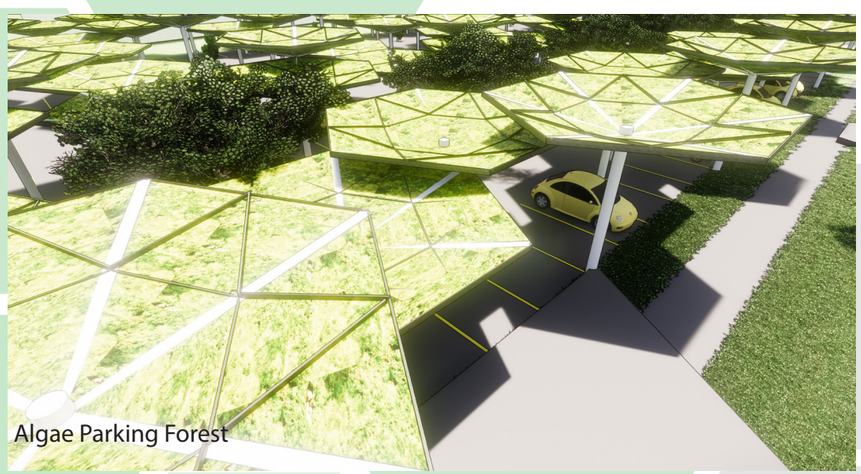
FINAL ITERATION



1 Ford Parkway Transit
2 Bicycle Arrival
3 Parking/Car Charge
4 Urban Agriculture
5 Raised Walkway
6 Open Public Space


View of Transit on Ford Parkway


Pedestrian and Biker Entry


Algae Parking Forest

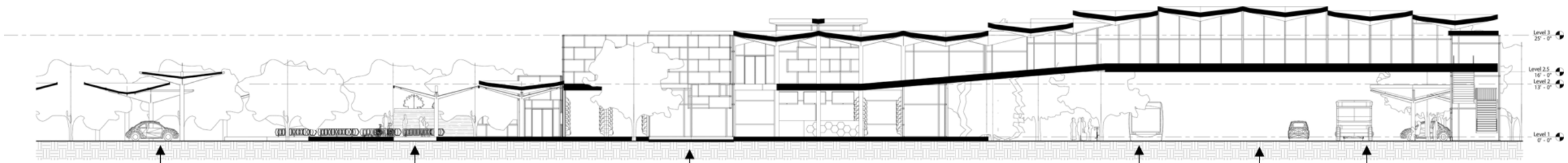

Raised Walkway Along Algae Screen


View Towards Minneapolis


Open Public Space

SECTIONS

NORTH - SOUTH



Parking lot/
car charging

Bike storage &
pedestrian entry

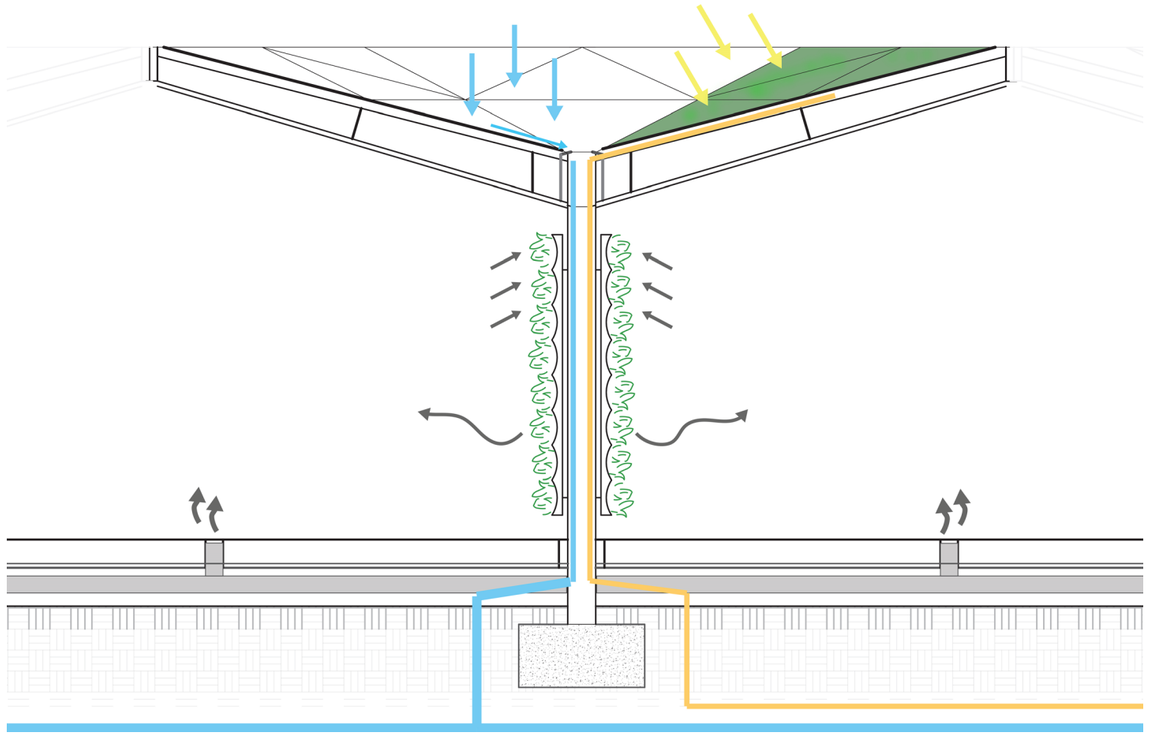
Main Building

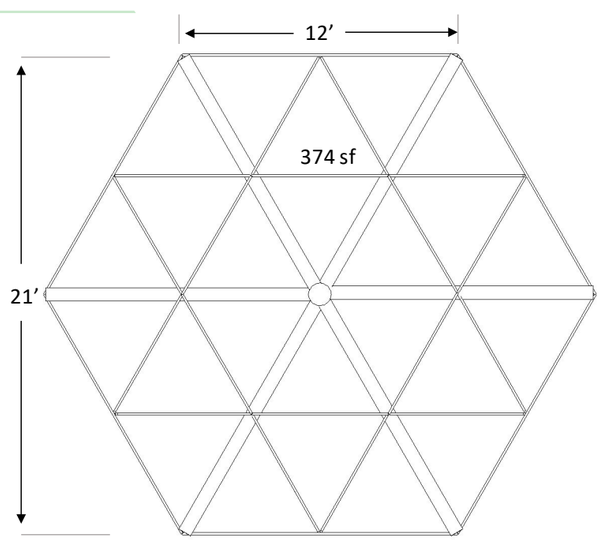
New Modern
Street Car route

