Thesis Proposal

Regenerative Architecture

Making nature an equal partner in design

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Regenerative Architecture

Making nature an equal partner in design

A Design Thesis Submitted to the
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By
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Thesis Abstract

The current example in the field of architecture today is one of degeneration and obsolete building technologies. Regenerative architecture is the practice of engaging the natural world as the medium for, and producer of the architecture. It responds to and employs the living and natural systems that exist on a site that become the "building blocks" of the architecture. Regenerative architecture has two focuses; the first is to design with attention to conservation and performance through reduction on the environmental impacts of a building and the following is to make the environment an equal partner in design.

Thesis Narrative

Architecture is an ever growing and evolving field. One trend that has emerged through the years is green building design. This is in part due to climate change and also, because we have become more conscious of being wasteful. This has been shown through organizations such as LEED (Leadership in Energy and Environmental Design), USGBC (United States Green Building Council), and others similar. One growing trend in this field is sustainable design. The basis behind sustainable is to conserve what we have now to save it for future generations. While this may sound like a smart thing to do, reason dictates this line of thinking will not work and a search for a better solution is still coming.

Imagine all the worlds resources are put into a bucket. These resources include things such as clean water, fossil fuels, and most other forms of producing energy such as nuclear power. This is a finite amount of resources. Over the years, resources are taken out of this bucket. The biggest contributors to this decrease are industry, development, and population growth. Over time this bucket gets reduced to a point where people start worrying. These resources won't last forever so they implement sustainable design to contradict this decrease. As was explained earlier, sustainable design is about conserving what we have now to save it for future generations, so we limit resources dedicated to industry, resources set away for development are limited as well, and even resources reserved for the population get limited. Humanity can only be restrained so far before they go without water and energy and the quality of life decreases. There's a minimum amount of resources that need to be pulled from this bucket to fulfil basic human needs.

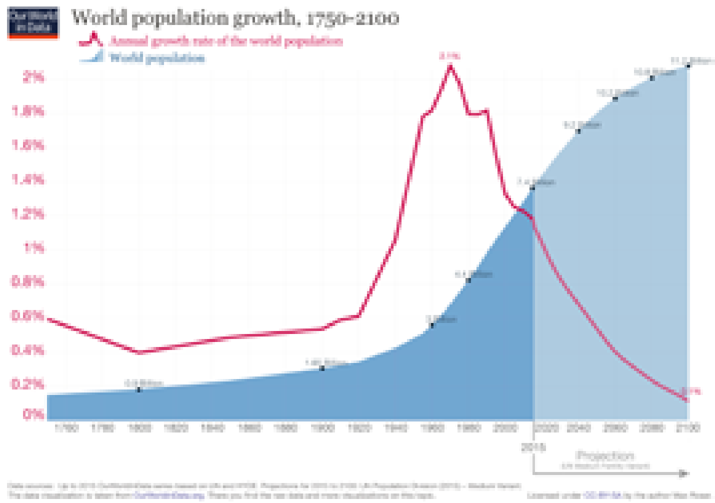

Figure 1. This chart predicts that population growth will slow down significantly but is still on the rise

As the population grows which it doesn't show to be stopping, those resources will start decreasing at an exponential rate no matter how much you try to limit until there is none left. It is in this that we can see that sustainable design just simply won't work. Not only does it not work but it also brings down the quality of life from what it once was. With that said, the idea of sustainability is a step in the right direction. This thinking just hasn't been pushed far enough. We need to find a way to not only stop the emptying of this bucket but find a way to start filling this bucket back up.

The idea that is being proposed is to introduce the use of regenerative design and fully define what regenerative architecture ensues. This way of thinking idolizes the idea of making the landscape an equal partner in design. Architecture is typically defined as "the design and construction of a building on a site". It never talks about designing the site itself which has many design opportunities that can benefit the building. Architecture is considered regenerative when it incorporates more than just the building. It's a design that is one with the natural environment; the essence that has given mankind so much and still has much more to offer. The building and the natural environment are one system and once this system of thinking is adopted the possibilities to renew what has been taken is can be tangible. By fully adopting this philosophy the health of the ecosystem is improved by revitalizing our fresh water supply specifically the groundwater, and the architecture is now producing more energy than it consumes having a positive existence; this is what is called regenerative architecture.

Regenerative architecture can be possible when the production of resources outweighs the consumption in a building system. The architecture in its new definition is producing more clean water that it consumes, more electricity than is needed, and a surplus of food. It does this by exploring new green technologies as well as looking at the natural environment and letting it dictate how a successful design is built.

Determining how well these systems work in a building is crucial for the success of the design. A bigger focus is how the many regenerative systems will work together. Some of the important ones include: energy generation, energy conservation, thermal conservation, water collection and water preservation. Each system has their own job, but they must work as a whole to achieve the goal of regenerative architecture. A study on multiple systems integrated into a building is to be conducted later in the process.

With this we must come to an understanding that everything is related through the web of mutually supportive relationships and we must put ourselves back into the environment. If we accept that we are part of nature, then we have the ability to improve the health of the environment and in turn ourselves.

Building Typology

For this project I aim to redesign the wildlife research center in Ely, Minnesota better known as Boundary Waters. This project aims to study the impact that buildings have on the environment and the wildlife research center fits in this idea because of the similarities in philosophies that the two share such as leaving as little of a footprint as possible. The building will be a facility not only for research, but also a place for the public to come and learn about the philosophies put forth by the design. It is meant to set a precedent on how regenerative design should be implemented and can be used as a learning tool to teach the public.

Typological Research

The goal through these case studies was to find the relationship between each case and find out which elements they share that make them successful designs. The focus of the studies was on their environmental impact and the design strategies used to mitigate these impacts. The criteria for the case study selection was as such: the project had to be bigger than 10,000 ft2, must be recognized by at least one green building association, and must have a similar climate to the one this project is taking place.

Many sustainable technologies were discovered in these case studies. Many design strategies were shared from case to case such as the use of a green roof and rain water collection. With that being said, each one had its own way of being unique such as the Bullitt Center's composting toilets, or CIRS' glue laminated beam structure. The most important thing that has been taken out of these studies is that every one of these cases had to put hard long thought into design to tailor their building to the site. They took what the site was telling them and ran with it.

Case Study #1

Bullitt Center

44,700 sq. ft.

Miller Hull

Seattle, WA

This report is a documentation on the design and performance of the Bullitt Center. It was designed by the architecture firm Miller Hull. Primarily this will focus on what decisions were made consider this building "one of the greenest buildings in the world" This six-story office building located in Seattle is an experiment to set a precedent on how 21st century architecture can be designed. This was only possible through complete coordination between the owner, the designers, and the construction team with one goal in mind, to set off to create a radical shift in 21st century building design through a super high-performance building.

This center that boasts 44,700 sq. ft., is home to several different businesses and is the pinnacle of green design. It incorporates many sustainable technologies integrated into one system to maximize its saving potential. These systems range anywhere from passive energy generation to grey water treatment systems. This all comes together to achieve their goal of being a net-positive work environment. This building holds many accreditations including Net-Zero Water, Net-Zero Energy, Living Building, and Architecture 2030.

The Bullitt set a high goal through first year for its thermal efficiency while also keeping it comfortable. During the winter it was reported that the interior was contentedly warm with no drafts and during the summer it was able to be kept cool all the while having plenty of daylighting. PAE Engineering established a benchmark for the average energy usage of an office building in Seattle. The results concluded that the average was 72 kBTU/sf year. The Bullitt Center averages only 10 kBTU/sf year.

They accomplished this through a few different ways. The first system that was implemented was a geo-exchange system that gather energy from the earth to provide an efficient heating and cooling system. They did this by running water through pipes deep under the earth which stays at a constant temperature. The water regulates to the temperature of the earth which ranges between 50 and 60 degrees. This temperature is easier to either heat or cool than what it would be coming from outside. Once the water is either heated or cooled to the desired temperature, it is pumped through pipes in the floors which dissipates the heat to either create the desired temperature in the room.

Even though the heating and cooling system is efficient, it still needs the power to supply this heat. The Bullitt Center is equipped with a 242kW photovoltaic array produced 60% more energy than the building used in 2014. Based on the fact that Seattle only averages 2019 hours a year with sunshine which calculates to 84 days. This ties back into the average yearly energy use. To support a typical office building the same size as the Bullitt Center, a PV array of 51,004 ft2 would be needed. Since the Bullitt Center 1/7 the power, it only needs a PV array of 14,303 ft2 to support its needs which is very achievable.

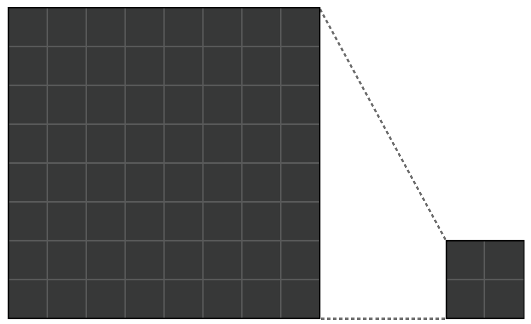

Figure 2. Photovoltaic Array area comparrison

The last component to this system is the reduction of plug loads. Plug loads account for roughly twenty percent of a commercial buildings yearly energy usage. The Bullitt Center set out to reduce theirs by 78 percent. They accomplished this using cloud-based servers, thin client work stations, and laptops replacing desktop computing equipment. With these systems in combination together it is possible to reach Net-Zero Energy.

The owner and designers of this building decided that being Net-Zero Energy wasn't enough. To radically change how 21st century architecture is designed they had to push further. Water often gets overlooked as a valuable resource until there is none left. They had enough insight to this to decide that going Net-Zero Water was an important achievement to tackle. Again, just like becoming Net-Zero Energy, one system wouldn't solve everything, but a combination of systems would.

The first thought was water collection. The less that was taken from the city water the less that was used. To collect this water, they implemented a green roof and a constructed wetland. What water that was collected by these was then stored in a 56000-gallon cistern. This water is considered grey water which could be used for watering various plants or be used in restrooms to flush toilets. Most of the water that was collected was sent through a filtration system to turn it into potable water. The amount of water collected by this roof is enough to support the entire building.

56000 gallons is typically not enough to support a building of this size. What the Bullitt Center does is incorporate a few water efficiency systems to alleviate the load. The initial step was to practically eliminate water being used in restrooms. They carried this out by using the first inhouse composting toilets in the state of Washington. By using foam to flush the toilets they used 96% less water in the restrooms. This compost is then used as fertilizer at the end of the process.

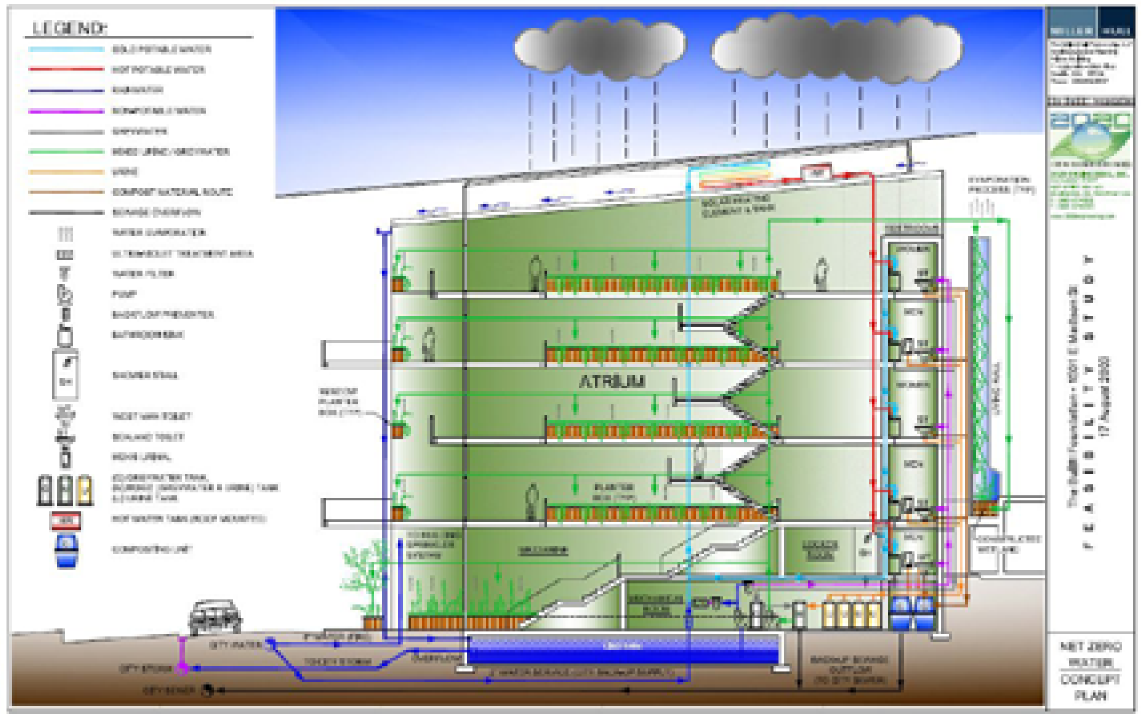

Figure 3. Section cut of the Bullitt Center displaying its various water systems

The latter part to this water saving system is the grey water treatment system. All water from faucets and showers within the building is stored in a 500-gallon cistern in the basement which is then pumped up to the third floor where it is put into a constructed wetland. These wetlands over time clean this water of most impurities and is then either sent back into the ground or sent into the atmosphere through evapotranspiration.

In summary the people who were apart of the construction and maintenance of this building pulled out all the stops for going green. While this building is a large office building, these system can still be used in the research center albeit smaller. The Bullitt Center set a standard that very few buildings have achieved with its integration of the highest preforming technologies to date. This is a building that can truly be considered regenerative architecture.

Case Study #2

The Centre for Interactive Research on Sustainability

61,000 sq. ft.

Busby, Perkins+Will

Vancouver, Canada

This study is a report on the environmental impacts and story of the Centre for Interactive Research on Sustainability (CIRS) and the technologies that it employs. This building is an experiment from the University of British Columbia designed as a living laboratory to test sustainable building strategies and accelerate their adoption into urban development. The project estimated at 30 million US dollars and was completed in 2011 with 61,000 square feet. It has the earned the LEED Platinum Certification and is seeking Living Building Challenge recognition. This building is a research laboratory hosting offices and computer labs, an auditorium, meeting rooms, a café and open spaces for social interaction. The performance of the building is itself a research project for the researchers inside and is equipped with over 3000 sensors to monitor the buildings sustainable performance. It is intended to be a 100-year study and be an ever changing and improving project. CIRS' sustainable design goals were organized into four categories: design principles; water supply treatment and reuse; daylighting and solar shading; and energy modelling.

When design was first being proposed, technology partners were brought to design charrettes to propose different sustainable technologies. They accumulated these charrettes together into a report and was referenced in the design process. Before any thought on the active systems was considered, major thought was put into the reduction of the water demand and energy load to a minimum through passive systems. The design team also focused on water and energy harvesting from what they called "free" sources such as waste thermal energy, renewable energy and rainwater.

Figure 4. This picture is showing CIRS's green roof

Figure 5. Interior veiw of the engineered wood members

Quick Energy Guide

Annual Energy Use Intensity 41.4 kBtu/ft^2
Electricity From Grid 41.2 kBtu/ft^2
Renewable Energy .2 kBtu/ft^2
Geothermal Heat Absorbtion And Rejection 5.4 kBtu/ft^2

Annual Net Energy Use Intensity 41.2 kBtu/ft^2

Annual Energy Cost Index $.60/$ft^2$

Savings vs. Canadian National Median 32%

Carbon Footprint .369 lb CO_2e/ft^2 x Year

Annual Hours Occupied 1,976

One focus of the team was the lighting of the building. The CIRS has two wings on each side with large swathes of glass on both sides of the wings which gives the building most of the daylighting that it needs even on a cloudy day. When daylighting isn't enough they use a programable florescent fixtures to supplement. The key to this system is that every light is connected to a motion sensors and photocells. What this does is turn the lights off if there is no one in the room or when there is adequate light. This eliminates any unnecessary lights being on and waste of energy.

Monthly Energy Usage 2012-2013

	Electricity use (kWh)	PV Electricity (kWh)
April 2012	58,645	N/A
May 2012	55,640	N/A
June 2012	55,372	N/A
July 2012	56,374	N/A
August 2012	54,509	N/A
September 2012	57,081	341
October 2012	65,476	885
November 2012	67,333	398
December 2012	69,551	115
January 2013	84,007	361
Feburary 2013	64,986	366
March 2013	65,817	1,632
Totals	745,791	4,137

The CIRS incorporates the use of plants in its façade. On the west façade a network of vines is hung off the structure which shades the building during the summer blocking heat and lets sunlight in the atrium in the winter. The team also installed a vegetative roof which significantly reduces the storm water runoff and cools the building in the summer through evapotranspiration.

Buidling Envelope

Roof
Overall R-Value 40
Reflectivity .79 (White plastic roofing membrane)

Walls
Overall R-Value min 20
Glazing Perc. 35%

Windows
Solar Heat Gain Coefficient
No more than .35
U-Factor
no more than .16
Visual Transmittance
no less than .45

An important figure that is used in measuring a buildings energy performance is the annual energy use intensity or EUI. Energy Star reports say that a typical higher education building in Canada runs at about 104 kBtu/ft2. The CIRS runs at under half that at 41.2 kBtu/ft2 they accomplish this through a couple different strategies. The first design strategy is a series of evacuated vacuum tube solar collectors that are used to preheat domestic water. A second bigger system that was incorporated was the capture of the waste heat of the neighboring buildings and use it to produce energy. This system aimed to be able to return up to 600 MWh back to campus. The biggest factor to this low EUI is the buildings very high R-Value building envelope. It utilizes low-e triple-pane sealed curtainwall glass modules that limits solar heat gain.

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Case Study #3

The Newberg Center

13,500 sq. ft.

Hennebery EddyArchitects

Portland Oregon

This report will document and analyze the sustainable systems that are incorporated in this design. The Newberg Center was built in 2011 in Portland Oregon and is an institutional building. This building was designed to be Net-Zero Energy, as well as Carbon Neutral. This design was awarded LEED Platinum certification on completion and has held it to this today. The building systems consists of passive ventilation, radiant heating, natural daylight and solar energy, and incorporate a variety of green-building materials.

