90% Preliminary Design Report Draft: Stoughton Hydro Power Station Adaptive Reuse Project

Prepared for the City of Stoughton, Wisconsin

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Report By Team 8: SAGA Consulting Firm

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Disclaimer

The concepts, drawings and written materials provided here were prepared by students in the Department of Civil & Environmental Engineering at the University of Wisconsin-Madison as an activity in the course Civ Engr 578 – Senior Capstone Design/GLE 479 – Geological Engineering Design. These do not represent the work products of licensed Professional Engineers. These are not for construction purposes.

Executive Summary

Project Description

The client, the City of Stoughton, has requested that the historic Hydro Power Plant Station be repurposed into a space for the community to enjoy. The Stoughton Power Plant No. 1 is the oldest remaining element of the Stoughton Municipality's Utility System. It was built in 1911 and generated electrical power through 2007. This power was drawn from a dam located upstream of the building. The adaptive reuse of the building has the potential to preserve Stoughton's history and bolster the local economy, all while creating a recreational center to bring residents closer. This project is a small part of a larger Yahara Riverfront renovation project as the building is located on the banks of the Yahara River. Also included in this project is a parking lot located 30 feet east of the building. The City of Stoughton will be in charge of providing all of the funding required for this project.

Project Goals:

- Provide a community space that will attract families to the City of Stoughton
- Preserve the historical aspects of the building
- Recognition of hydroelectric origins
- Enhance the larger Yahara Riverfront Redevelopment project
- Create a stream of revenue for the city
- Improve the building's environmental footprint

Although the focus of this project is the historical restoration and adaptive reuse of the building itself, we have factored in the parking lot and the proposed changes to the surrounding riverfront area. Our aim is to design a building that effectively promotes community cohesion, outdoor recreation, and emphasizes the historic significance of the building. Pleasing the City of Stoughton and its residents while considering probable costs, project schedule, and the social affects within the community is our goal.

Design Constraints

- Economic
- Environmental
- Social
- Political
- Ethical
- Health and Safety
- Constructability
- Codes and Standards

Existing Conditions

The preliminary assessment of the building conditions revealed that the interior needs comprehensive renovation. Most of the interior finishes, flooring, and ceiling require complete replacement; however, the structural integrity of the building appears to be intact. Structural walls and the basement staircase are unlikely to require replacement. The load-bearing brick walls may require masonry work due to settling cracks located in the northeast corner of the building. Notable deficiencies include deteriorated floors, a compromised roofing system, and damaged interior partitions. Presently, the building lacks functional electrical, HVAC, and plumbing systems. The basement, primarily constructed with concrete, will likely require substantial rehabilitation; however, less future maintenance is

anticipated. There is approximately an inch of standing water on the lower level due to existing water passageways; however, it is anticipated they will be backfilled by the larger redevelopment project.

Design Alternatives

Alternative 1: Equipment Rental and Storage

- Multi season equipment rental opportunities
    - Fishing poles, bikes, kayaks, ice skates, bait sales for fishing
    - Outdoor community engagement for all ages
    - Tie into Mandt Park and proposed pedestrian path
- Ice skating rink in parking lot during winter
- Lounge area inside with seasonal amenities
- Self-serve Counter
- Basement used as a storage area
- Medium deck size: 344 sq ft

Alternative 2: Community Center with Educational Workshops

- Community engagement focused on kids and members of the community
- Science, math, technology, art, and music workshops and classes
- The main floor will be split into three rooms
    - Conference room: 340 sq ft
    - Classroom: 345 sq ft
    - Main room: 858 sq ft
    - Kitchen and serving area: 162 sq ft
    - Art storage room: 64 sq ft
- Small lounge area with a small catering kitchen and serving counter
- Large outdoor deck used as a community garden
- Cistern for rainwater collection to water the garden and reduce runoff from the roof
- Basement used as a storage area

Alternative 3: Privately Leased Retail

- Café or Beer Garden
- Large outdoor, wrap around deck and seating area overlooking river
- Promotes local, small businesses
- Opportunity for financial success
- Main floor split into three sections
    - Main dining room and bar area: 1418 sq ft
    - Kitchen: 222 sq ft on the first floor, 800 sq ft in the basement