Cars share Ford
Parkway with
Public Transit

Current bus route
remains

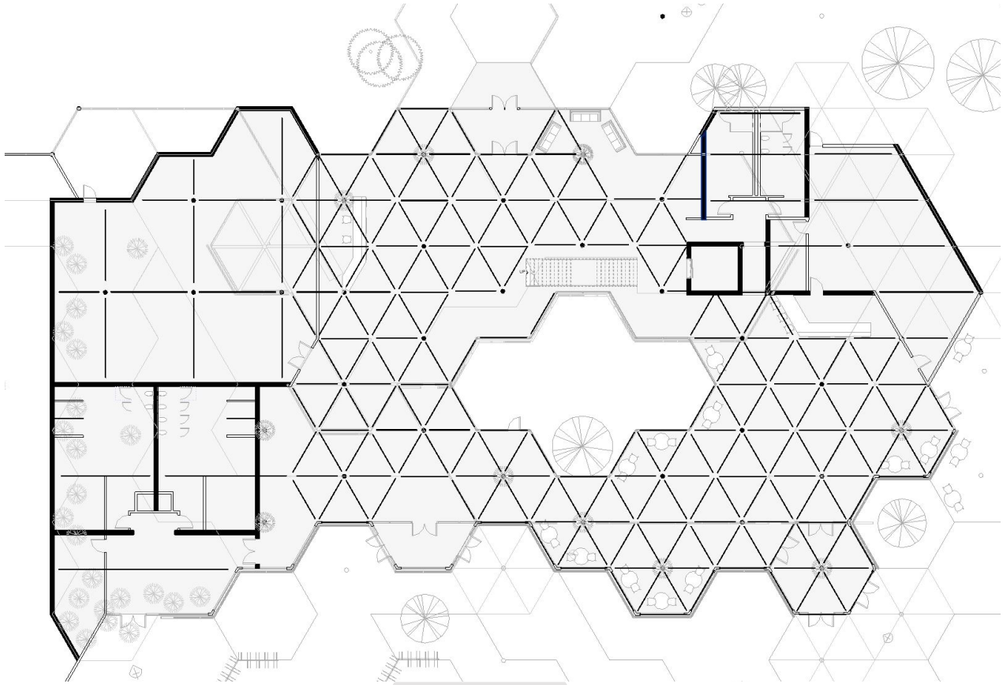
EAST - WEST





Structure

As previously mentioned, the buildings structure is made up of modular hexagons. These hexagons, detailed left, offer lightweight construction and are carried throughout the site as shade structures. The natural basin created by sloping the hexagonal roof form allows for easy resource capture. The columns along the building’s interior can then be outfitted with greenery for natural air phytoremediation (picutred left). The interior structural layout can be seen below.