One thing it has in common with the CIRS is its state of the art lighting control. Each light in the building is connected to motion sensors as well as photocells which turn the lights off if no one is in the room or if there is enough light in the room. This cuts down on unneeded lighting which in turn lowers the energy consumption of the building

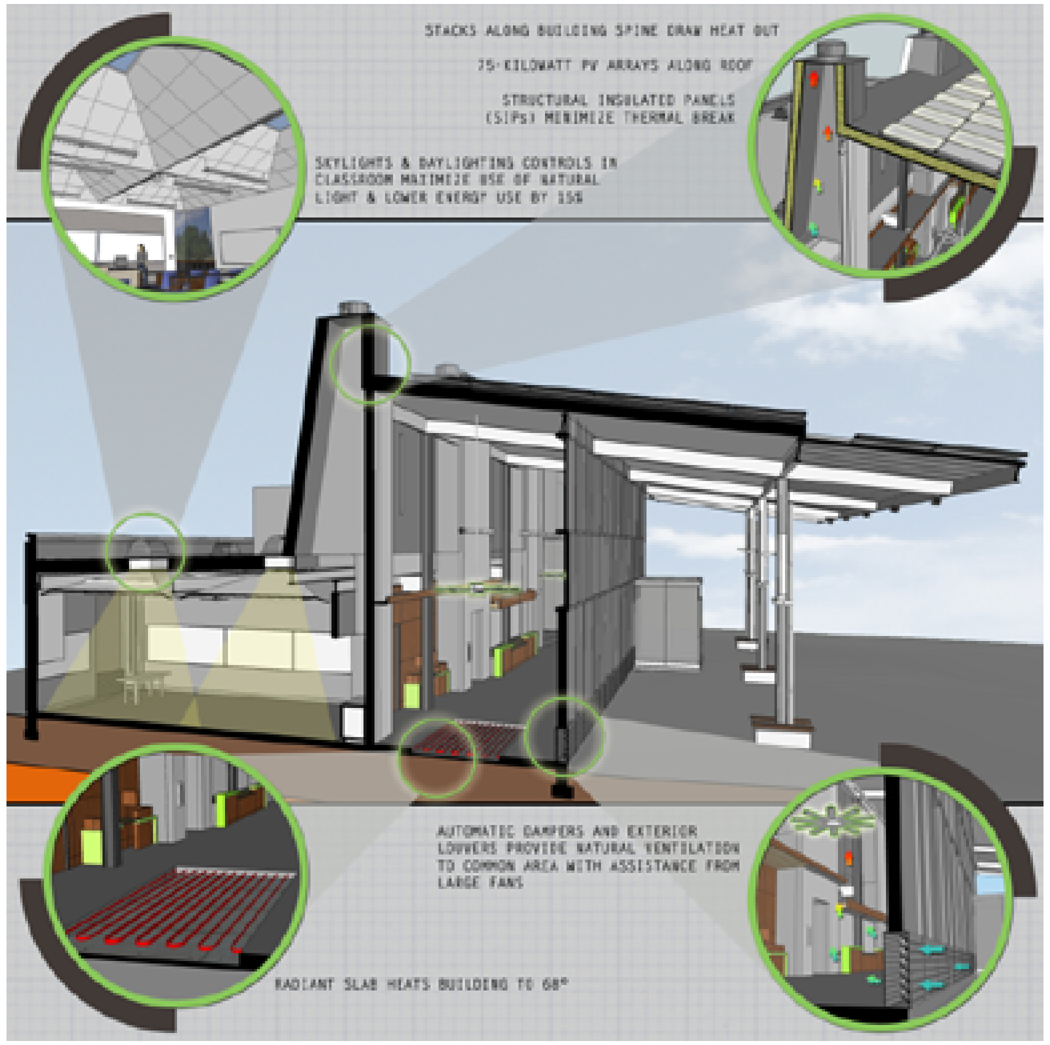


Figure 6. Section View of showing the various sustainable systems

Quick Energy Guide

Annual Energy Use Intensity 33.2 kBtu/ft²
Electricity From Grid 27.8kBtu/ft²
Renewable Energy 5.4 kBtu/ft²
Annual On Site Renewable Energy Exported 17.9 kBtu/ft²

Annual Net Energy Use Intensity 41.2 kBtu/ft²

Savings vs. Standard 90.1 2004 50.3%

Annual Hours Occupied 4200

Monthly Energy Usage 2012-2013

	Electricity use (kWh)	PV Electricity Production (kWh)
April 2012	9,440	7,328
May 2012	6,960	11,476
June 2012	4,240	11,059
July 2012	3,920	12,404
August 2012	4,880	12,368
September 2012	4,720	10,348
October 2012	6,560	6,097
November 2012	14,480	3,006
December 2012	14,880	2,142
January 2013	19,360	3,171
Feburary 2013	11,680	4,385
March 2013	8,880	8,369
Totals	110,000	92,151

To reduce to cooling cost on the building they implemented a night flush cooling system. What this does is essentially make the building one big wind tunnel. They open vents at each end of the building during the cool night hours and with the use of fans the flush the hot air out and bring the cool night air in. They then close the vents and the building stays cool through the rest of the day with proper insulation.

To conserve this cooling in the summer and also the heat in the winter, the design team took an outside in approach. They created what they called a super envelop with the use of a structurally insulated panel system. The walls have an R-Value of 31 and the roof has an R-Value of 47. They introduced double paned glass filled with argon for windows that had a U-Factor of .29. With all this combined and much more, the Newberg Center is Portland Community College's first step to a Net-Zero campus.

Project Elements

To understand what regenerative architecture is, it must be defined. Jacob Littman best describes it in his paper as "the practice of engaging the natural world as the medium for, and generator of architecture". What this means is that the architecture not only responds to but utilizes the natural systems and resources on the site. Instead of fighting against the environment, regenerative architecture aims to work for and with the environment.

Regenerative architecture has two emphases; the first is to take principles from sustainable design such as a focus on conservation and performance by reducing the environmental impact that a building will place on a site. This is primarily done with careful choice of materials, green technologies that will reduce water usage, power consumption, etc.., and with a knowledgeable design that puts these all together. The second emphasis is to let the environment dictate how a building is designed. The site should be treated as an equal partner in design. The building must fit within the context of a site and is only one part of a larger whole. It can be as high performance as possible but still not fit into a site. Bill Reed describes it perfectly as" a high performance building is like a high performance liver. Certainly, the limitations of that liver are pretty obvious outside the context of the whole body". A building can be a high-performance machine but that does nothing if the it doesn't fit the site. Regenerative design can be summed up on the premise that everything we build has the possibility of mixing and melding with the natural environment making it an equal partner in design.

As going with the first emphasis there are many decisions to be had to meet these criteria. The first being the selection of material. While there are many sustainable and ecofriendly materials out on the market today, what the focus for material selection should be on is locally sourced materials. The biggest reason for this is because if it is locally sourced materials then the energy that was used to transport to the manufacturer and then to the site are kept to a minimum. Sourcing materials within approximately a one-hundred-mile radius will be the goal. The site is located in a wooded area that covers most of northern Minnesota, so stick framing or the use of SIP panels will be in consideration. A very popular window and door company is located within this area as well that offers the latest in energy efficient designs.

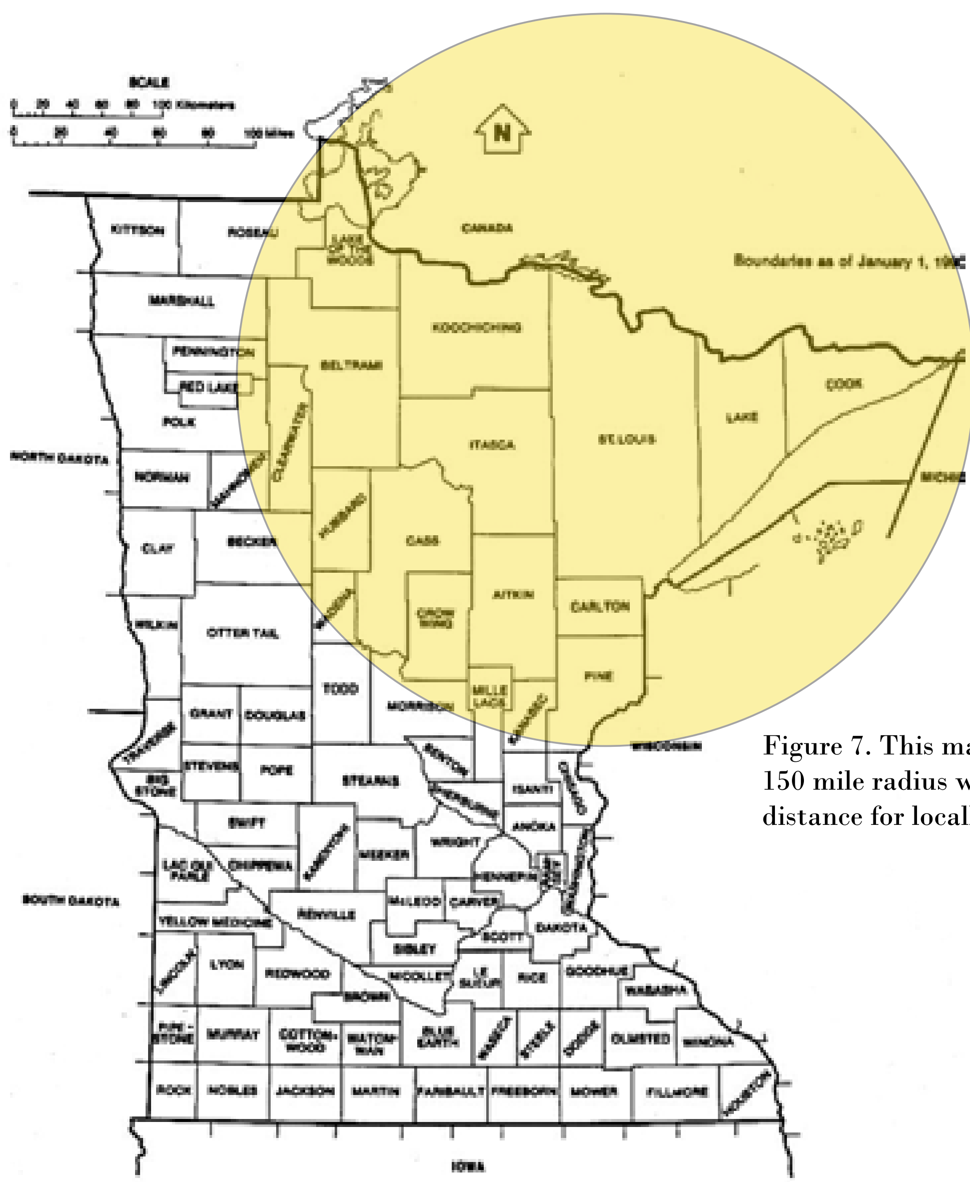


Figure 7. This map shows a 150 mile radius which is the distance for locally materials

Just like how the building is only a part of the larger body of the site, each regenerative system is just a part of the building as a whole. Each regenerative system must be integrated together to create a seamless and truly regenerative design. A focus for system designs is to be able to meet most if not all the needs for the building on site. The environment can provide the answers to how to take that step forward past sustainable, and the challenge is how to find these answers. The systems that will be focused on will be water collection, water retention, energy generation, and efficient energy use. Each of these separately will benefit a design, but intelligently combining each regenerative method will put this project one step closer to our definition of regenerative design.

Water is a valuable resource and a finite one that gets overlooked in many cases because as of right now it is quite abundant. Minnesota is the place known as the land of ten thousand lakes, but one day that might be so true. California for example at one point was water rich which in turn brought agriculture to the land which in turn brought more and more people to the area. Due to poor irrigation practices and water usage over the years, the ground water has decreased to the point that California especially the Tulare Basin is in a drought and suffering from lack of water as shown in figure 3. State laws have been implemented to reduce the use of water, but at this point it might be too late.

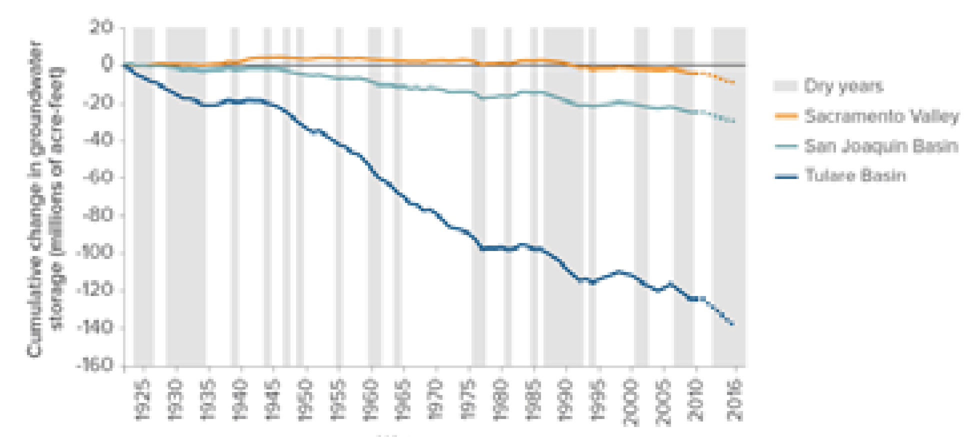


Figure 8. Chart showing water depletion in California

Water collection is going to accomplished with a combination of a few approaches. Ely, Minnesota averages 27 inches of precipitation annually. A gutter system will be implemented to collect this water and store it in a cistern on site. This water can then be treated as grey water which then can be used for lavatory facilities such as flushing toilets or the water can be run through a filtration system and treated to be used as potable water for many purposes on the site. While this will not be possible during the winter months due to snow, the idea is to collect enough water and be able to reuse this water down the road. The process is as old as time and is effective but has been lost to most of society due to the ease of pumping water from a well.

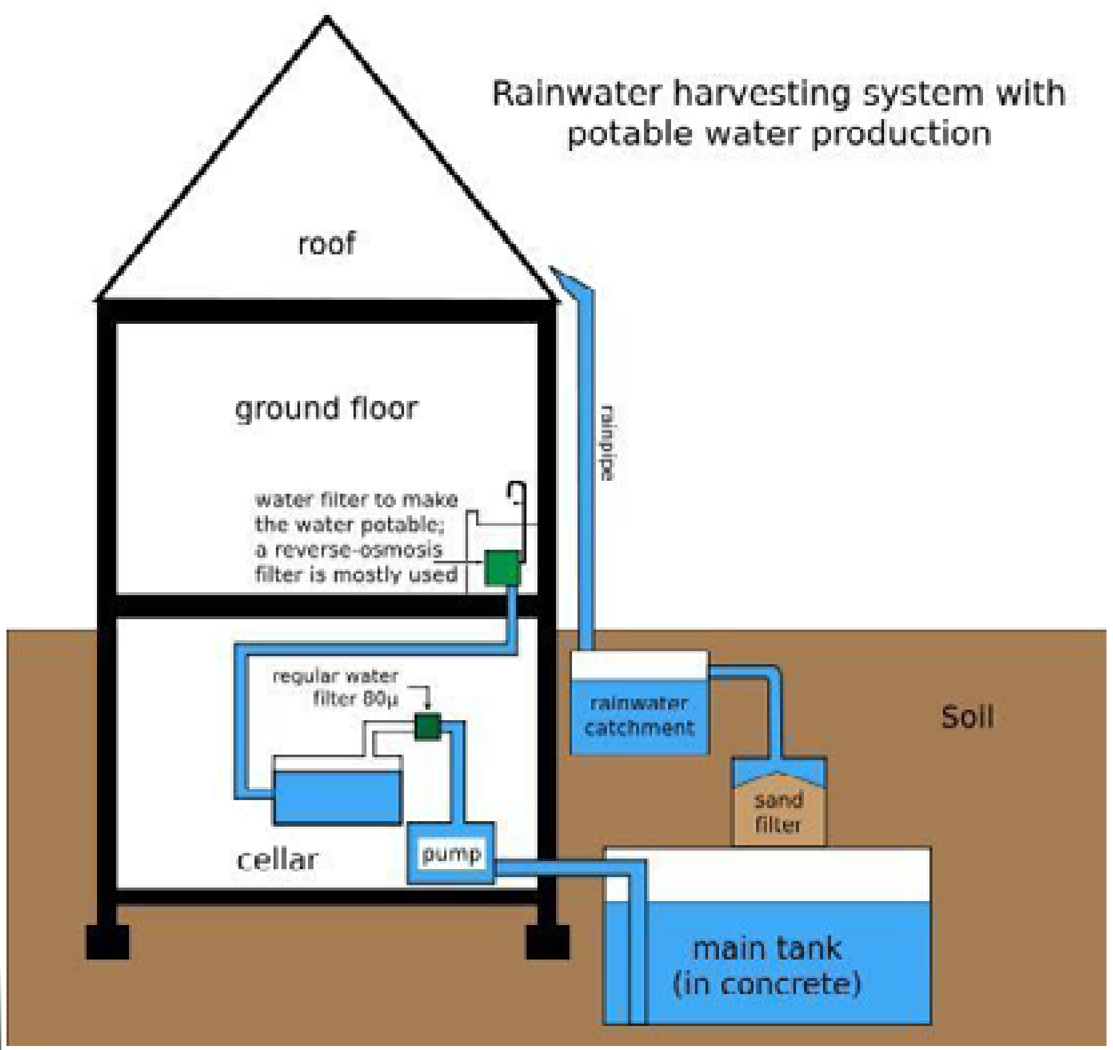


Figure 9. Diagram of a rain harveting system

In a typical building the water that is being collected from the rain water system would not be enough to sustain it for any period. To fix this issue a water recycling and a water conservation method will need to be used. One water recycling method that has been gaining popularity is using constructed wetlands. For a project like this there is a choice of using an outdoor system which has the ability cleaning large quantities of water, and smaller, condensed indoor ones such as living machines or both. The concept of how both work is similar. Constructed wetlands harness the cleaning power of natural wetlands to recycle grey water and treat it to make the water usable again. This is a natural alternative to conventional waste water treatment and is a proven method. However, the understanding of how the bacteria, root systems, and substrate clean the water is still incomplete. These wetlands typically consist of three cells or ponds connected end to end so the first flows through the second and then into the third. The first cell is a settling pond. This cell typically has no plants and only acts to remove large objects from the water. The second cell is the main treatment cell and is filled with various wetland plants with a course substrate. The third and final cell is the polishing cell which finishes up the treatment process. The plants themselves do none of the cleaning themselves but rather creates the substrate and the bacteria that treat the wastewater. How they do this is not completely known. Once the water is treated it can either go through a sanitation process and be used again or be put back in the ground to add to the existing ground water.