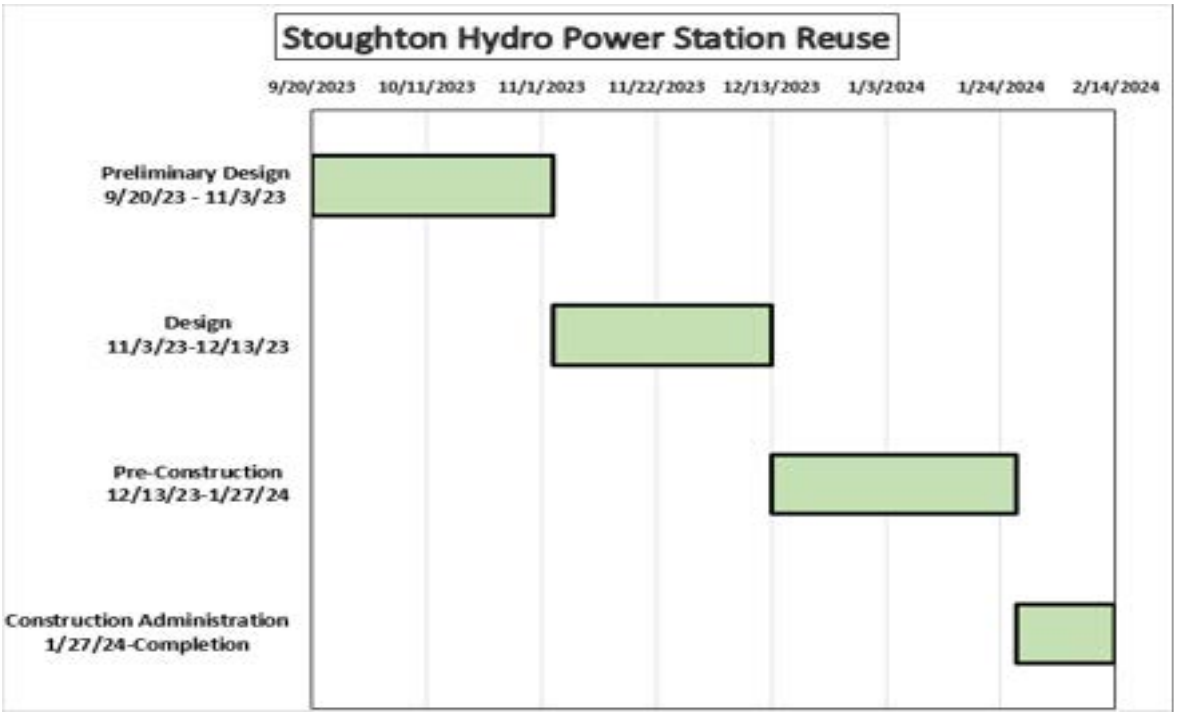
Project Schedule

As displayed in Figure 1 below, this project is split into four major sections: preliminary design, design, pre-construction, construction. A more detailed schedule is provided in the schedules section of this report.

- Preliminary Design: September 2023 – November 2023 (44 Days)
- Design: November 2023 – December 2023 (40 Days)

- Pre-Construction: December 2023 – January 2024 (45 Days)
- Construction: January 2024 – March 2025 (399 Days)

Figure 1: Project Schedule Gantt Chart



Opinion of Probable Cost

Table 1 provides an initial opinion of probable cost for the design and construction of the three alternatives based on a 30-year life cycle. The costs were calculated from national industry standards, financial evaluation of similar projects, and discussion with the City of Stoughton. Included in the table are the fundamental cost considerations that will be factored in to all three of the alternatives. When calculating the net present cost, a 30-year project lifetime was assumed as well as an inflation rate of 3%. Due to the preliminary stages of design, there are uncertainties for existing site conditions and exact design details. This estimate is likely to change as more information is obtained during the final design phase. Due to these uncertainties, a 25% contingency has been added to the base cost. The privately leased retail alternative is anticipated to have a stream of income that will offset the costs for Stoughton; however, Table 1 analyzes net present costs only.