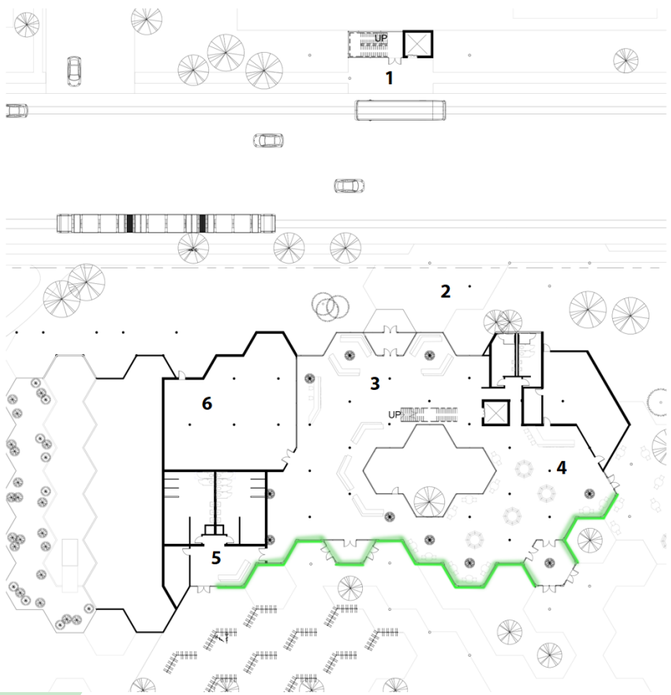


FLOOR PLANS

Ground Floor

1. North loading zone
2. South loading zone
3. Waiting area
4. Café
5. Biker/walker entry
6. Open mechanical space

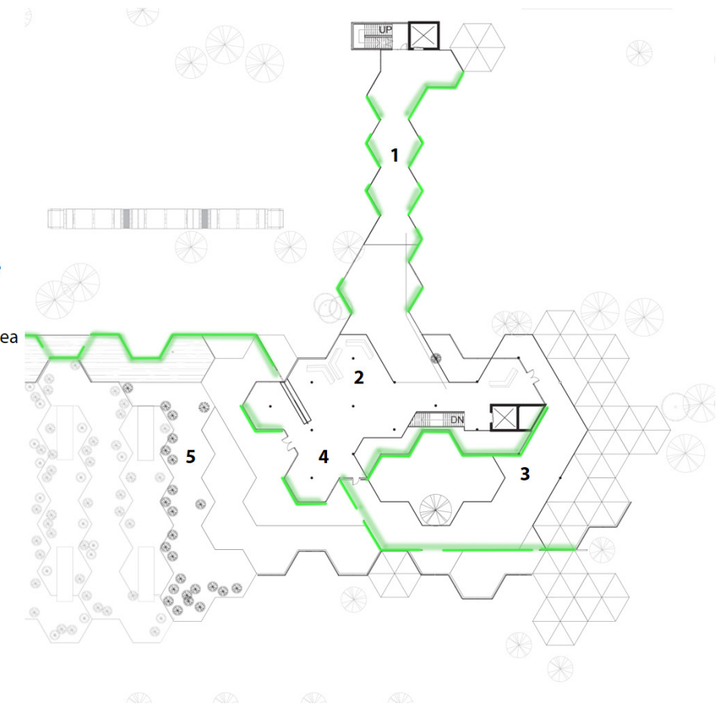
0' 10' 20' N



Upper Floor

1. Skyway to North loading zone
2. Waiting area
3. Rooftop flex space
4. Building systems education area
5. Access to community garden