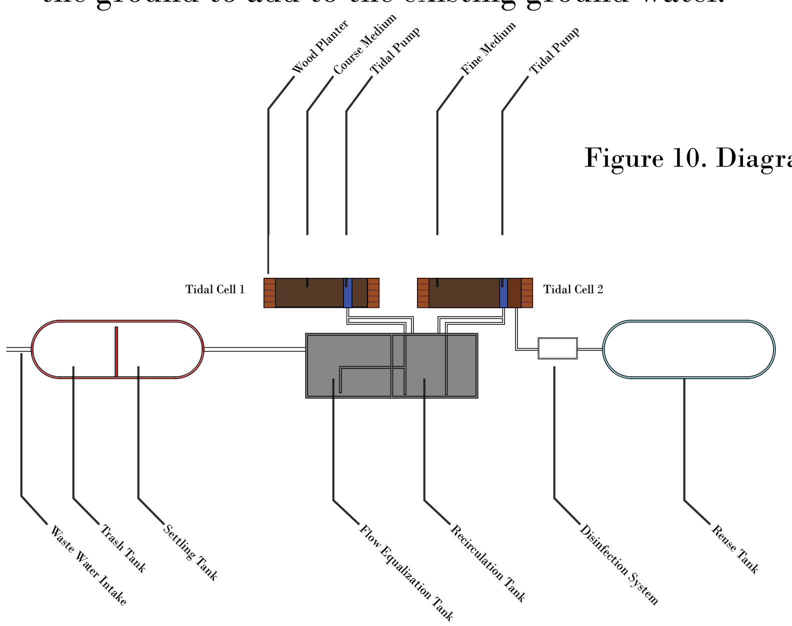
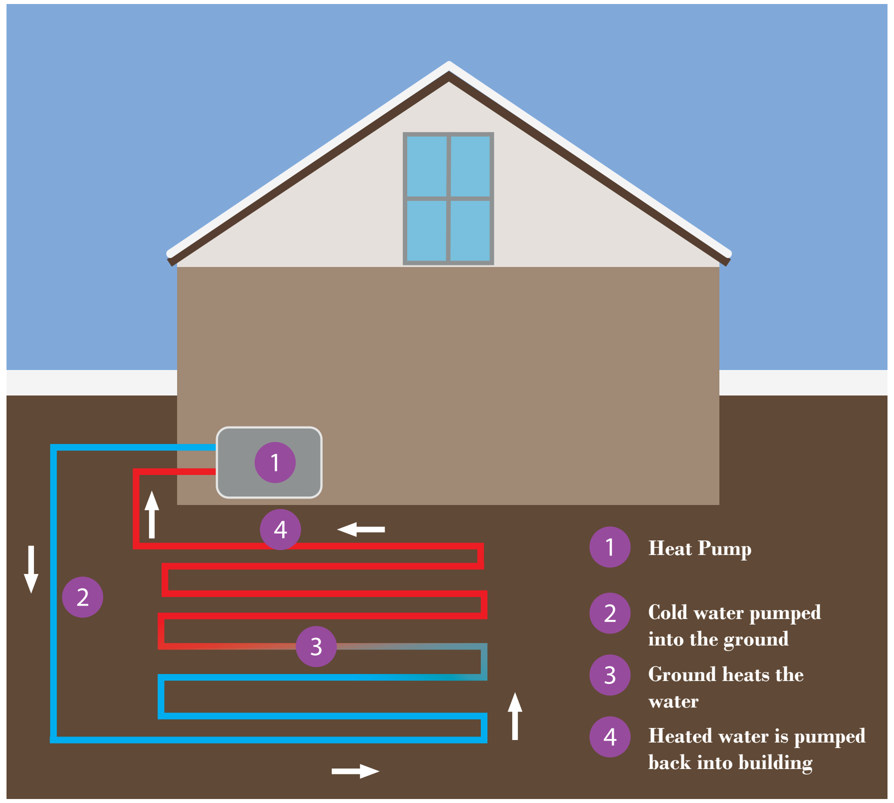


Figure 10. Diagram of a Living Machine

Toilets typically account for 24% of water usage in a building per year. Older models use up to 7 gallons of water per flush with newer high performance claiming to use 1.6 gallons per flush. To reduce the water load on the building a composting toilet system will be used in the project. These toilets flush with foam and in at the end of the process ends up as fertilizer. This system claims to reduce water usage for toilets by 98%.

With all water being collected on site, energy production will follow suit. The bulk of the energy will be produced by an array of photovoltaic or PV panels. This technology has been around for quite some time but is only now beginning to be efficient enough to be a viable option in an energy source. Factors such as yearly hours of sunshine, the building's energy efficiency, and the efficiency of the PV panels will dictate how large of an area the array will be. A secondary wind turbine system will supplement the energy production if the load is too great for the PV array to handle. To try and mitigate the load the building imposes, a few thermal efficient systems and energy reduction techniques will be used. These include geo thermal heating and cooling, high performance insulation, triple paned windows, and generous amount of glazing on the southern façade to maximize solar heat gain in the winter.

Figure 11. Diagram showing the basics of a Geothermal Heating System



Client Description

Since this building will be a natural wildlife research center, the client will be the Department of Natural Resources. This stands by what the department stands for and offers an opportunity for them to connect with the community. The Department of Natural Resources is funded by the state of Minnesota who will be sponsoring this project.

Biologist and researchers will be occupying a portion of the building conducting studies. There are expected to be approximately three or four biologists or other scientists along with a number of graduate students conducting studies of their own. With this comes a director who will run the center as well as be a liaison between the researchers and the public.

Lastly and the largest user of the site will be the public. Tours of the building will be conducted, and people will get a glimpse at what the researchers do. Here they will come to learn about wildlife and also about how this building was constructed and its many regenerative features that one day will be common practice.

Site Context

The site is located in Ely, Minnesota which is close to the United States-Canadian border. Ely was first selected for its proximity to the Boundary Waters. Boundary Waters and more specifically the Boundary Waters Canoe Area is state protected land for its natural resources. Most of this land has been untouched or touched very little human hands. The Department of Natural Resources or DNR strives to keep it that way so it makes this area a great area for researchers to study wildlife in as natural of a habitat. The ideals of the DNR will be refelcted on the building by leavings as little of a footprint as possible and in a way help the environment. The second reason the site was selected was because the town already has an etablished natural wildlife research center. This means that the center can be redeveloped to suit the researchers needs and the new center will already have people that are familiar with this line of work to populate it.

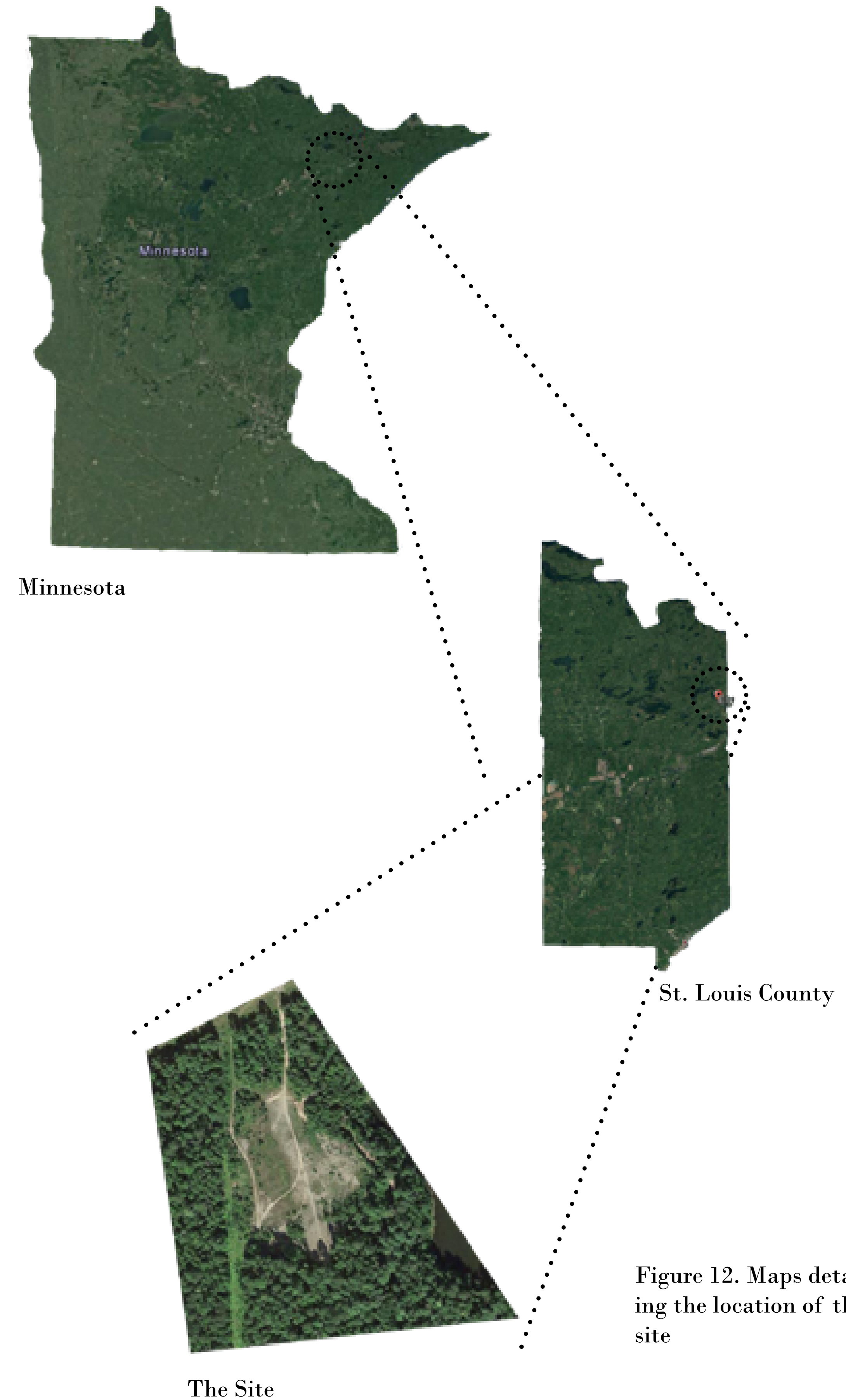


Figure 12. Maps detailing the location of the site

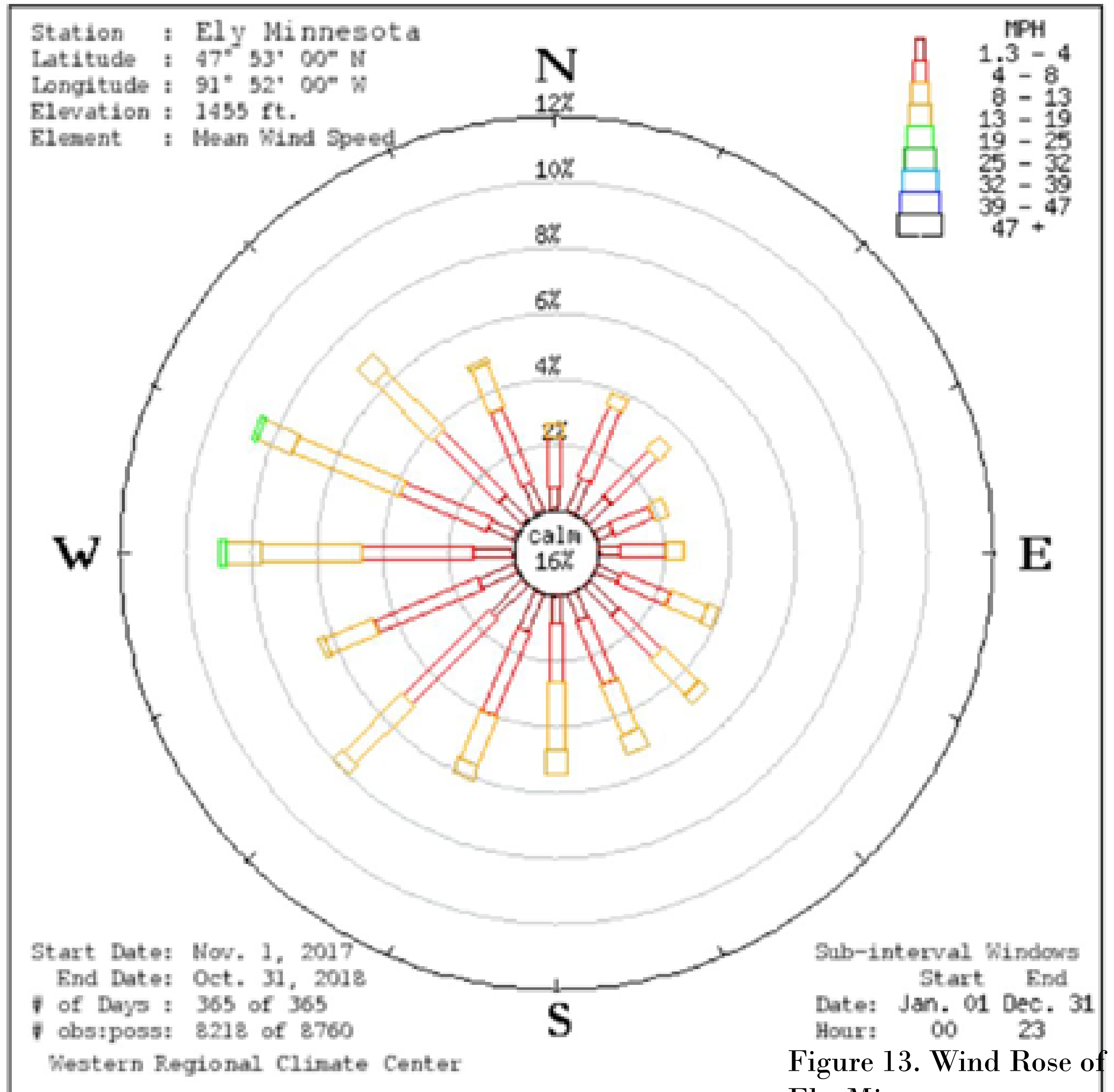


Figure 13. Wind Rose of Ely, Minnesota

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F:	17	25	38	52	67	75
Average low in °F:	-7	-1	11	25	37	48
Av. precipitation in inch:	1.06	0.67	1.18	2.24	3.03	3.94
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-
Average snowfall in inch:	14	9	8	8	0	0

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in °F:	79	78	67	-	35	20
Average low in °F:	53	52	43	-	19	1
Av. precipitation in inch:	4.25	3.66	4.02	-	1.69	1.26
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-
Average snowfall in inch:	0	0	0	-	10	13

Figure 14. Table showing the climate averages in Ely, Minnesota

Project Emphasis

Over the course of the semester a large amount of time with be dedicated to the research of green technologies. To be more specific the focus will be on technologies such as energy creation, energy conservation, water conservation, water gathering, and water filtration to name a few. A bigger challenge will be learning how all these systems will be interlinked together to make one single self-sustaining system. On top of this a thorough and conclusive site analysis will need to be conducted to give me insight on what building will need to suit the needs of the site. The emphasis is to make the landscape an equal partner in design. The object is not to fight the environment to find a way to work with it

Project Goals

This document has mentioned what the goals for this project is vaguely, but all fall on the same path; regenerative design. To further break this down there are a number of criteria that are going to be met. The first criteria which is nationally acknowledged is to make the building LEED Platinum. LEED is a building rating system that is recognized worldwide, and Platinum Certification is highest standard for a building to achieve. This criteria is very hard to achieve because it sets a very high standard for green design having to meet a plethora various requirements.

One other rating system that has been gaining movement is to be labeled a Passive House. This rating includes similarities with LEED Certification, but takes a step further in terms of energy efficiency. The label "Passive House" is a misnomer because it is not limited to single family homes. It can be applied to any building typology including this research center. A key principle is to have continuous insulation running through the entire building with no thermal bridging. This ties into another principle which is to make the building an airtight space so as to stop any unnecessary heat gain or loss. With more principles and guidelines tied into Passive House design, it leads to net-zero or even a net-positive building which ties into the ultimate goal and of regenerative architecture.

Apart from the goals of the building, I have a few personal goals as well. The most important goal for me is to use this project to further my knowledge in sustainable technologies and have an understanding how these are used in a project. The second goal is to take everything that I have learned since I have been at North Dakota State University and produce the best work I can do. In expectation of completing the previous goal, my last goal is to win the Peter McKenzie Memorial Award with my thesis project.

Plans For Proceeding

Furthering in this project investigations will need to be done looking at the site and the research that I would like to explore. I have already been to the site, but I would like to go back in order to spend more time. I will need to take pictures of the sites opportunities and take detailed notes on what is there so as to make an accurate site analysis and have my design fit it.

A main focus for my research will be discovering and learning about new sustainable systems and then also determining if they will fit into the project. Things such as constructed wetlands are complex and will take some time to study to do right.