Table 1: Summary of Opinion of Probable Cost for Each Alternative

30 Year Life Cycle Cost Analysis			
Description	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Capital Cost	$1,103,000	$1,161,000	$1,263,000
Annual O&M Cost	$66,000	$40,000	$10,000
Net Present Cost	**$2,397,000**	**$1,945,000**	**$1,459,000**

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Introduction

The reuse of the Stoughton Hydro Power Plant is part of a larger redevelopment goal in the City of Stoughton aimed at revitalizing the Yahara Riverfront and surrounding land. Three alternative design solutions are provided for the reuse of the Stoughton Hydro Power Plant and a recommendation is provided for the City of Stoughton after multidisciplinary engineering analysis. This recommendation is our best option to preserve the historic integrity of the building and foster community engagement all while being economically viable.

Background

The Stoughton Hydro Power building was originally built in 1911. It served as the flagship power plant as it was one of the three hydroelectric power plants that supplied electricity for Stoughton. This building served Stoughton's public electrical utility system until the mid-1970s, and it is the last remaining building of their hydroelectric power plant fleet. As of August 20, 2021, the Stoughton Municipal Power Plant No. 1 was placed on the State Register of Historic Places. The reuse of this building must also fit in with the larger Yahara Riverfront Redevelopment plan.

Figure 2: Historic Image of the Hydro Power Plant Building

Identification of Project Needs

- **Building Reuse**

  One goal of this reuse project is to turn the building into a hub for the community to gather around. Both city council and community members have expressed their desire that the reuse of the building cater to a younger family demographic. The adaptive reuse of the building must maintain the building's original exterior walls and convey its historical significance to maintain its place on the State Register of Historic Places.

- **Site Development and Environmental**

  The reuse of the Hydro Power building is a part of a larger land redevelopment project. The portion of the river that feeds into the turbine room is to be backfilled and the dam upstream of the building is to be removed. A walk and bike path will be constructed along the Yahara River as seen in Figures 30-32 and 34 in Appendix A. Reconstructing the parking lot with permeable pavement and reducing the area will help control the amount and quality of runoff from the site. Environmental impacts of this project will be monitored to ensure the safety of the wildlife and habitat. Environmental remediation will be monitored outside this project. Additionally, the final building design must follow ADA Standards for access and egress, parking lots, and bathrooms as the existing building does not comply with such standards.

Figure 3: Image of the Present-Day Yahara Riverfront

- **Budget and Funding**

  Additionally, the project needs to be financially self-sustainable. Currently, there is no proposed budget or funding source. It can be assumed that the funding for the project will come from multiple sources such as, a raise in local taxes, non-profit organizations, state and federal grants, donations, and fundraisers. Since there is not a defined budget for the project, the final design must have enough community engagement to gain support through fundraisers, donations, and possible increases in local taxes.

Analysis of Existing Conditions

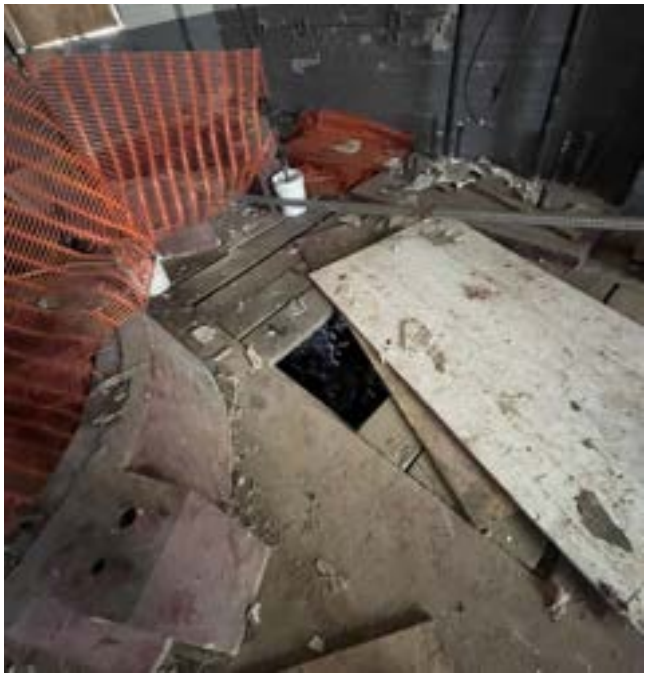
The Stoughton Hydro Power building is located at 515 S. Fourth Street in Stoughton, Wisconsin. It sits on the Yahara River and leakage still flows through its turbine room despite the building not being in use. The exterior of the building poses some concern: the retaining wall supporting the building above the river shows signs of stress and the roof needs replacement. In the interior, the concrete floor has two large holes; one where the old turbine was placed to reach the river shown in Figure 7, and the other one just inside the doorway. There is also a section of concrete that is broken-off near the door. As seen in Figure 6, the insulation from the ceiling is falling and the brick walls are assumed to be covered with lead paint. The insulation is assumed to be asbestos, and abatement must be completed. The building does not have a working HVAC, electrical and plumbing systems. The basement is prone to flooding and the existing bathroom is not up to the ADA code. Additionally, next to the building is a 20,000 sq. ft concrete parking lot and additional street parking is available on South Fourth Street. This parking lot is very large compared to the size of the Hydro Power Plant and is creating a large source of runoff volumes that could potentially enter the Yahara River. These existing conditions can be seen as Figures 17 – 25 and 29 in Appendix A.