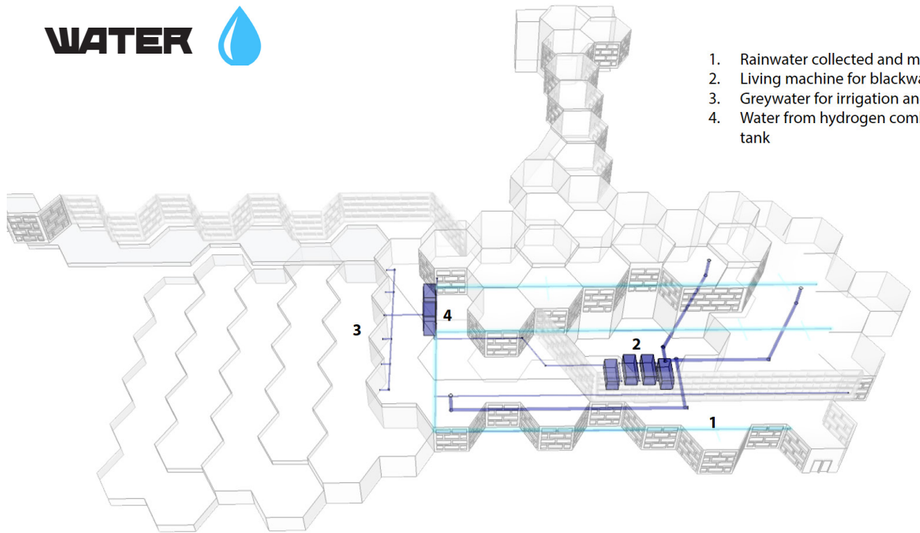
0' 10' 20' N

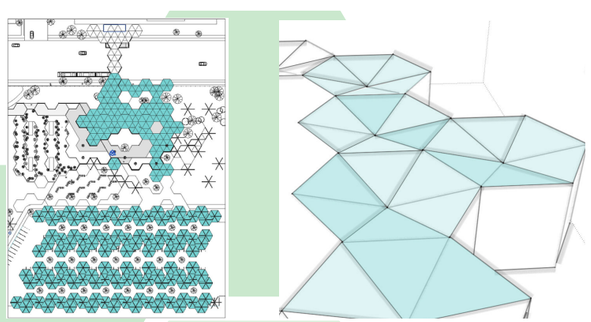


BUILDING SYSTEMS

WATER

1. Rainwater collected and moved to holding tank
2. Living machine for blackwater processing
3. Greywater for irrigation and toilets
4. Water from hydrogen combustion transferred to tank

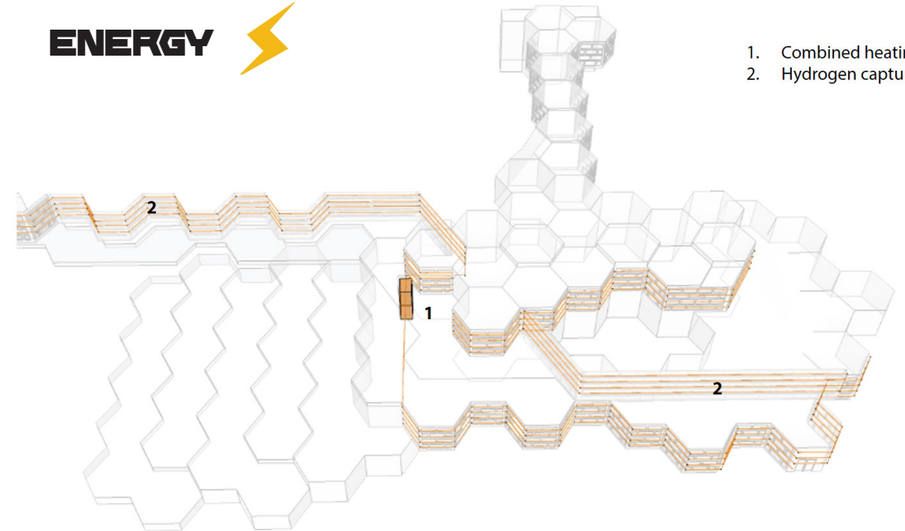


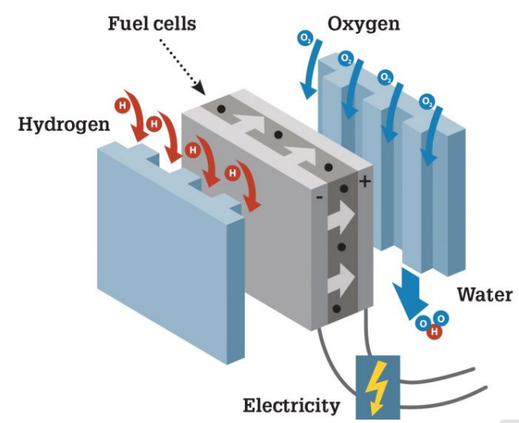


Net Positive Water
The building's modular hexagonal roof pattern allows it for easy water capture. Based on the current design, the building offers nearly 60,000 square feet of capture area which can harvest over 1.1 million gallons of water per year.