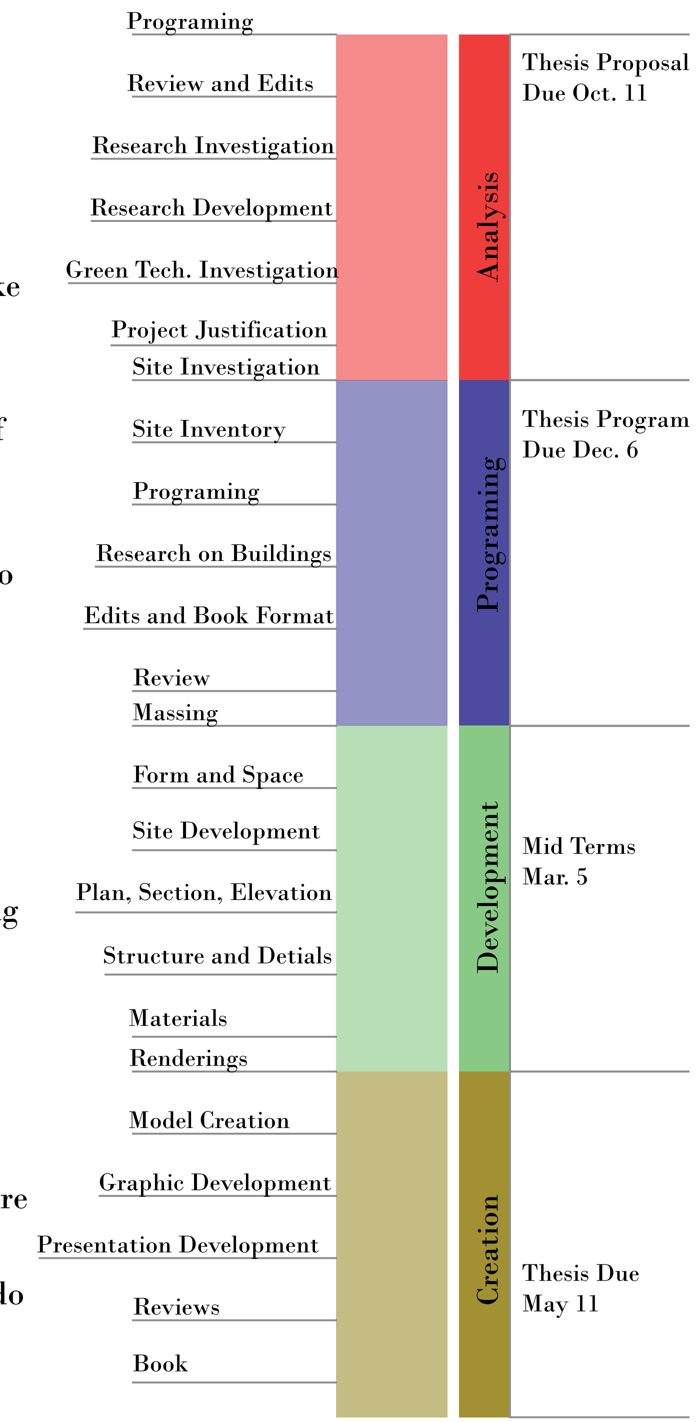
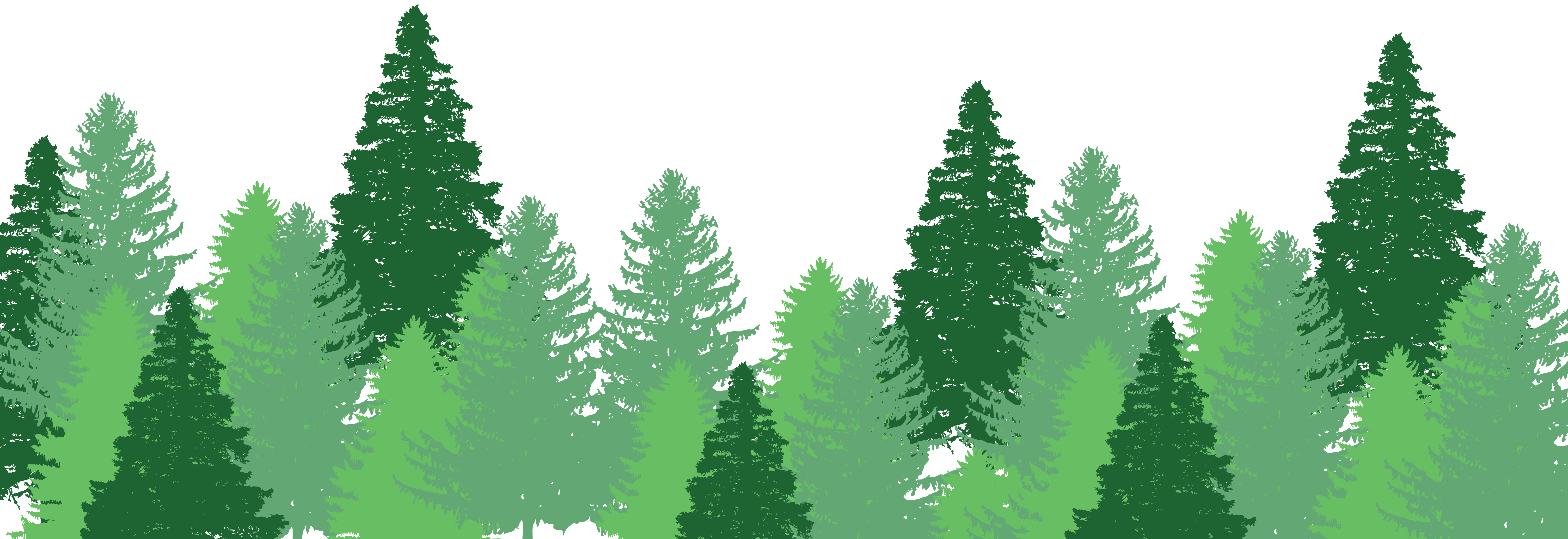


Figure 15. Proposed timeline for the rest of thesis



Thesis Program

a process leading to the statement of a design problem
and the requirements to be met in offering a solution

Theoretical Premise Results

LIVING, REGENERATIVE, AND ADAPTIVE BUILDINGS

By: Sarah Nugent, Anna Packard, Erica Brabon, and Stephanie Vierra

The article "LIVING, REGENERATIVE, AND ADAPTIVE BUILDINGS" is written by a series of authors from Vierra Design & Education Services. They first discuss how buildings have been viewed throughout time and how they lack interaction with the environment. Buildings are thought of as static elements that are meant to last for decades and act as a sole element. They then discuss the early forms of sustainable design through sustainable design rating systems and criteria. As time has progressed, several interrelated, innovative building concepts are being introduced into the field that are changing our thinking on green building design.

Living buildings are considered to be structures that are not reliant on the electrical grid or other outside utilities. This concept ties in with the ideas of net zero which means the resources that are being used are equal to or less that the resources collected on site. These buildings generate their power on site as well as collecting water and other resources similar. Although these buildings don't need to be connected to the electrical grid, they are typically still connected to kick back excess power. Living buildings integrate or imitate natural systems to produce the resources they need to negate any environmental impact. Along with this they emit zero greenhouse gases.

In the article they discuss that regenerative architecture goes a step beyond. They take the concept of net zero and turn it into net positive. Not only do they integrate with the natural environment, but they improve upon it. All water that is collected on site is not only used but is then treated and released back into the natural system to improve the hydrology. They also support urban agriculture such as green roof gardens to produce food for building occupants. The extra energy produced is sent to neighboring buildings to support their energy needs. The distinction between restorative design versus regenerative design is that restorative design aims to improve a site to its original state while regenerative design aims to improve its state through biotic and abiotic means to encourage a healthy and growing environment. The authors stress that this process takes more than recommending green technologies, it requires an understanding of how they can all work together to enhance the environment around them.

This article breaks down into a few different categories

- Climate adaptation
- Material and waste
- Water
- Energy

They stress that climate adaptation is key factor in a successful design. They stress this because this will limit risks from climate change and water shortages which can cause a redesign or in the worst-case scenario a rebuild. Such strategies may include flood resistant materials and drainage planning, drought resistant landscaping, passive cooling, planting for shade, enhanced foundations, and careful planning of vegetation, ensuring buildings do not obstruct biodiversity corridors, and material selection based on heat island effect.

A big factor for considering materials is to appropriately source them. Renewable technologies should come no further than 15,000 KM away while high density materials would come no further than 500 KM away. What this does is support local economies and limits transportation which reduces CO2 emissions. It is state that all timber products must be salvaged or felled on site. These products should only be taken from a responsibly managed forest. The range for waste materials to be recycled and diverted from landfills should fall between 80%-100%.

Water is a big topic deliberated in regenerative design. A building must be 100% self-reliant and not require water from a municipal supply. Water is collected through rain water harvest, stored in cisterns and is kept in a closed loop system. This reduces runoff and stresses in on local water reservoirs. The best way to conserve water is to use compostable toilets, waterless urinals or high efficiency toilets and low flow facets.

To be a regenerative building it needs to be net zero energy. All the energy the building requires has to be generated on site through renewable options. These can include photovoltaic panels, wind turbines, or even fuel cells powered by hydrogen. The building must also conserve the energy it has. This can be accomplished through low energy lighting, high efficiency heating systems and natural ventilation, but more importantly is having a very tight and energy efficient building envelope.

With these working together, a building can be considered "regenerative". This article is important to my project because it highlights and defines what is exactly need for a successful design. One thing I wish was in this document was how to put all these tactics and strategies together. What can be taken away from this is the outline for what is needed for my design. It proves that to better the environment around us we need to take that extra leap beyond sustainable design.

The Green Studio Handbook: Environmental Strategies for Schematic Design

By: Alison G. Kwok and Walter T. Grondzik

The Green Studio Handbook is a guide for environmental strategies for schematic design. The book was written by Alison G. Kwok and Walter T. Grondzik. This book goes over in depth on many different environmental strategies, but the focus will only be on a few of them. I will focus on ground source heat pumps, plug loads, and structurally insulated panels.

Ground Source Heat Pump

In the book the authors discuss how a ground source heat pump works. The basis behind this system is the use the mass of the earth to reduce the temperature swings to improve performance of a vapor compression refrigeration cycle. This in turn heats and cools a building. The shear mass of the earth acts as an insulator making major temperature swings outside seem very mild at moderate depths. By harnessing this consistent temperature through a ground source loop, it can significantly reduce the heating and cooling load the heat pump would typically have to deal with. This piece of equipment while more expensive than a typical heat pump will make save on heating and cooling costs for a long time down the road. With the vast temperature swings in northern Minnesota this will work well in the design.

The basic components of a ground source heat pump consist of a vapor compression cycle that heats and cools the building, an air or water loop to distribute the heating and cooling, and a pump and tube system to receive or disperse heat into the soil. These tubes are typically filled with a refrigerant and made out of high density polyethylene allowing the fluid to absorb heat during the winter and discard heat during the summer. A heat exchanger is then used to transfer the heat from the refrigerant to air or water that is dispersed throughout the building.

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While this system is versatile the cost is dependent on the depth of the frost line. Because the site is in northern Minnesota the tubing with have to be ran very deep in order to avoid the frost line. The book provides various configurations of the tubing field. The one that would best be suited for the climate is a vertical field to get as deep as possible. The biggest concern is the cost of excavation which can also be difficult due to possible utilities already in the ground to work around. The vertical loop depth ranges anywhere between 150-450 feet. About 150 ft2 of contact area is needed to supply 3.5 kw of heating/ cooling capacity. This system is typically used in conjunction with other heating and cooling systems to adequately control the climate of a building.

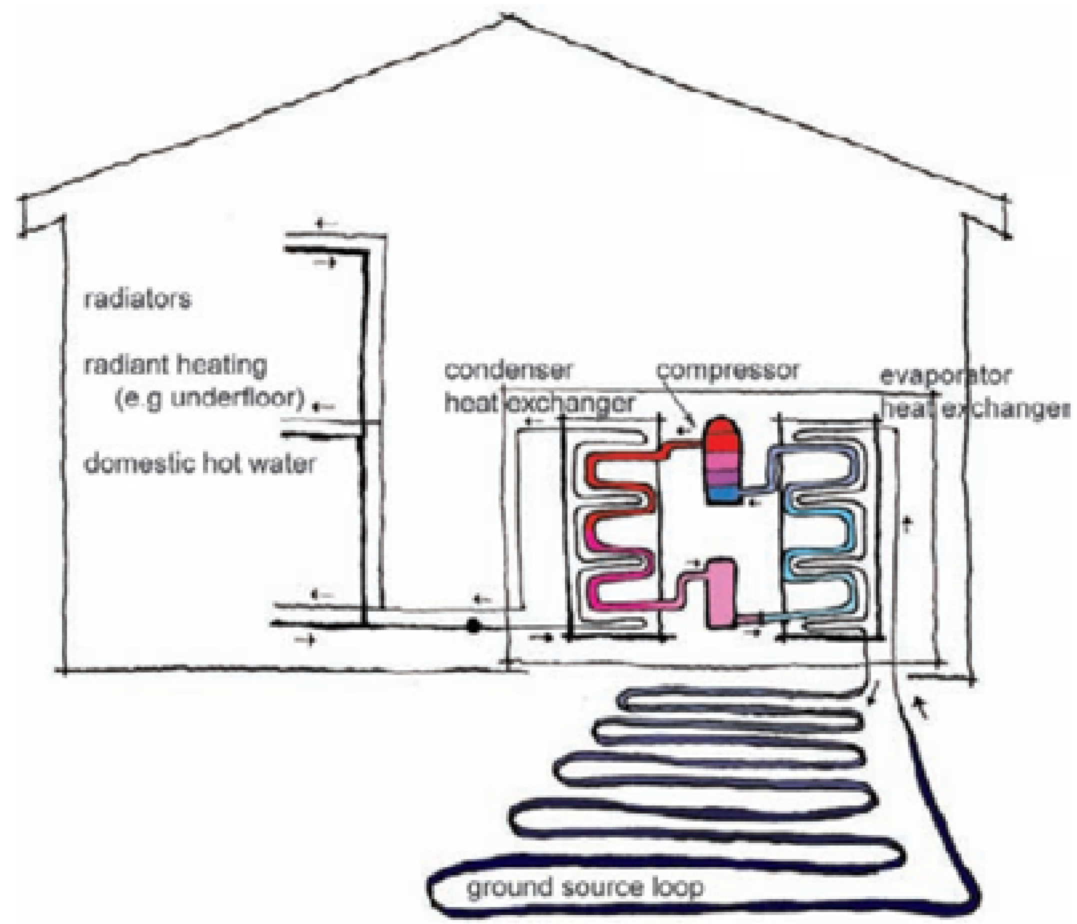


Figure 16- Ground Source Heat Pump Diagram

Plug Loads

The book states that plug loads "represent the electrical consumption potential of all the appliances and smaller equipment in a building". The chart provided states that plug loads account for approximately 19% of a buildings electrical usage which comes in second for highest electrical consumption right behind space heating. With that being said these loads can be met with a fairly small on site power system such as PV panels.

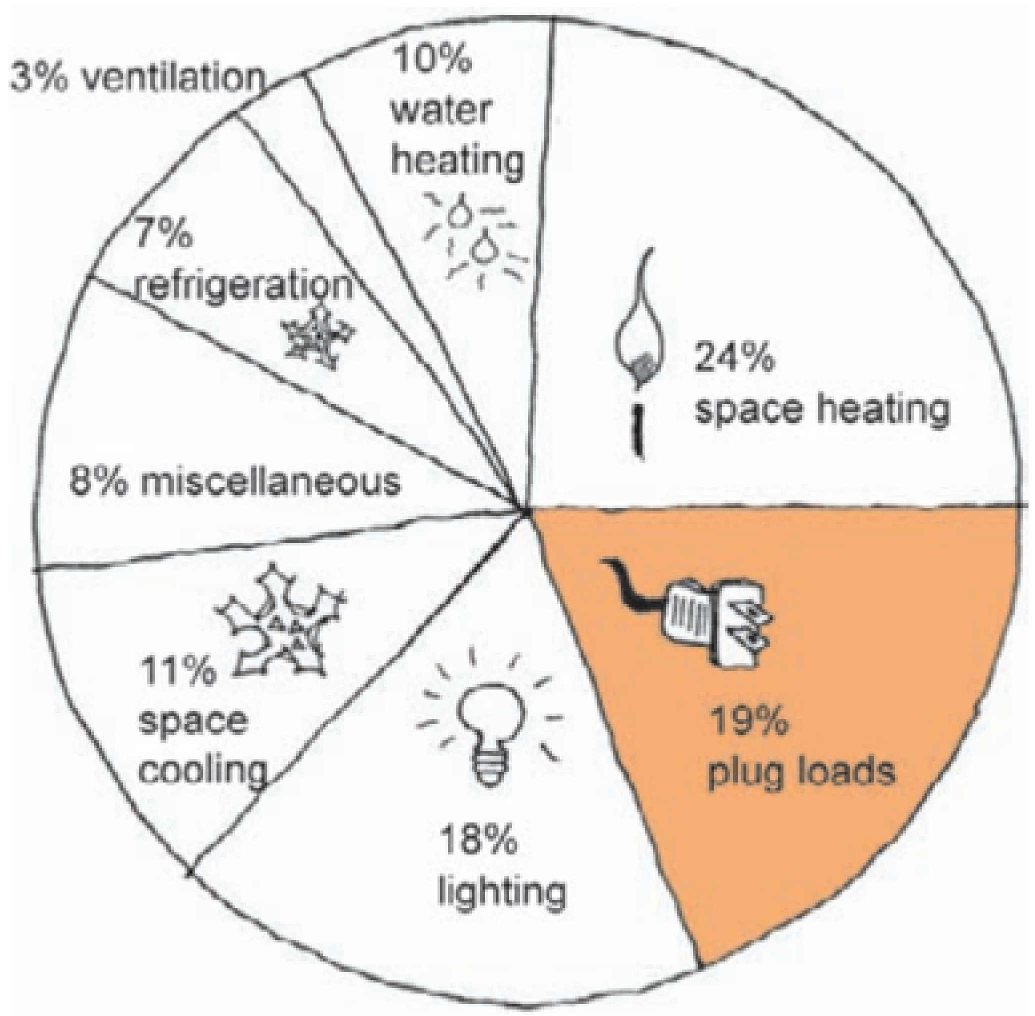


Figure 17- Electricity Consumption Pie Chart

The book goes on to talk how plug loads contribute to the overall cooling load of a building. The equation says that for every watt of a plug load it contributes 1 watt of cooling load. The book then goes on to describe how to estimate a building's plug load to accurately size the onsite power generating system and also the cooling system of the building. It describes "phantom loads" which consists of appliances that continuing to draw a small amount of power even when they are turned off which increases energy consumption and accounts for wasted energy.

To estimate the kilowatt hours for the buildings plugs you first have to create a list of all the typical appliances that will be used in the building and determine their respective wattages. These are typically found one the appliance themselves. Then estimate the number of hours each appliance will be used in a typical day and multiply it by the wattage. Don't forget to include phantom loads in this estimation. The sum of these numbers is the kwh of a typical day and can be calculated out for the year. The list is typically sorted in decreasing order of magnitude of daily energy consumption.

While this part of the book goes in depth on describing what plug loads are and how to calculate them. It doesn't describe any strategies on how to reduce these loads besides using energy efficient appliances. While this is a simple thing to do it doesn't provide any further strategies and is limited in on its effectiveness without any detail on these appliances. A further look into this topic will be required in order to flesh out this part in the design. There is a mention of reducing plug loads in the earlier case study on the Bullitt Center where they reduced their plug loads by 78% using cloud based servers and a few other strategies.

Structural Insulated Panels

This last article discusses Structural Insulated Panels or SIPS. It describes these as "an insulating core element sandwich between two skins". It's a structural element where the skin acts in tension and compression while the rigid insulation handles shear and buckling. The authors state that these panels are typically constructed with expanded polystyrene or EPS and oriented-strand board or OSB. The panels are premanufactured and can be custom made to fit a project which means they can be put up quite fast. A typical panel is 4 to 8 feet wide and 8 to 24 feet long going up at 2-foot increments. The thickness varies depending on the R-value needed, but since this project will be pushing for the maximum efficiency possible the 12.25-inch panel will be used which is the thickest one offered. This will yield an R-value of 41 compared to a stick framed wall of the same thickness yielding an R-value of 20.

In this next part they talk about the benefits of SIPS. These panels have been proven to be more energy efficient than standard stick framing due to thermal bridging. Since there are limited studs there is little thermal bridging. They also say that they are stronger than typical stud framing claiming that homes built this way have survived tornadoes and earthquakes. Another benefit is that SIPS are resource efficient. OSB typically comes from tree farms which are abundant in northern Minnesota, and EPS is made without ozone damaging CFCs or HCFCs. One design consideration mentioned in the book is make certain there is adequate ventilation due to the reduced infiltration from the walls.

Judging from these benefits this material fits very well with the philosophy of my project. They can be used for both exterior walls, roofs, and floors. When constructed properly it creates a completely sealed envelope allowing for minimum heat loss. This is a very versatile material as well as efficient. This construction method is growing, and I see no reason why it shouldn't be used in this project.