Figure 4: Aerial Image of Hydro Power Plant and the Greater Stoughton Area

Figure 5: Present Day Photo of the Hydro Power Plant Building (Direction: SE)

Figure 6: Existing Interior of the Building - View of the South and West Walls (Direction: S)

Figure 7: View of West Wall Hydro Turbine Hole



Community Interaction Plan

Project Overview

The adaptive reuse of the Hydro Power Plant in Stoughton is a community-focused project aimed at serving our client, the City of Stoughton. Stoughton is committed to repurposing the building in a way that benefits the entire community. The main goals for the reuse of the Hydro Power Plant building are increased community engagement and support, preserving the historical integrity of the building, and an economically viable project for the city. The reuse of the building will also focus on drawing in families. Some important groups to focus on for community engagement are city council members, children in the Stoughton school system, the elderly community, and those who pay taxes and could be economically affected by the reuse of the Hydro Power Plant. Our goal is informed consent and access for all stakeholders; therefore, a comprehensive community interaction plan has been developed. This plan emphasizes transparency, engagement, fulfilling project goals, and addressing special interests within the community.

Public Communication

To present the project to the public, we will work closely with the City of Stoughton, leveraging their city council and community participation. We have created a detailed project proposal and presentation, which will be shared with interested parties at city council meetings and town halls. This approach creates an organized and democratic way to disseminate information about the project. All members of the community, especially those with disabilities, are being considered. Accommodation for interpreters, accessible entrance and exits at meetings, and recorded and livestreamed meetings can be expected. We also plan to prepare meeting minutes and send out a newsletter with project updates that interested members can sign up for at no cost. A website will be created for access to all meeting information and meeting schedules in an organized fashion.

Timing and Frequency

Regular updates will be provided to the public throughout the project's lifecycle. We will hold initial project meetings during city council meetings and subsequent updates will be shared to ensure that the community is informed about the project's progress and any developments. In the design phase we plan on meetings for the 90% and 100% design documents every other week. In the construction phase, we plan on having weekly meetings and newsletters to document project completion and safety.

Budget Allocation

A specific budget will be allocated for community interaction and engagement. The exact amount will be determined based on the project's scope and needs, with a commitment to maximizing community involvement within budget constraints. The budget will cover any time spent traveling to community interaction events and money used to promote engagement at these events such as renting out space, providing brochures, printing design plans for review, and food provided at events.

Special Interest Groups

We recognize the special interests in the Stoughton community, particularly the desire to increase family presence and improve schools. To address these concerns, we will incorporate a way to receive feedback for our project alternatives. For instance, one of our reuse alternatives is a community center,

which can offer educational workshops for kids, after-school programs, and courses for the elderly population. This approach aligns with the community's goals of creating a more family-friendly and educationally enriched environment. Our equipment rental alternative promotes a healthy, outdoors lifestyle and provides a space for many family-friendly activities such as fishing and biking.

Issue Avoidance

To prevent issues and conflicts, we will actively engage with the community by participating in preplanned city council meetings and attending town hall sessions. By doing so, we demonstrate our commitment to serving the community's interests and ensuring transparency throughout the project. We will also actively seek feedback, addressing concerns promptly and incorporating constructive suggestions into our project plans. Due to differing opinions and city politics, we expect issues to come up during meetings and will make sure that all voices are heard equally.

To make sure all members of the community are being considered, special accommodation will be made for those who can't attend meetings in person. We plan to livestream meetings so that they can input their opinion with virtual tools such as Zoom or Microsoft Teams. An online survey will be available at all times on the website for constant feedback.