ENERGY

1. Combined heating and power fuel cell
2. Hydrogen captured from algae panels

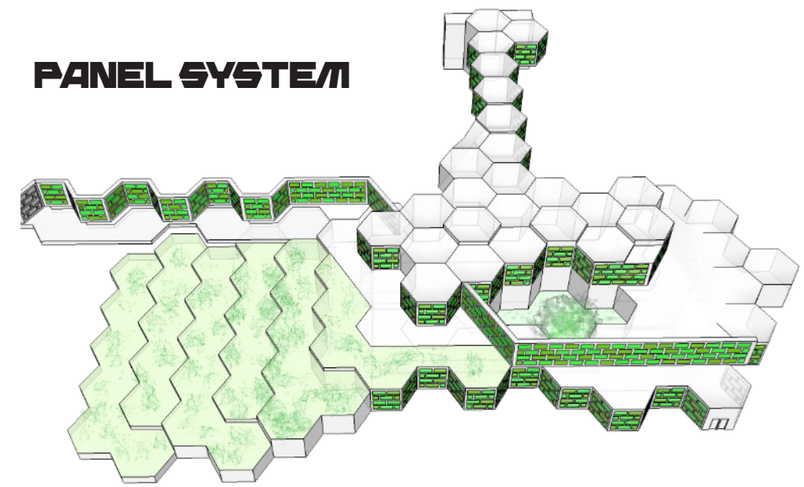




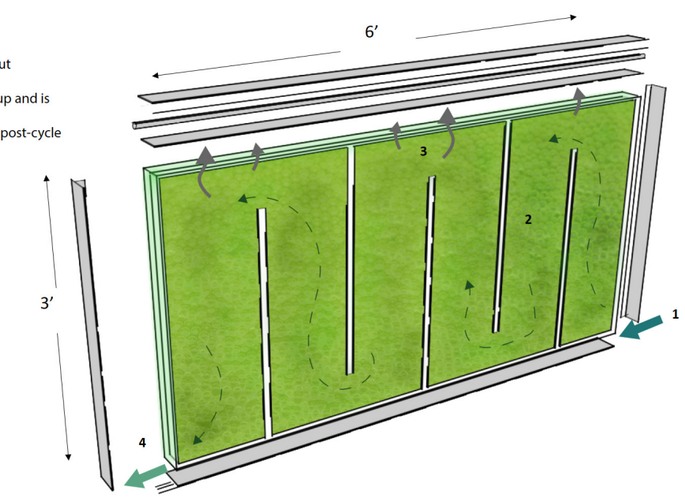
Net Positive Energy
The hydrogen that is produced by the algae panels is the main ingredient for a combustion reaction in the building's fuel cell. This reaction will produce both energy and heat for the building as well as water that can be recycled. As a reference, approximately 1 kg of Hydrogen will produce 33 kwh or 113,500 btu as well as 2.4 gallons of water (Lazo).

Modular Algae Panel System

There are approximately 1000 panels on the building not-including the panels on top of the parking structures. That means the main building is covered in almost 20,000 sf of hydrogen producing algae panels. . In the right conditions, it would take about 50 panels to produce this much energy per day (Hydral). As a whole this system of 1000 panels would produce about 25 kg of hydrogen per day for nearly 2,000,000 btu/day or approximately 800 kwh.

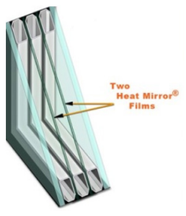


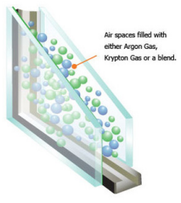
1. Water and nutrients input
2. Algae circulation
3. Hydrogen gas bubbles up and is transported to fuel cell
4. Algae biomass recycled post-cycle