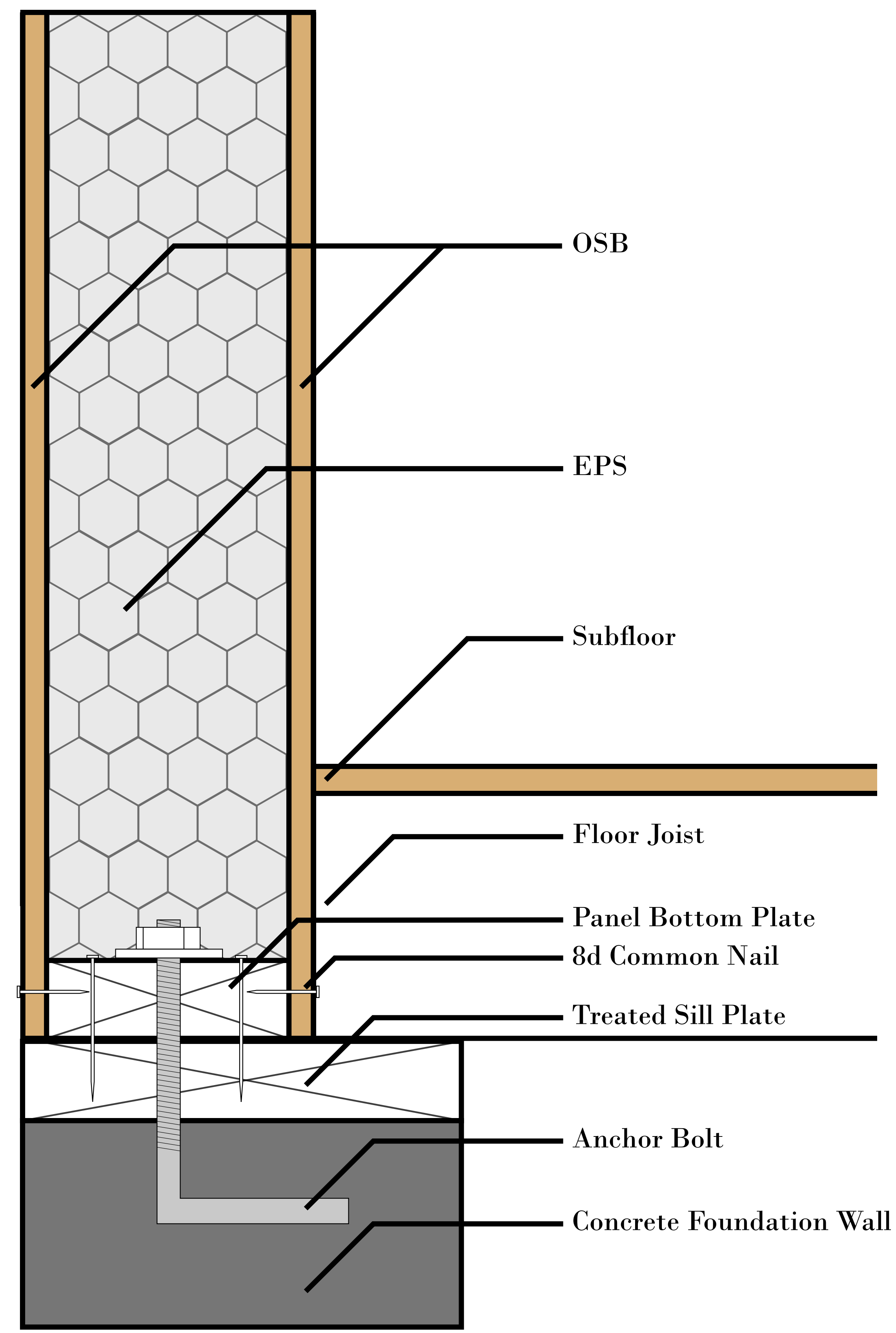


Figure 18- SIP Wall Detail

Constructed Wetlands as a Sustainable Wastewater Treatment Method in Communities

By: Z. ElZein, A. Abdou, and I. ElGawad

The paper "Constructed Wetlands as a Sustainable Wastewater Treatment Method in Communities" is written by Z. ElZein a teaching assistant, A. Abdou a professor, and I. ElGawad an associate professor who are all a part of the architecture department at Helwan University in Cairo, Egypt. In this paper they discuss the importance of safe drinking water for a city as well as public green spaces which are being lost to other construction developments.

The authors put their focus Egypt and its growing population concentration in the Nile Valley and Delta. The country is trying to redistribute this population, but outside of this area is water scarcity. Because of this Egypt is searching for a way of conserving water and the solution these authors propose using constructed wetlands to utilize the natural processes involving wetland vegetation, soils, and the associated microbial assemblies to assist in treating wastewater. This is proposed as an alternative to costly infrastructure.

While this paper is talking about using this in a different climate, the variables are still the same. The difference between my project and theirs is that their water scarcity is urgent and they have no control over it while mine is by choice. While they are talking about doing this at an urban level mine will be at a much smaller scale.

After presenting the need for safe drinking water and offering a solution, they go into detail and break down exactly what a constructed wetland does. Constructed wetlands is considered a holistic approach, integrating wastewater treatment, flood protection, and storm water management. Grey water is typically first collected into a primary treatment system such as a septic tank and is then brought to the wetland through the inlet where it passes through the filter media, allowing solids to settle. This water then comes into contact with bacterial populations on the surface of the media and plant stems. Eventually after repeated cycles, comes out water that ready to be reused. It does all of this at a portion of the energy demand of standard water treatment processes. The most important feature of this system is simultaneous nitrification and denitrification. Nitrification occurs in drained wetland cells while denitrification occurs in flooded wetland cells.

In this paper they break down the oxygenation process both in words and with a diagram. The word description uses a lot of chemical names and terms that is a difficult to understand, but the diagram breaks it down quite nicely. Essentially with the use of cation exchange chemistry and thin film aeration the system accomplishes nitrification and denitrification. The water flows in and the plants go through their process and as the water flows out it removes all the nitrogen, biochemical oxygen demand, and suspended solids. This process is repeated many times over to thoroughly remove these elements.

They also discuss 3 different types of constructed wetlands and each has their pros and cons. The first one discussed is the surface flow constructed wetland. This one is the cheapest to construct, but it also takes up the most amount of land. To adequately handle the water demand it needs 5-10 m2 (54-108 ft2) per person. The second one which is the vertical subsurface flow wetland acts as the counter to the previous type. While this one is more expensive to build, it uses a fraction of the land at 1-2 m2 (11-22 ft2) per person. The last one described as a horizontal subsurface flow constructed wetland acts as the middle ground between the other two. It needs about 3-5 m2 (32-54 ft2) per person. With this information in mind I am leaning towards using the surface flow constructed wetland because the site I have chosen does not limit me for space.

They also break down the cost these systems compared to another popular low cost and low maintenance water treatment system described as an activated sludge system. Their results show that the average investment cost for a constructed wetland was 110 €/p.e.* or $125/p.e. and for the activated sludge system was 190 €/p.e. or $216/p.e. As for the operation costs, constructed wetlands cost on average 1.30 €/p.e. or $1.48/p.e. annually while the activated sludge system cost 6.50 €/p.e. or $7.39/p.e. annually. This mean that constructed wetlands not only cost less to construct, but also have a lower operating cost. This technology is a very versatile system at a third of the construction cost of a conventional water treatment system and a quarter of the maintenance cost. On top of this they are more durable as they have almost no moving parts resulting in a typical life span of 15 years minimum. With the statements said in this paper I believe there is no reason not to use this technology in my project. Not only will it save water, but it also provides green space for the public to use.

* Population equivalent or unit per capita loading, (PE), in waste-water treatment is the number expressing the ratio of the sum of the pollution load produced during 24 hours by industrial facilities and services to the individual pollution load in household sewage produced by one person in the same time.

Project Justification

This project is significant to me because of my fascination with the outdoors. This fascination came about growing up in rural northern Minnesota where there is nothing else to do but go outside. Lots of memories were made in nature and I want to preserve those memories as best as possible by preserving where they took place.

This thesis project is important at this stage of my academic development because this topic requires a very in-depth analysis and research that I am only capable of fully doing at this stage. It requires everything I have learned up till now and also the work ethic I have built through many projects.

This project is important for my professional development because it teaches me how to design in a way that integrates many systems together into a cohesive whole which many designs in the professional world already do.
On top of that many firms are going towards if not have already adopted a sustainable design mindset and with this study and design it puts me one step ahead of the field.

This project has taught me many things as far as sustainable and beyond sustainable design goes. Not only have I learned about the vast variety of technologies used in the industry, but I have also learned about the various practices and values that go into creating a truly integrated and regenerative design.

One of the biggest things this project is giving as far as skills is truly thinking about where our power comes from and how it is used. I have learned the basics as well as beyond the basics about correct wall assemblies, thermal bridging, solar heat gain, etc.

Because the industry is moving towards green building and "LEED" design, it makes the project very relevant and important to the profession because it sets a precedent or gold standard on how buildings should be designed. While going the LEED route is good, this project shows that it just isn't far enough.

This project is important as an academic exercise because it makes you think in a different way. Not only are you designing for the people inside butt you are also designing for the environment around it. This other variable should be crucial in everyone's academic life because the impact of what we do on the environment is so great. With even a base knowledge of what this exercise is accomplishing, a real change can be made on the environment from the built world.
How this project is justified economically is a tricky question to answer because most people only look at the initial building cost and ask why someone would build this if it costs more at first to build. The average cost of a regenerative design will initially cost about 15%-25% more to construct than typical construction. The reason to spend this extra money is because the initial construction only accounts for 25% of the buildings overall life cycle cost with the other 75% being broken down between maintenance and utilities. With regenerative architecture we can reduce these costs significantly and over time make up this extra cost and even save money in the long run by reduction of heating, electrical and water costs.

The plan for the funds is to come from a grant of some sort from the state of Minnesota through the Department of Natural Resources. Minnesota is a progressive state and as proven through its various state parks that it is environmentally conscious and would want to conserve one of the states more important resources through a project like this.

The environmental impacts of this building will be significant and the most crucial part of the design. This project aims to improve the environment around it through low impact energy usage, carbon sequestration, and reintroducing water back into the ground. This project aims to leave as little of a footprint as possible but impact the environment is significantly positive way.

The technologies that will be implemented into the design are vast and varied. While each of them has the one goal of creating a regenerative design, they will be accomplishing them in different ways. None of the technologies I am using go against the philosophy iterated throughout the design.

This project is important in the social context because it is a public space where people can come and learn why and how it was built which spreads the philosophy of the design. The building aims to be viewed as the gold standard of green design and how every building should be created.

The site was chosen because of its adjacency to boundary waters canoe area. This area adopts the same philosophy as the project which is to leave the natural environment the way you found with as little of a footprint as possible. The boundary waters is all about preserving what is already there. When staying there you are forced to work with nature instead of fighting against it which is what this project is all about.

Like I have stated before this project contributes to the profession because it sets a precedent or gold standard of what a green building design should be. People will be able to use this building as a case study for their own designs to improve on the environmental impact.
While the research center itself is not imperative, the idea behind the design of regenerative architecture is. As described in the proposal this will be crucial in the overall health of our environment in the near future. The research center acts as a vehicle to carry the idea of regenerative architecture into solid form.

This project could definitely be solved by someone else in the profession and I hope it does, but it would take a special kind of person to put the effort in. This person would have to as passionate about ecofriendly design as I am in order to do this. In a way, I hope others do solve this problem. I hope that from my research, others can come along and redefine and improve upon regenerative architecture. I am doing this work so others after me do not have to reinvent the wheel. This research provides the foundation, so this line of thinking can advance by leaps and bounds.

Historical Context

While the philosophy of regenerative architecture has been gaining steam over the past decade, the idea orginated over 40 years ago from a landscape architecture profesorr named John Lyle. He challenged he is students to"envision a community in which daily activities were based on the value of living within the limits of available renewable resources without environmental degradation".

Over the next decade, his students and fellow faculty researched and designed ways of creating a community that made use of on-site resources, operated with renewable energy, and worked with biologically based processes. A few of these faculty came together started an institute that would offer a holistic and cooperative model of community development. This institute was later named the John T. Lyle Center for Regenerative Studies.

Figure 19-John T. Lyle Center for Regenerative Studies

John T. Lyle taught at Cal Poly Pomona and was one of the founders of the Center for Regenerative Studies. He graduated from Tulane University in 1957 with a bachelor's degree in architecture, and in 1965 completed his graduate studies in landscape architecture at UC Berkeley. He began teaching at Cal Poly Pomona in 1968 primarily teaching landscape architecture and urban design. In 1971 he became the program director.

After winning several awards throughout the years and teaching the 606 studio which had students work with real clients, he retired in 1997. He continued working on various projects with the most notable being the center that was eventually named after him. He is also known for writing for writing two influential books that paved the way for regenerative design. The first was Design for Human Ecosystems written in 1985 and the second was Regenerative Design for Sustainable Development written in 1994.

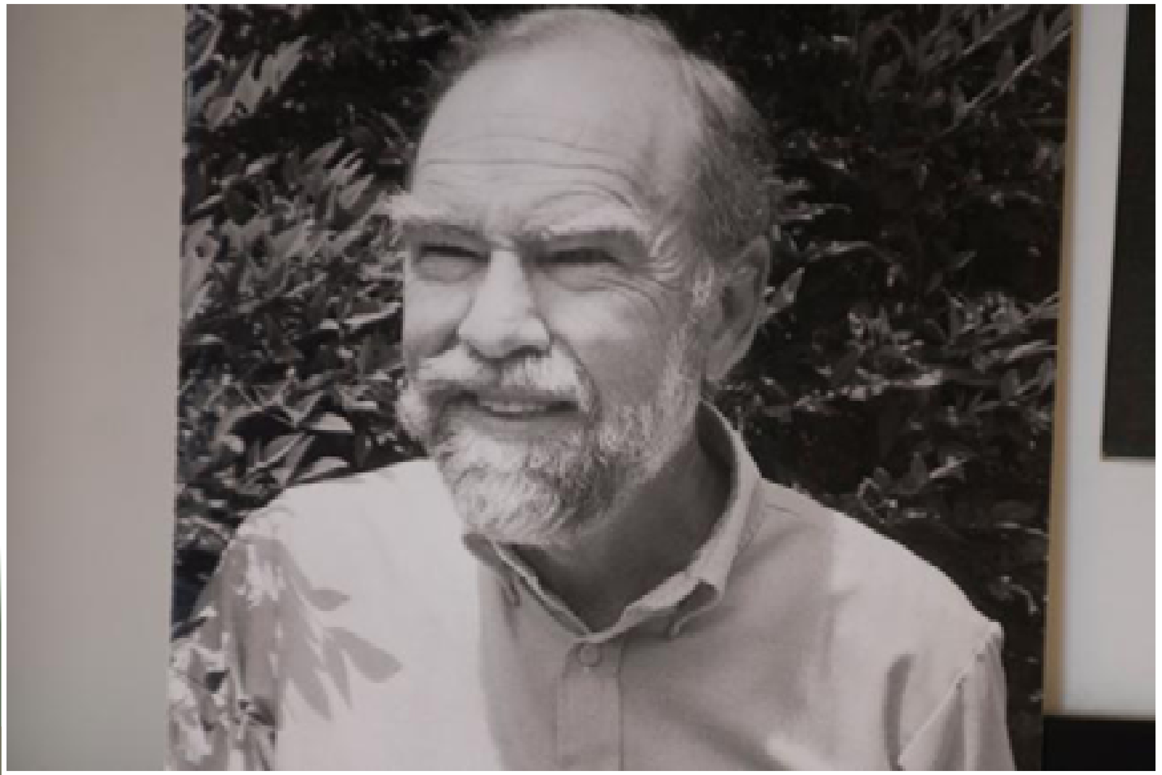


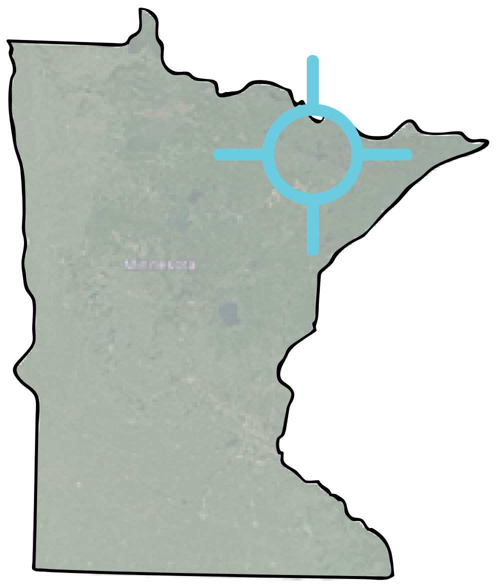
Figure 20-John T. Lyle


Figure 21- Center Site Plan


Figure 22- Center Constructed Wetlands


Figure 23- Center Solar Arrays

Site Anaylisis



The site is located just east of Ely which is in northern Minnesota

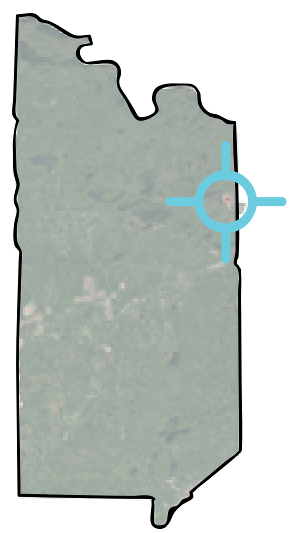


Figure 24-Vacinity Map

Figure 25- Road Map with Points of Interest

The site is located right next to the International Wolf Center just east of Ely. The site has one enterance off of Highway 169. This road sees lots of traffic because it is the main road for campers to go from Ely to the rest of Boundary Waters.

Site Narrative
Site Visit - June 30th, 2018

This summer I took a camping trip with my siblings to Boundary Waters Canoe Area or BWCA. It is my third time going, but the first two times were when I was young. I needed to get a feel for the place again with fresh eyes. I had already decided my project would take place in the area, but I hadn't chosen a specific site. This trip was designed to help me get the lay of the land and capture the essence of Boundary Waters as a whole.

To say you're camping in BWCA is a broad statement. It stretches over 1,090,000 acres with nearly 20 percent of it water. This suggests there are quite a few camp sites and many things to see. With that being said, most trips start out the same way and that's through the little town known as Ely.

As you enter the town you get a sense that you're truly up north. Log sided business line the street and every other store is either a bait shop, camping supply store, or knick-knack shop. This town survives off tourism. While there were many Minnesota license plates lining the streets, there were just as many out of state plates with the farthest one being from Georgia.