Safety is a main priority at community meetings. Before meetings begin, a head count will be taken, ADA complaint exits and entrances will be communicated to all in attendance, and the location of first aid will be communicated to all.

Stakeholder Involvement

Stakeholders will be actively involved throughout the project's development. This includes the City of Stoughton, local businesses, educational institutions, and the broader community. Stakeholder engagement will be ongoing, with regular opportunities for input and feedback.

In summary, our community interaction plan is designed to promote transparency, encourage community engagement, and address special interests within the City of Stoughton. Safety and accessibility of community meetings is of utmost importance to ensure that all members of the community have an equal say in project decisions. By actively involving the public and aligning with the community's values, we hope to ultimately repurpose the Hydro Power Plant into a space that can be cherished and benefit all of Stoughton's residents.

Identification of Constraints

Economic

After conversations with city representatives, the budget will be a limiting factor and is a crucial part of decision making. There is no budget specified and the funding for the project will need to come from a variety of sources including community support, grants, and possible TIF funding. Therefore, the budget for this project will be a significant design constraint and uncertainty. The cost of the adaptive reuse project will be between 1.4 million – 2.4 million. The alternatives will vary in cost depending on the usage and operation of the building; however, the square footage of 2,900 will limit extreme variance in alternative designs. With the goal of reducing costs, we will cautiously choose materials for the design of the interior, roof, and decking.

Environmental

The adaptive reuse project is located on the banks of the Yahara River, leading to many concerns about environmental aspects of the project. EPA codes and standards will be followed, as well as the City of Stoughton's ordinances. This list includes but is not limited to design of sanitary and water lines, emissions during the lifecycle of the project, energy usage during the lifecycle of the project, identification of native vegetation and endangered species subject to city regulations, and stormwater and runoff management. Environmental remediation, such as Phase I and Phase II Environmental Site Assessments will be outside of the scope of the project, done previously by consultants working on the larger redevelopment plan along the Yahara River.

LEED or other sustainable certifications will not be in the scope of this project; however, sustainable design practices will be considered in the process. A THICK Sustainability Analysis will be performed for the lifecycle of the building and project to determine if it preserves, restores, and mitigates natural capital to promote long-term sustainability and benefits to the community and surrounding ecosystem.

Social

There have been many opinions voiced from the Stoughton community on how redevelopment along the Yahara riverbanks should be handled, which is important as they will ultimately be the beneficiaries. There is a petition online to stop removal of the dam across the street from Stoughton Hydro Power Station, which emphasizes the importance of the community interaction plan. During a site visit, there was an interaction with two long term Stoughton residents who voiced their preference for new infrastructure to support community interaction and attract families to improve Stoughton public school systems. Both instances prove that Stoughton's community cares about the reuse of the Hydro Power Station and its place in the larger Yahara Riverfront Redevelopment. The adaptive reuse project will attempt to capture the beauty and history of Stoughton, while offering a place for neighbors to interact and get involved. The concerns of every community member are important, and the community interaction plan focuses on listening to all opinions while working towards informed consent of the project.

Political

A larger redevelopment plan is occurring along the Yahara River and around the Hydro Power Station site, overseen by the Stoughton Redevelopment Authority. Communication and understanding of surrounding projects will be an important factor to stay up to date on through the adaptive reuse project lifecycle. This redevelopment plan includes significant changes to the landscape and surrounding environment on both a geological and hydrological level. Any unforeseen complications with the larger redevelopment plan may have an effect on the construction and operation of the adaptive reuse project. Additionally, the petition, mentioned in the social constraint, closely resembles a Not In My Backyard (NIMBY) group. As stated, the community interaction plan hopes to address any concerns and work towards informed consent of the adaptive reuse project.

Ethical

Engineers have an ethical responsibility to protect the public throughout a design's lifecycle. Stoughton community members will be a part of the project's entire lifecycle and the NSPE's Code of Ethics for Engineers will be followed rigorously during pre-construction, construction, and operation of the project. NSPE's Code of Ethics for Engineers has six Fundamental Canons listed below that will be abided by through every aspect of the project.

1. Hold paramount the safety, health, and welfare of the public.

2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

ADA Standards for Accessible Design will also need to be incorporated in the alternative adaptive reuse designs. Designs will follow the 2010 minimum requirements listed in the revised Title II and Title III. This includes area of restrooms, being aware of path of travel, and handicap parking spaces.