ANALYSIS

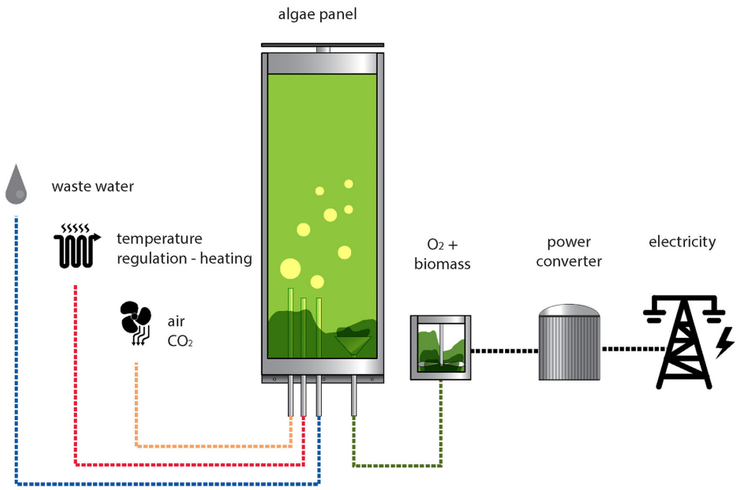
Would it work?
The short answer is yes but there are some obvious issues that need to be worked out with further studies. Right now there are a large amount of stability issues with this technology and many factors can effect its operating efficiency. To solve certain problems, such as freezing temperatures of Minnesota Winters, options would include insulation of the glass and/or heating of water to prevent freezing in the winter, this would definitely keep the algae alive, however it is unclear how the results of hydrogen production could be effected.





The BIQ building in hamburg(right) is currently the only real world application of algae panels and Hamburg does have below freezing temperatures in the winter. To combat this they actual have another input for temperature regulation from the building's waste heat (Loomas). This is a system that could be further studied for application in a climate zone such as Minnesota's.

Regardless this technology is something I hope to follow and revisit in the future.



Response to Precedent and Research
In short, I believe this project was a successful exploration into the chosen premise. By taking real and measured problems such as the impact of buildings on climate change, and applying research & design, I was able to achieve a creative architectural solution. After the project's completion, I fully believe that architecture and ecology have a future together that will lead us into a greener future.

I also believe that my project will encourage others to explore collaboration with outside disciplines to accomplish architectural goals and I can't wait to see what students come up with in the future.

My thesis question was interested in the future of the built environment and the inherent dichotomy it creates with the natural one. By focusing on architecture + Ecology, I believe that future is a bright one.

Response to Goals and Emphasis
At the beginning of the thesis process I laid out seven goals that I hoped to accomplish over the course of the year. These goals are laid out in more detail in the proposal section of this document, but I believe I met, if not exceeded my own expectations in the following ways:

Goal 1: Learn about biodesign and how it could shape the future:
Admittedly I barely scraped the surface of what could be a lifetime of scientific research. However the studies I conducted and research I did opened the eyes of not only myself, but those around me to what could be possible and for that I am proud.

Goal 2: Explore sustainable software and standards:
Working through the Living Building Challenge was a very challenging but rewarding experience - one that a truly hope to experience in the professional world. I believe their ideals and aspirations are vital to change the mindset of the young architects that will bring true change.

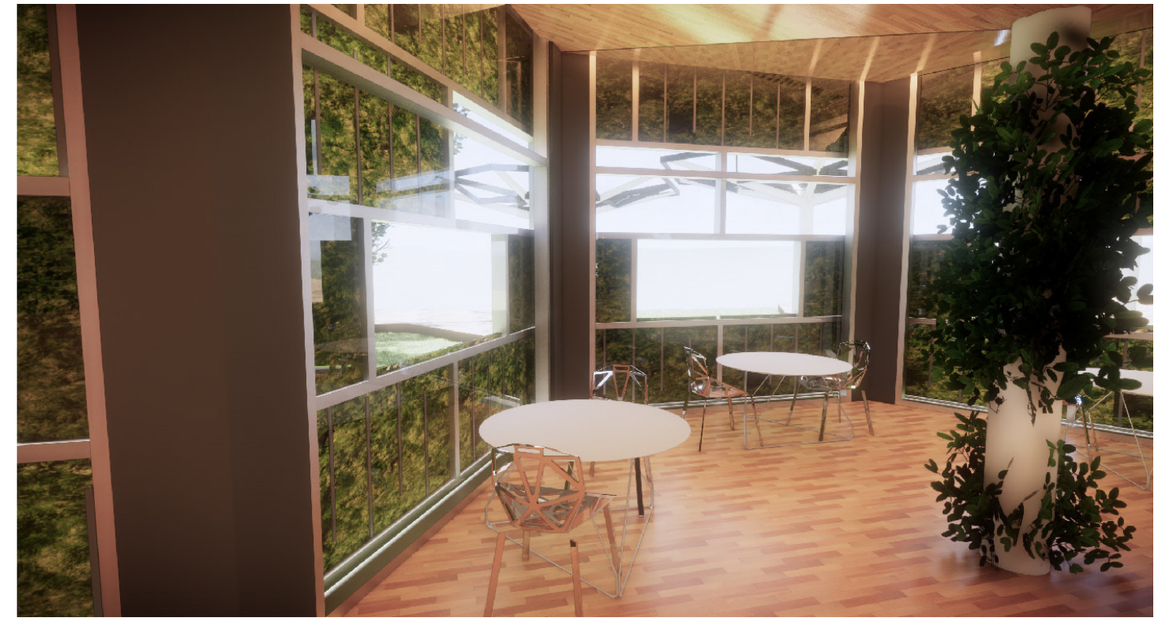
Goals 3&5: Communicate my exploration in a way I can be proud of:
Winning the McKenzie Award for Outstanding Thesis Design was outside of my wildest expectations. A truly humbling honor.