Once you leave town it's at least a 45-minute drive on small winding roads to get to an access. This part of Minnesota is on the southern edge of the boreal forest biome. This means the whole drive is weaving around lakes and trees. The trees are so thick you can't see more than 10 feet in. The forest mainly consisted of red and spruce pine mixed in with a few tamaracks. It felt as though you were driving through a tunnel because of the canopies overhead.


Figure 26- Downtown Ely


Figure27- Further Downtown Ely


Figure 28- Road to access

Site Narrative
Site Visit - June 30th, 2018

Once we got to our outfitter we were equipped with canoes and paddles and we were ready to take off. Many of these lakes are chained together through small channels or are only separated by a small gap of land short enough to portage over. The journey started out on Moose lake and the camp site was 3 miles up the chain on Sucker lake. The terrain there is very rocky with cliffs sometimes upward of 40 feet lining the shore. Many rock outcroppings poked through the water and some were large enough to be considered islands. This part of Minnesota has large deposits of iron and it seeps into the water making it a rusty color with low visibility.

The shoreline has many bends to it and can be confusing trying to find the campsite on the map. Half a dozen times I thought the site was right around the bend to only find yet another corner to go around. After a 3-hour canoe ride the campsite was found, and we began to set up shop. The DNR has one rule they take seriously, and it is to leave the site how you found it. This means no cutting down live wood or leaving trash behind. A site typically consists of a fire pit equipped with a grill rack, a bear box to store food away from bears, and flat sandbox to put a tent down. The ground was comprised of a variation of a thin layer of topsoil over rock and exposed rock. Other than the clearings for the tents and firepit, everywhere you look is covered by dense tree cover and shrubbery. This makes hiking quite slow and difficult. Canoeing is the preferred method of travel and sightseeing. The lakes contain many islands both large and small to encourage exploration and are easily accessible. A few of the islands have high cliffs offering great views over the lake.

Through this whole experience you get the feeling that you are in a different world. It's a place that civilization hasn't touched, and it aims to stay that way. It's a place for people to escape. There is no cell service and there is no electricity, so it is just you and your surroundings. Thankfully the BWCA offers many things see and discover.


Figure 29- Campsite


Figure 30- Campsite #2 Firepit


Figure 31- Cliff

Site Narrative
Site Visit - November 10th, 2018

It is now my second time visiting the little town of Ely this year. The first time was in the summer during the busy tourism time and now the town has different feel as winter creeps in. The streets are not yet covered in snow but they don't have the same liveliness they had just six months ago. While I still saw out of state license plates, this time they were few and far between. In this transition between summer camping and winter fishing, I was able to catch the town in temporary lull.

The site I have chosen is located just east of the town. The road leading to it is easy to miss because there are no signs and it's a small gravel road. The road goes up a hill surrounded by trees to open up to a vast clearing on the north side. I estimate it to be about 2 acres or so. The ground is made up mostly of gravel and a few small plants. At the edges of this clearing is mix of white pine, jack pine, and cedar trees making a thick wall difficult to see through.

As I walked to the west side of the clearing I saw that this edge was trimmed down to make room for power lines. Further in there is a chain link fence marking the end of the property. On the other side is the International Wolf Center and the chain link fence is part of the wolf enclosure. I made note that a connection between the two buildings would be an interesting design opportunity.

Along the south side of clearing there is a trail that leads to a gravel road used for residence that live back there. Besides the trail the south side makes a good portion of the trees on the site. There were a few deer trails winding around, but other than that this side didn't offer much interest. As I went along the east side I noticed there was a small drop off that lead to a clearing. As I got closer to the clearing I saw that it was actually a pond and quite a big one. There was a house across on the other side and another to the south. This pond provides a perfect opportunity to implement a constructed wetland with the pond being used as the holding tank for the treated water. I have thoughts of designing a path down to the pond, but it will be difficult to get around the trees tightly packed together. Overall this sight is large enough to handle what I have in mind and offers quite a few exciting design opportunities.


Figure 32- Wolf Fence


Figure 33- Southern Trail


Figure 34- Pond

Site Narrative
Site Visit - November 24th, 2018

After walking around my site, I figured it would be important to check out the surrounding area. Since the International Wolf Center was next door I assumed it would be entertaining as well. As you walk in you are greeted by a lobby and gift shop. The interior of the building consisted mostly of knotty pine giving it warm and cozy feel. The structure looked similar to that of Thorncrown Chapel with the high exposed crossing rafters. Along many of the walls were small triangular window placed close together to make a larger window. Adjacent to the lobby is the dark exhibit where they have a large taxidermy display with smaller displays lining the outside of it.

A hallway off of the lobby brings you to the next part of the center which has the light exhibit, theater, and classroom. The light exhibit was smaller than the dark exhibit and had a temporary display on one side with a large window with seating on the other. From this window you can almost see the wolf enclosure. The light exhibit space was only slightly larger than the hallway before it and acted as circulation into the last room which was the auditorium.

The auditorium had stadium seating along the north wall that could hold approximately 40 people for a presentation. The south wall was essentially three large viewing windows looking out over the wolf enclosure. The main enclosure is about an acre and a half and holds six fully grown wolves. On the east side there is a smaller enclosure called the retirement enclosure that holds three more wolves that are too old to be with the rest of the pack.

The site that was chosen was picked specifically because of its proximity to this center. The center has a similar objective as my project albeit more specific. A connection between the two is a priority and will make for an interesting design concept.


Figure 35- IWC Structure


Figure 36- Dark Exhibit Display


Figure 37- Auditorium

Climate Data

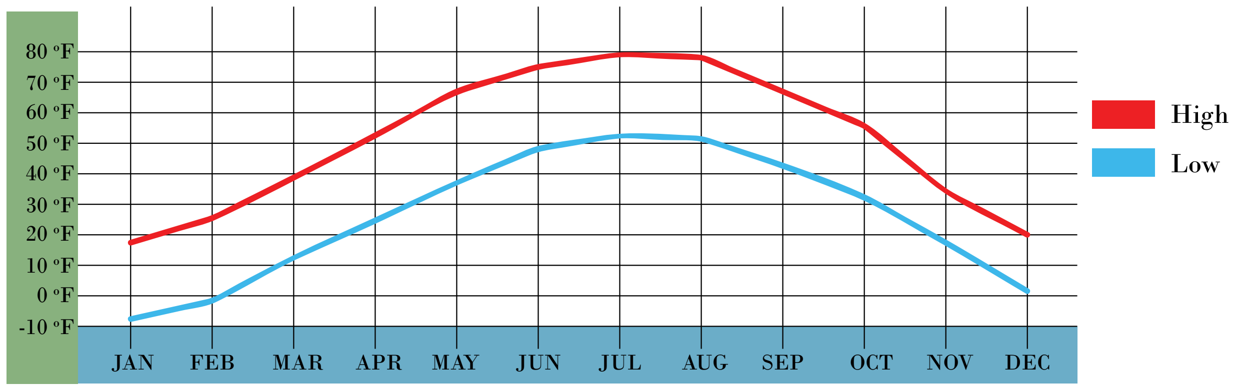


Figure XX- Average Monthly Temperature

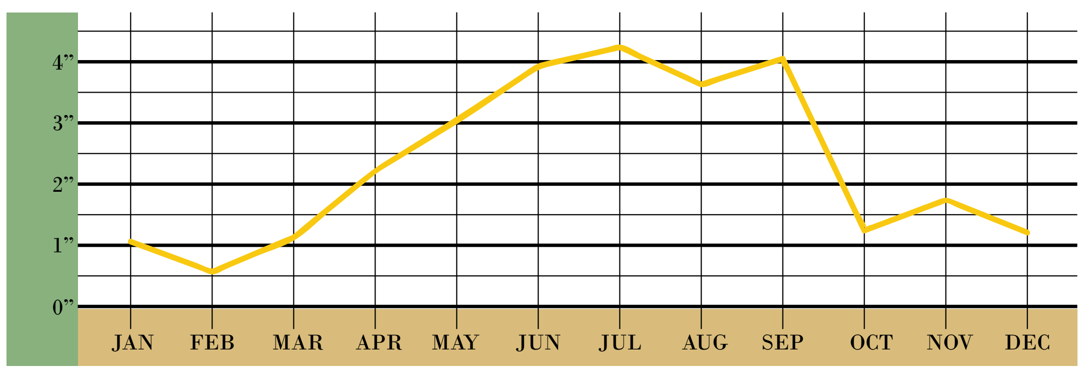


Figure XX- Average Monthly Precipitation

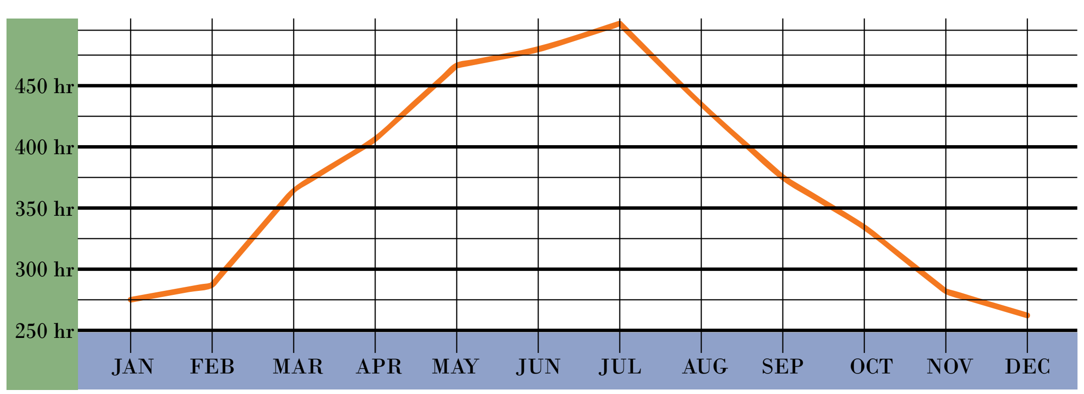


Figure 38- Average Monthly Hours of Sunlight

Soil Data

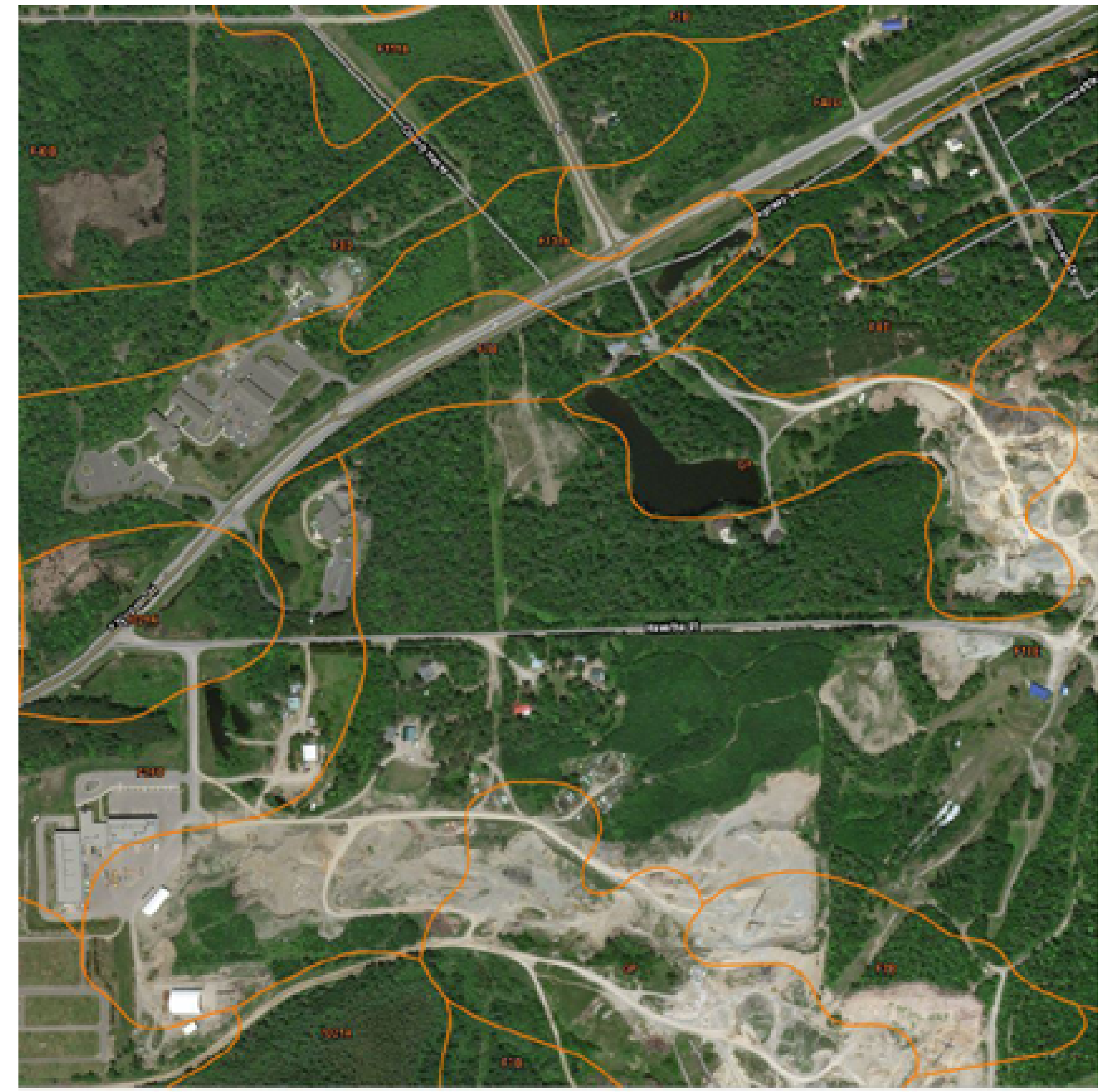


Figure 39- Soil Map Showing Slope and Soil Types

GP- Pits, gravel-Udipsamments complex
F40B- Rollins cobbly sandy loam, 2 to 8 percent slopes
F151A- Tacoosh mucky peat, dense substratum, 0 to 1 percent slopes
F8D- Biwabik-Graycalm-Friendship complex, pitted, 0 to 18 percent slopes
F7B- Biwabik-Graycalm complex, 1 to 8 percent slopes
1021A- Bowstring and Fluvaquents, loamy, 0 to 2 percent slopes, frequently flooded
F10E- Cloquet-Pequaywan complex, pitted, 0 to 45 percent slopes

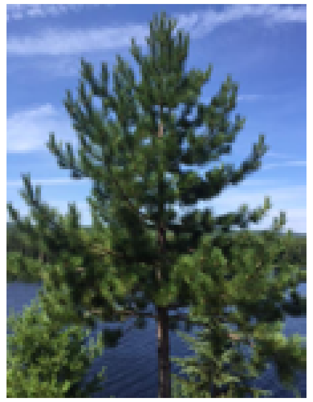
Vegitation

This area is home to thousands of species of plants so to cover all of them would take more time than is given and is a research topic all on its own. For this part of the site analysis it will be breaking down the most common plants.

White Pine

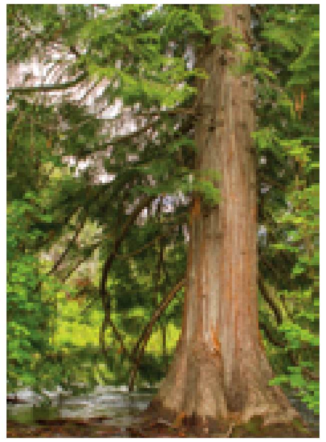
The white pine grows quite large up to 180 ft and can get up to 3ft-5ft in diameter. this tree dominates the landscape. The soft needles come in clusters of 5 and make a thick bed underneath the tree allowing few plants to grow underneath. The peaks of these trees are a common home for bald eagle and osprey nests.

Red Pine



The red pine is the second most common tree in this area and also grows similar in size. They are distinguishable from the white through their needles which are longer and come in clusters of 2. In denser forests they are known to prune themselves and only have living branches on the top third of the tree.

Red Cedar



The cedar has flat groupings of scaly leaves or needles. Cedars love low-lying wet areas especially near rapids and shorelines. It is a dense and slow growing tree that will only grow into a bush if it is poor soil conditions. This wood is known for its resistance to rotting.

Red Osier Dogwood

This plant commonly grows in areas of damp soil such as near wetlands. It is a deciduous shrub growing anywhere from 5ft-13ft tall and 10ft-16ft wide. It is frequently used for waterway bank erosion protection and restoration in the United States and Canada. Its root system provides excellent soil retention.

Bunchberry

Bunchberry is a low lying shrub that creates a carpet like mat across the ground. It is a hardy plant that covers much of is this area. The flowers produce small berries that are edible and taste similar to an apple. These are popular for birds to eat.

Big Bluestem

One of the few predominent grasses in this area is the big bluestem. It ranges anywhere from 2ft-7ft tall and is found in open forest areas in dry soil. This grass covers most of minnesota and is typically known as a prairie grass, but it has made its way up to north.

Topography Map

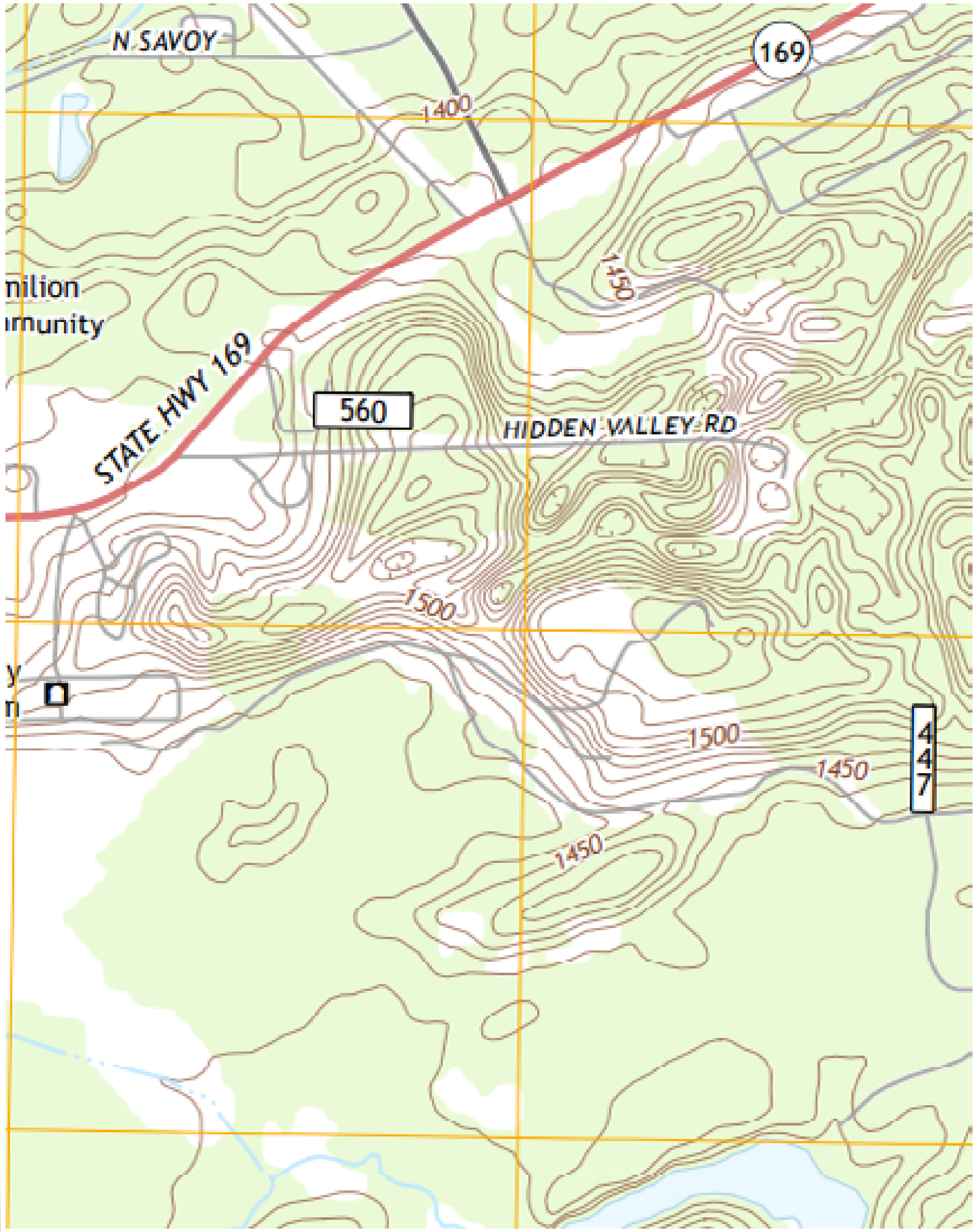


Figure 40- Soil Map Showing Slope and Soil Types

Net Positive Water

Water Production:

Net Positive Water is goal for a design to collect more water on site than the building can use. This can topic can be broken down into two parts: water production and water consumption. Water production is a variable that will change from month to month depending on the time of year. During the springs months Ely tends to have more precipitation than during the fall months. During the winter even though precipitation is quite heavy, it will be more difficult to generate that into useful water due to it being frozen. Ultimately the amount of water will be measured by the gallon on an annual basis, but this can also be broken down into a month by month basis as well to get a more accurate depiction of what is going on. This will be measured by a meter coming from the onsite water collection device that will be monitored closely. As far as trying to analyze how it will perform before it is constructed, this will be accomplished by estimating how much water a building needs based off its building type and square footage that it shares with similar buildings. We can then determine how much is needed to be collected from perception, fog catchers, etc... and what will be needed to be taken from the local water supply.

Ideally the goal is to meet all the buildings water needs just by harvesting from the site without having to use outside sources such as the city's water supply or a well as well collect enough to be able to disperse the surplus back into the groundwater system. There is a pond on site, but that is not in consideration of being used because it will be utilized in the water recycling process with the proposed constructed wetland. While I don't believe a building of this size can be supported solely from onsite collection, the second part of this topic discusses reduced water consumption to try to bring that water need down.

Water Consumption:

As said before this is a two-part topic. In this part we aim to reduce the usage of water down to an amount to where our onsite water collection can sustain the need of the building. The measurement that will be used is again gallons per year but can be broken down month by month. This will be accomplished by measuring the output of grey and blackwater with a meter excluding the grey water that will be transferred to the proposed constructed wetland because this water will be recycled and used again in the building. For the analysis I will estimate the average annual water use of a similar building with normal market plumbing fixtures and compare that same building as if it had the proposed water efficient fixtures. I will take that number and subtract the amount of water that will be filtered through the constructed wetland and this will generate the buildings actual annual water usage. The goal is to reduce the amount used to the point where the onsite water collection is producing more water than is being consumed achieving the overall goal of Net Positive Water.

Total Water Consumption = Grey Water + Blackwater - Grey Water to Ponds

Net Positive Water = Total Water Consumption < Total Water Collection

Net Positive Energy

Energy Production:

This is going to mirror a lot of ideas talked about in the previous criteria about Net Positive Water. This topic will be split into two parts consisting of energy production and energy consumption. The objective is to produce more energy onsite than what is consumed. Whatever energy is left over (electricity in this case) will then be kicked back to the grid or sent to adjacent buildings. This type of criteria is normally measure in kilowatt hours (kwh) and is measured monthly.

There will be two proposed sources of energy production consisting of both wind and solar energy with the emphasis on solar. To calculate the needs of the building I will first have to analyze how much energy the design will require and then calculate how the square footage of PV panels that will be needed to produce that amount. This is accomplished by researching how many kwh per square foot the proposed PV panel can produce and then is multiplied to fit the needs of the building. If the space required is larger than what can be accomplished on the site, wind turbines will be implemented to supplement the energy need.

$$\text{Total Sq. Ft. of PV Panels} = \frac{\text{Electrical Load (KWH)}}{\text{KWH Per Sq. Ft. of PV Panel}}$$

Energy Consumption:

While energy production has a straight forward way of measuring by calculating raw electrical output, energy consumption has many different facets which each need to be measured individually and then added up to calculate the total energy reduction on the building which will be translated into electricity used or kwh. Reducing energy consumption can be broken down into two different categories with many strategies being implemented in this design for each. They include thermal efficiency which will be measured by heating and cooling loads on the building, and the electrical load from lights, equipment, and wall plugs. The former will be analyzed using energy modeling from Revit to determine the heating and cooling load for the heating and cooling system. From there I will calculate how much electricity these systems require to operate at an adequate level. The latter will be measured by calculating the total electrical load of all lights, equipment, and wall plugs based on the building being in use ten hours a day. I will then add the electricity consumption from both categories and compare that amount the amount of electricity produced. If the amount produced is higher than the amount consumed, then the goal of Net Positive Energy. The numbers for water production, energy production, water consumption, and energy consumption will be collected by a computer and put on display for the public to see.

Total Electrical Load = Heating/Cooling + Lighting + Equipment + Plug Loads

Net Positive Energy = Total Energy Consumption < Total Energy Production

LEED Platinum

LEED is the most widely used green building rating system in the world with LEED Platinum being their highest rating. The rating is based off the total score achieved from the checklist provided on their website. Only six percent of all LEED accredited buildings have reached platinum status, and this is an achievement that would get this design recognized by the community. After the design is finished I will go through the checklist and score the design to determine if it is qualified to be considered LEED Platinum.

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Y	?	N			
			Credit	Integrative Process	1
29	0	0		**Location and Transportation**	16
16			Credit	LEED for Neighborhood Development Location	16
1			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
5			Credit	Surrounding Density and Diverse Uses	5
5			Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1
6	0	0		**Sustainable Sites**	10
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
3			Credit	Rainwater Management	3
2			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1
9	0	0		**Water Efficiency**	11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
2			Credit	Outdoor Water Use Reduction	2
6			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1
32	0	0		**Energy and Atmosphere**	33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
6			Credit	Enhanced Commissioning	6
18			Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
2			Credit	Demand Response	2
3			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
2			Credit	Green Power and Carbon Offsets	2
0	0	0		**Materials and Resources**	13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2
6	0	0		**Indoor Environmental Quality**	16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
1			Credit	Thermal Comfort	1
2			Credit	Interior Lighting	2
3			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1
5	0	0		**Innovation**	6
5			Credit	Innovation	5
			Credit	LEED Accredited Professional	1
0	0	0		**Regional Priority**	4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
87	0	0		**TOTALS**	Possible Points: 110

;0 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Figure 41- LEED Scoring Chart

Room Spaces and Sizes

	Small Sq. Ft.	Average Sq. Ft.	Large Sq. Ft.
Lobby/Gift Shop	1,275	1,500	1,725
Dark exhibit	1,275	1,500	1,725
Light Exhibit	850	1,000	1,150
Café	128	150	173
Classroom	281	330	380
Theatre	340	400	460
Restrooms (2 pair)	680	800	920
Greenhouse	2,125	2,500	2,875
Lab	2,125	2,500	2,875
Grad Offices (6 open)	1,445	1,700	1,955
Mechanical	340	400	460
Biologist offices (3)	1,020	1,200	1,380
Directors Office	340	400	460
Conference Room (2)	680	800	920
Server Room	102	120	138
Janitor Closet	34	40	46
Storage	187	220	253
Circulation	2,253	2,650	3,048
Total	15,479	18,210	20,942

Figure 42- Spaces and Sizes

Lobby:
Entrance to the building that allows for vistors to come and enjoy the space

Dark Exhibit:
Exhibit void of natural light and flash photography. Meant for sensitive displays

Greenhouse:
A place for researches to grow plants all year round for studies

Light Exhibit:
Exibit meant to display everything else. Typically changed often

Theater:
Area with screen that allows for presentations for 25 people.

Classroom:
A place that allows educates guests about wildife as well as the building

Space Matrix Outling Spatial Diagraming

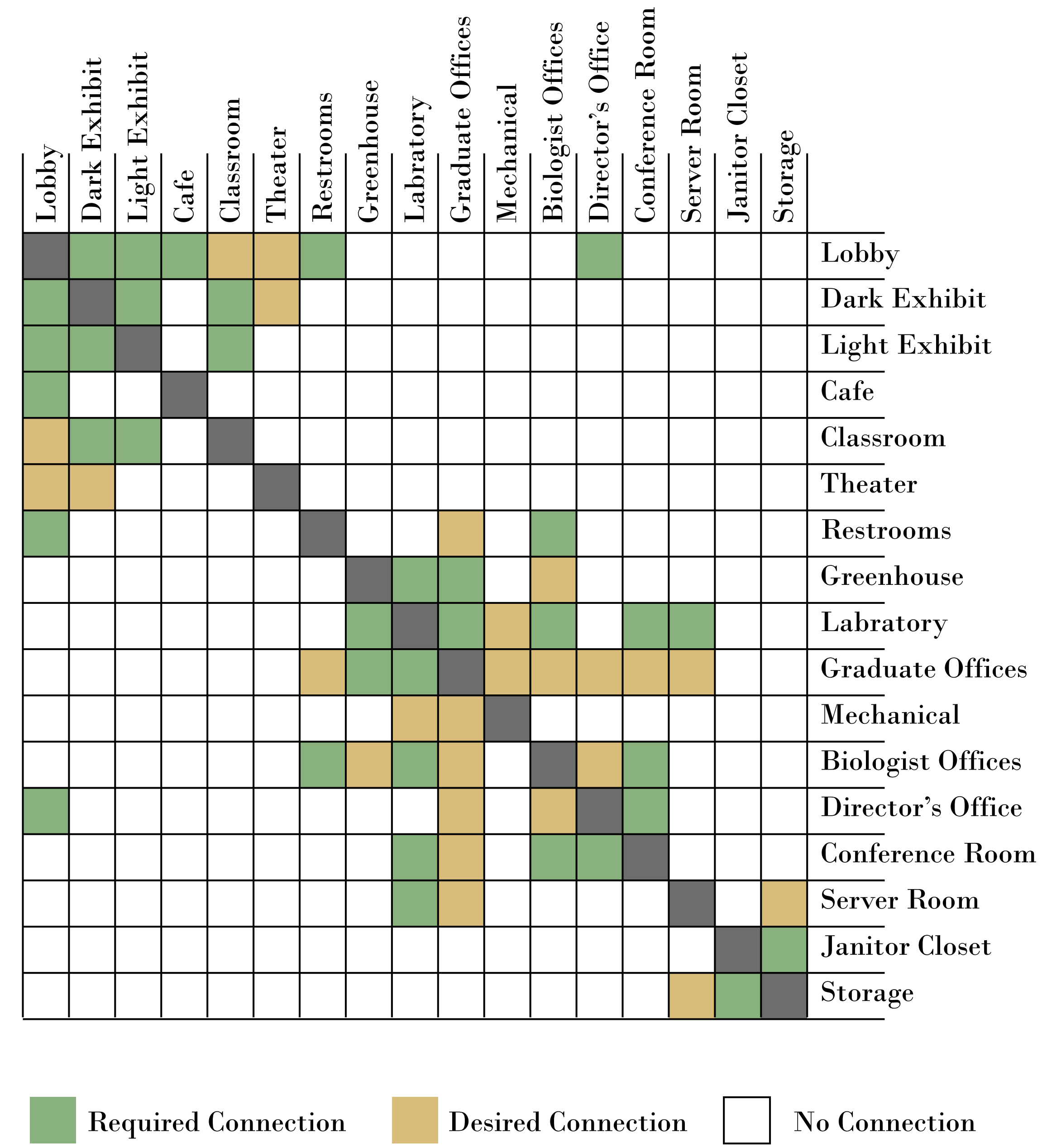


Figure 43- Space Matrix

Spatial Diagram of the Building Layout

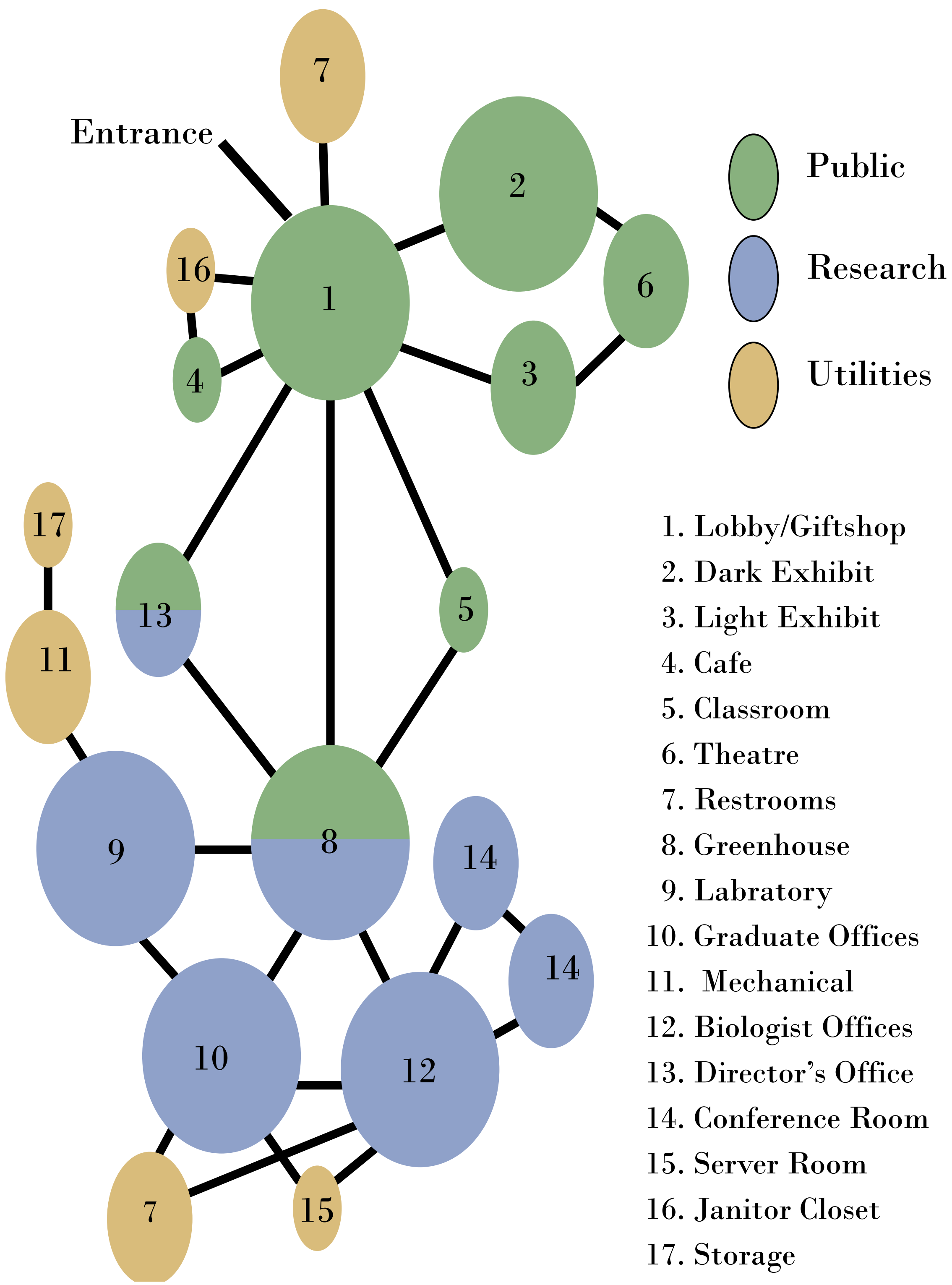


Figure 44- Spatial Diagram

Since there are two different functions of this building; first being research and the other being a public space, the spaces are laid out to somewhat seperate these parts. There are a couple of spaces that will be required on both sides because they serve both. While the layout seperates the two functions. The public will be allowed to walk through the entire building including the research side.

Executive Summary

All these criteria are all unique if their own right and are measured in many different ways. What they all have in common is the unifying idea of achieving the goal of this thesis which is regenerative architecture. Each one plays its own part in accomplishing this idea. I chose Net Positive Energy and Water because these are the meat of the design. These criteria are crucial to the success of the design and must be worked upon until the goal is met. These two criteria make up eighty five percent of what is trying to be accomplished with this project so due diligence is a must. LEED Platinum was picked for a criteria because it represents what Net Positive is doing to an extent, but also includes many smaller things that regenerative architecture represents such as reducing a smaller parking lot footprint and site development. Light quality was chosen as more of a personal goal than anything else. In past projects I have struggled to design with adequate daylighting and its hurt the project. By using this as a requirement I am forcing myself to think about daylighting all throughout the project. Laying out spaces and figuring out adjacencies early in a project creates a more cohesive floorplan and less waisted space. By doing this now it gives me an idea of what needs to go into this project and how it will fit together. Overall these goals were chosen because they can be proven with hard numbers. Numbers are not subjective therefore they cannot be argued. If these numbers work out, then ultimately this design will be a success.