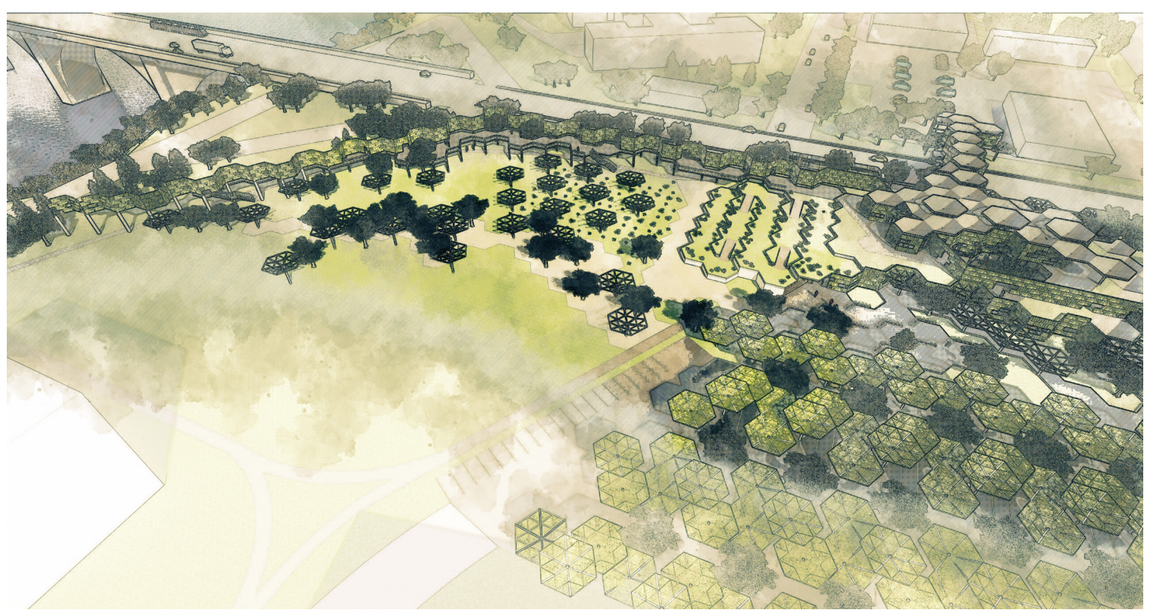
Goal 4: Increase my design abilities:
I think the research and collaboration portion of my thesis will become my greatest takeaway. It reinforced the importance of always being a student and working together. It seems an interesting time to use this saying having just completed the requirements for a Master of Architecture Degree, but it is important for me to see myself forever as a student, never a master.

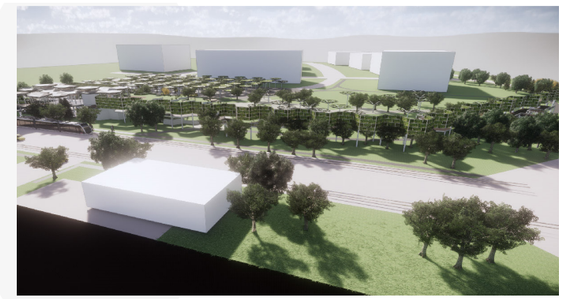
Goal 6: Obtain a Master of Architecture Degree
With this document I will have met all expectations.

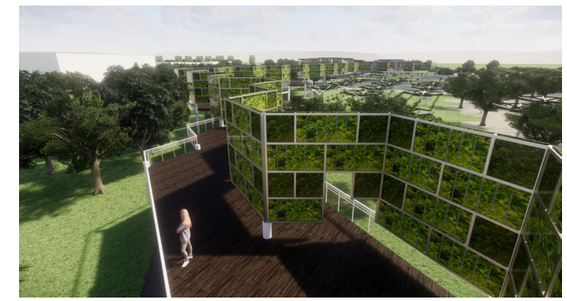
Goal 7: Have some fun:
I am very proud of the lifelong friends I have made here at NDSU and I cannot wait to move into the profession with this group of people. We did it together.

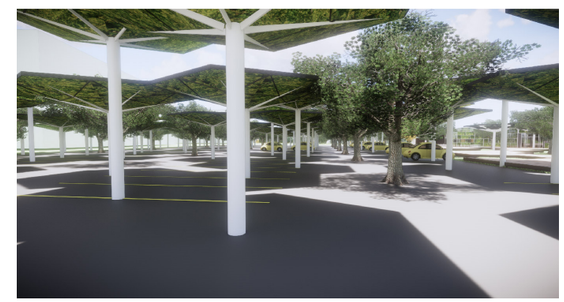
ADDITIONAL RENDERINGS

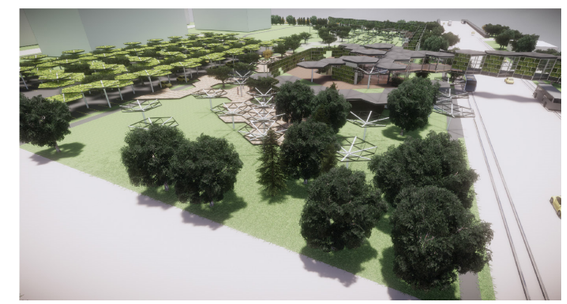


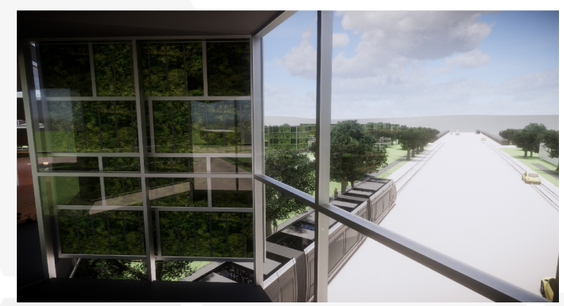


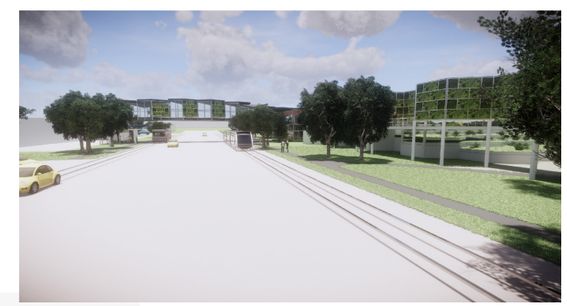












Design Programs Used
Revit 2018
Enscape
Adobe Photoshop
Adobe Illustrator

Thesis Display

The final thesis display included a 6′ x 6′ presentation board, a 1″=30′ site model and a glass panel filled with algae. The presentation also included a digital slide show.

Arcology was the recipient of the Peter F. McKenzie Memorial Award for Outstanding Thesis Design.

APPENDIX

"Here is to a new age of design, a new age of creation, that takes us from a nature-inspired design to a design-inspired nature."
- Neri Oxman

Glacier National Park, Montana USA

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STUDIO EXPERIENCE:

2 3 4 5

2nd Year

Term:	Fall, 2014	Spring, 2015
Name:	Daryl Booker	Cindy Urness
Projects:	Tea House; Moorhead, MN Boat House; Minneapolis, MN	Montessori School; Fargo, ND Birdhouse; Fargo, ND

3rd Year

Term:	Fall, 2015	Spring, 2016
Name:	Steve Martens	Bakr Aly Ahmed
Projects:	Fire station; Grey Eagle, MN Archeological Museum; Marmarth, ND	Culinary School; Fargo, ND Athletic Facility; San Diego, CA

4th Year

Term:	Fall, 2016	Spring, 2017
Name:	David Crutchfield	Paul Gleye
Projects:	Capstone High-Rise; San Francisco, CA	International Design Studio; Brussels, Belgium

5th Year

Term:	Fall, 2017
Name:	Elizabeth Medd
Projects:	Community Pavilion; Fargo, ND

Professional Experience

Year:	Summers 2016, 2017
Name:	BWBR, St. Paul, MN
Position:	Architectural Student Intern

The problem is not the science but the challenge of changing peoples opinions about what is possible. The challenge we have is moving from emotion to science. We can build like this, we just have to recalibrate our imaginations.

- Michael Green