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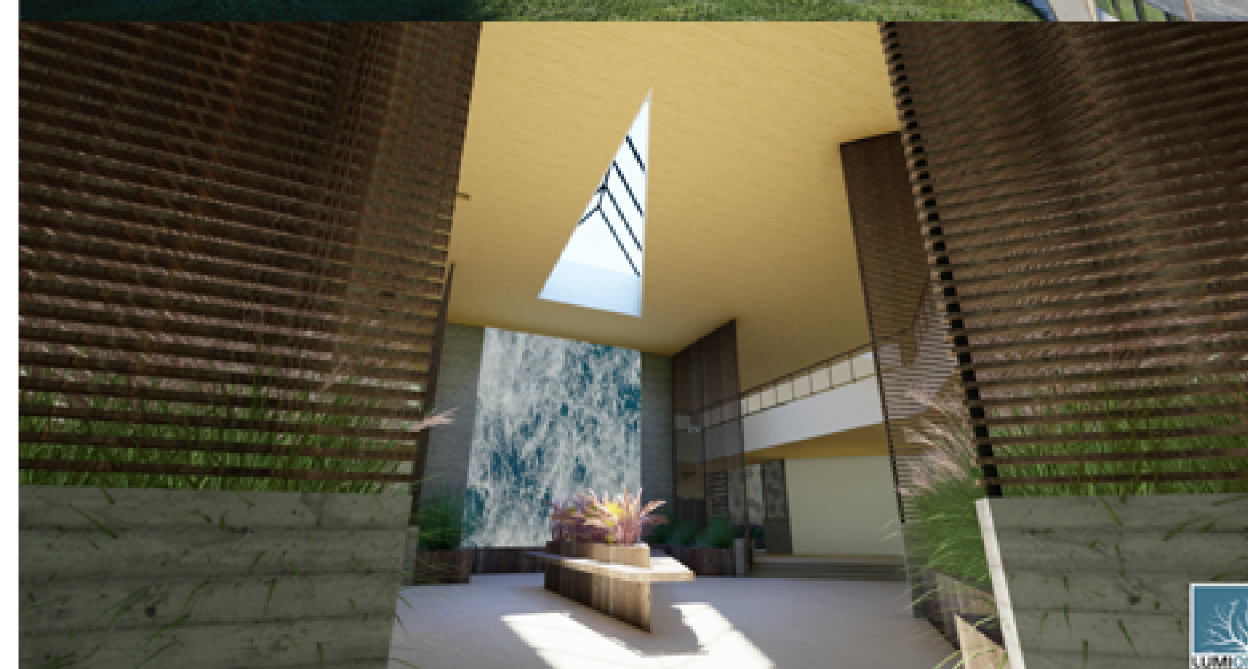
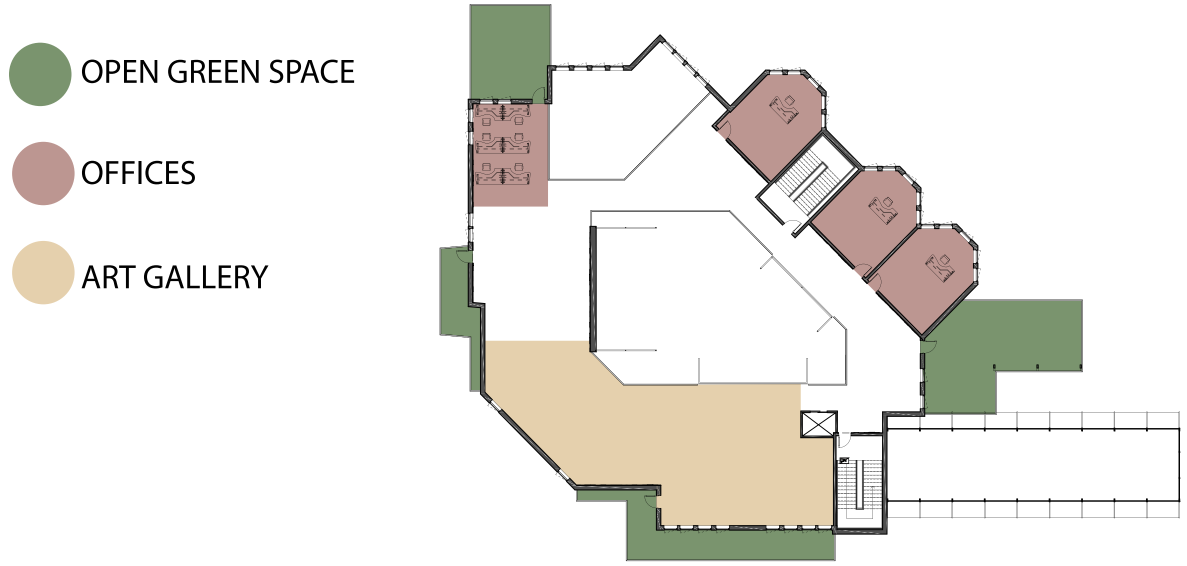
Design Solution



Site plan

Level 1



Level 2

PV Shading Device

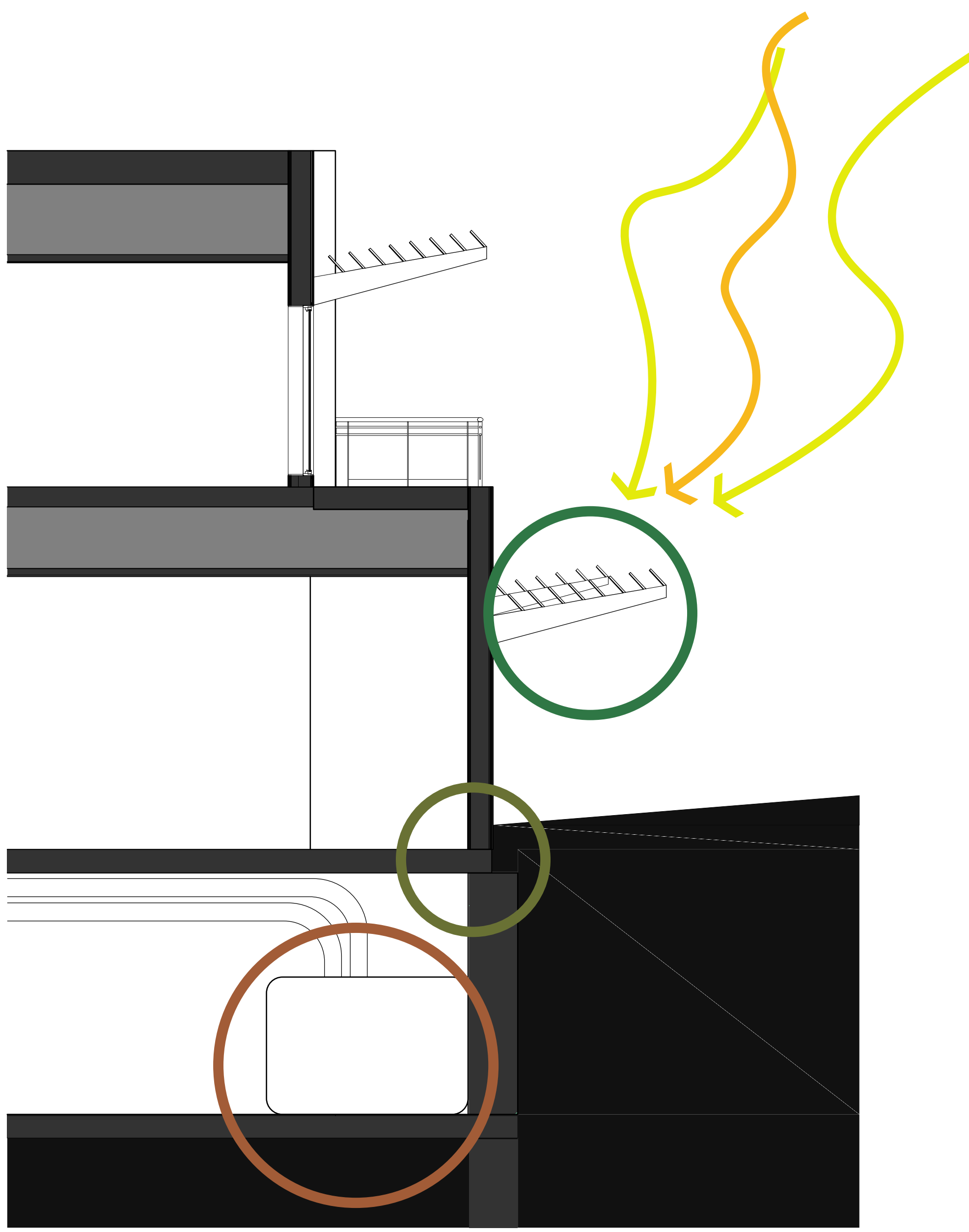
The adustable PV array doubles as both the buildings power source as well as a shading device used throughout the site.

Structurally Insulated Panels

The SIPs are used to create a sealed envelop with minimal thermal bridging which is key to thermal efficiency.

Ground Sourced Heat Pump

Acting similar to a standard heat pump, this system uses the consistent heat of the ground to heat or cool the building.



Collection

The green roof's gutter system collects rain water and is connected to a pipe that runs into the living machine.

Treatment

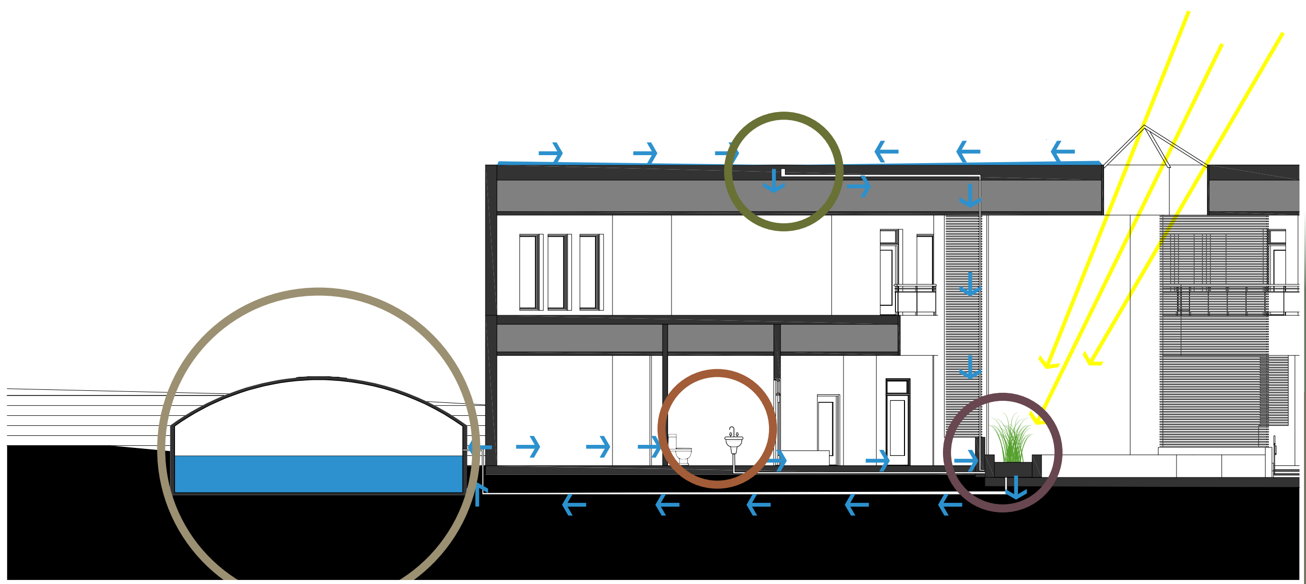
The rain water is treated through the living machine which utilizes the cleansing properties of coastal wetlands.

Storage

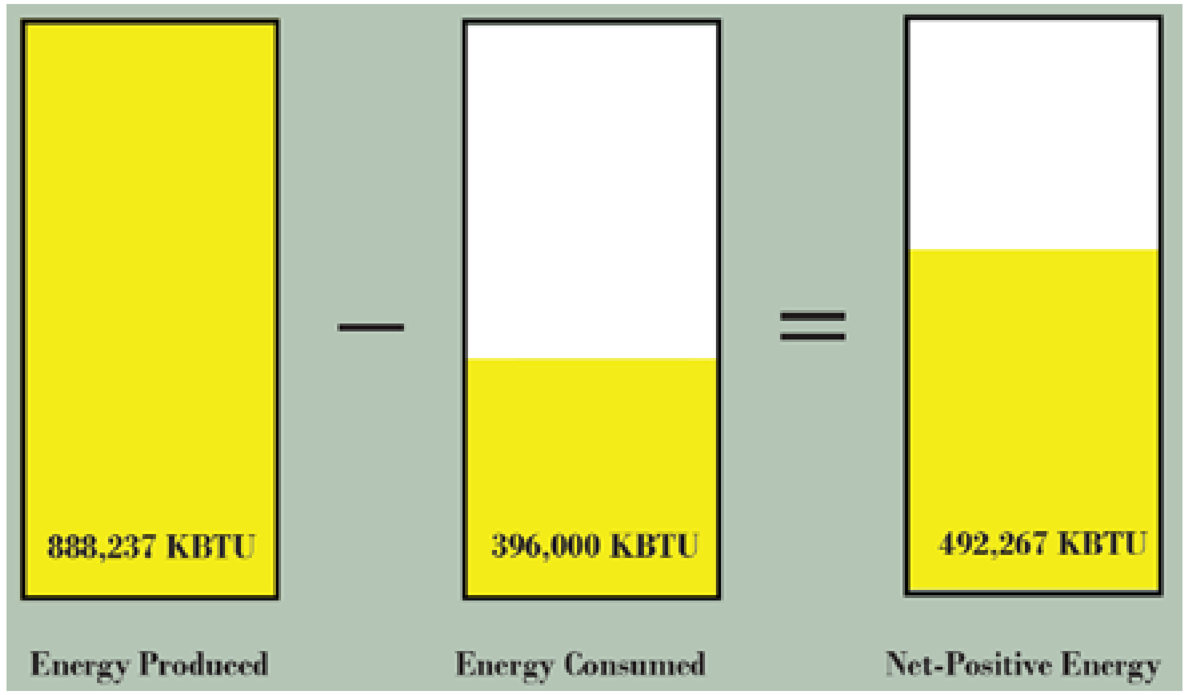
The treated water is then pumped to a cistern outside for further use.

Reuse

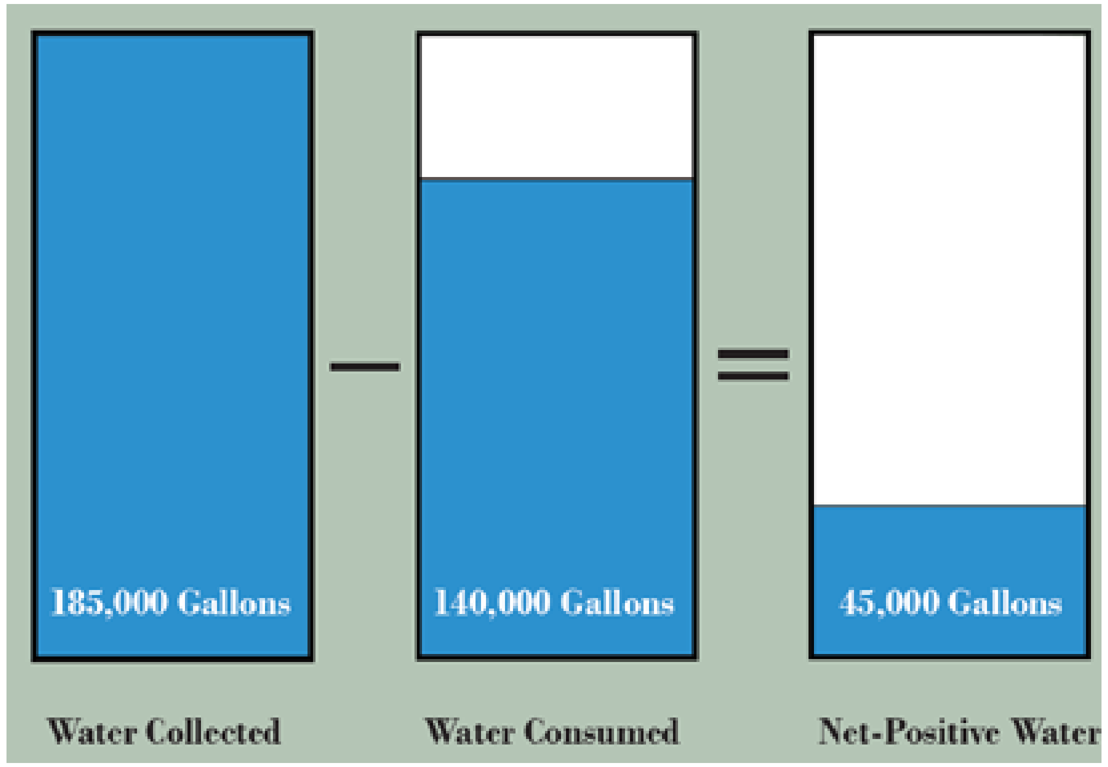
This water is then used for things such as running sinks and flushing toilets. Blackwater is sent to the constructed wetland to be treated and put back into the groundwater while the greywater is pumped back into the living machine to be treated again.



First with the energy I wanted to calculate how much energy my building consumed and after energy modeling the building out I was able to determine that the building uses about 18 kbtu per square foot yearly so multiplied by the square footage I was able to get the number shown here for total energy used throughout the year. After that I calculated the total energy produced. I totaled up the square footage of the pv panels, then multiplied it by how much they generate in watts per square foot per hour and then multiplied that by 5 for the amount of direct sunlight they would get per day. After that I multiplied again to get the years amount and then converted it into kbtus and I got the number seen here and as you can see I generate more than what is consumed making the building net positive for energy. All excess energy can be sent to neighboring buildings or sent back to the grid.



As for the water side I first calculated how much is used by the all the fixtures in the bathrooms as well and then doubled that amount for things in the lab as well as evaporation from the water wall. With all of that added together I came to the number seen here. Calculating water collected was fairly simple. I took the square footage of the roof that is collecting water and multiplied it by the average yearly amount of rainfall and got what is seen above. With this as well I was able to get net positive on that and the excess water can again be sent to neighboring buildings for their use or can be put back into the ground water. With these calculations I believe that ultimately the design of the building systems were a success and the building follows the ideology of regenerative design.



Previous Studio Experience

Second Year:
Fall 2015 Cindy Urness
Teahouse Project
Moorhead Teahouse
Birdhouse Project
Phillip Johnson Birdhouse

Third Year:
Fall 2016 Mike Christenson
Wood Structure
Winona Floating House
Masonry Structure
Winona Logging Museum

Fourth Year:
Fall 2017 David Crutchfield
Capstone Design Project
(Highrise) 255 3rd St.

Fifth Year:
Fall 2018 Mark Barnhouse
Advanced Architectural Design
Jacob Otte Wetlands
Reseach Center

Second Year:
Spring 2016 Darryl Booker
Montessori School
Building Block Project
Dwelling Project
Railroad Bridge Dwelling

Third Year:
Spring 2017 Regin Schwaen
Steel Structure
The Connection Center
Concrete Structure
Float

Fourth Year:
Spring 2018 Mark Barnhouse
Urban Design Studio
Minneapolis Arboretum
Marvin Windows Competition
Barnhouse Urness Residence

Fifth Year:
Spring 2019 Bakr Aly Ahmed
Design Thesis
Regenerative Design:
Wildlife Research Center

Personal Identification

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