This building is a part of the state registry as a historic building with the Wisconsin Historical Society and is owned by the City of Stoughton. As a historic building, all regulations under the Wisconsin Existing Building Code of 2015, specifically Chapter 12, Historic Buildings, will be followed. This includes any repairs, fire safety, alterations, and structural designs. This building will not be used as an exhibit building and is therefore exempt from Section 1205, Change of Occupancy regulations. Materials used for repair or additions must be permitted with original or like materials, along with original methods of construction. Hazardous materials are not permitted such as lead based paint or asbestos. All regulations will be closely followed while still trying to incorporate the clients' goals for the project.

Health and Safety

Health and safety of those working on the project and those who will use the building during the operational phase of the project will be held at a high precedence. Occupational Safety and Health Administration (OSHA) standards and regulations will be considered for, specifically during construction and the operational phase. A structural analysis will be performed to check that ASCE dead loads, live loads, and weather loads will be supported by the infrastructure to ensure public safety.

Heating, ventilation, and air conditioning will be considered and included in all design alternatives to manage air quality, prevent excess moisture, and control comfortability. Fire protection regulations will be followed for design of both the interior and exterior, including emergency exit plans. Sewer lines must be carefully designed to avoid exposure to humans and the environment. There will be two restrooms with a sanitary system connected to the main line located on South 4th street that will be located below the waterlines to prevent contamination. Asbestos removal will follow Wisconsin Department of Natural Resources Four Steps to a Successful Demolition or Renovation Project, Inspection, Notification, Removal, and Disposal.

Constructability

Materials used for constructed facilities will be important as a Historic Building. Procurement delays for these materials will be accounted for in the schedule to prevent unseen costs. These delays are probable as supply and shipping and handling can be uncertain. Temperature will matter for construction due to the brick exterior and thermal shrinkage and expansion. Weather conditions in Wisconsin can affect construction schedules; however, this uncertainty is considered in the budget with the contingency. Site staging will also be a constraint as this site is located to the Yahara River. Control of construction traffic and waste will have a detailed plan to maintain safety and prevent pollution on and around the construction site.

Codes and Professional Standards

Listed below are local and federal codes, regulations, and standards that will be followed throughout the duration of this project's lifecycle as constraints. Some codes and standards that will be followed have been mentioned explicitly in other sections of the report.

- **NSPE's Code of Ethics for Engineers –** Code of ethics for engineers where they shall be guided in all their relations by the highest standard of honesty and integrity.
- **ADA Standards for Accessible Design -** Design standards for those with disabilities to be included in new and existing buildings.
- **OSHA Infrastructure Safety and Health –** Infrastructure, construction and building safety regulations to ensure safe and healthy workplaces.
- **Wisconsin Department of Natural Resources: Asbestos Removal and Notification –** Standards for the removal of asbestos to protect the public from exposure to airborne contaminants.
- **Wisconsin Existing Building Code 2015 – Chapter 12: Historic Buildings** - Structural guidelines to repairs, fire safety, alterations, and change of occupancy for historic existing buildings.
- **ASCE Minimum Design Loads** – Minimum design loads for infrastructure to ensure structural integrity.
- **Municipal Code City of Stoughton, WI –** Code of ordinances including zoning, health and sanitation, historical preservation, stormwater management, and utilities.
- **Environmental Protection Agency: Clean Air Act –** Air pollution control rules for emissions
- **Environmental Protection Agency: Water Quality Standards Regulation** – Requirements of states to adopt water quality standards

Development of Three Design Alternatives

During the preliminary design process, many ideas were discussed for the reuse of the Hydro Power Station. After proposing ideas to the client, three alternatives were selected for further design and planning: an equipment rental and storage facility, a community center with educational workshops, and a privately leased retail space. These alternatives offer the client choices with various costs and benefits within the community so that the community's needs are accounted for while staying within Stoughton's budget. The historical preservation of the building prevents large variance in designs due to not changing the building size or exterior. Proposed reuses of the building offer a community focused tie into the previously planned developments of Mandt Park and the Yahara River walking path. All alternatives have taken the client's wishes for historical preservation into account with the utmost importance.

Design features that will be common across all alternatives are as follows:

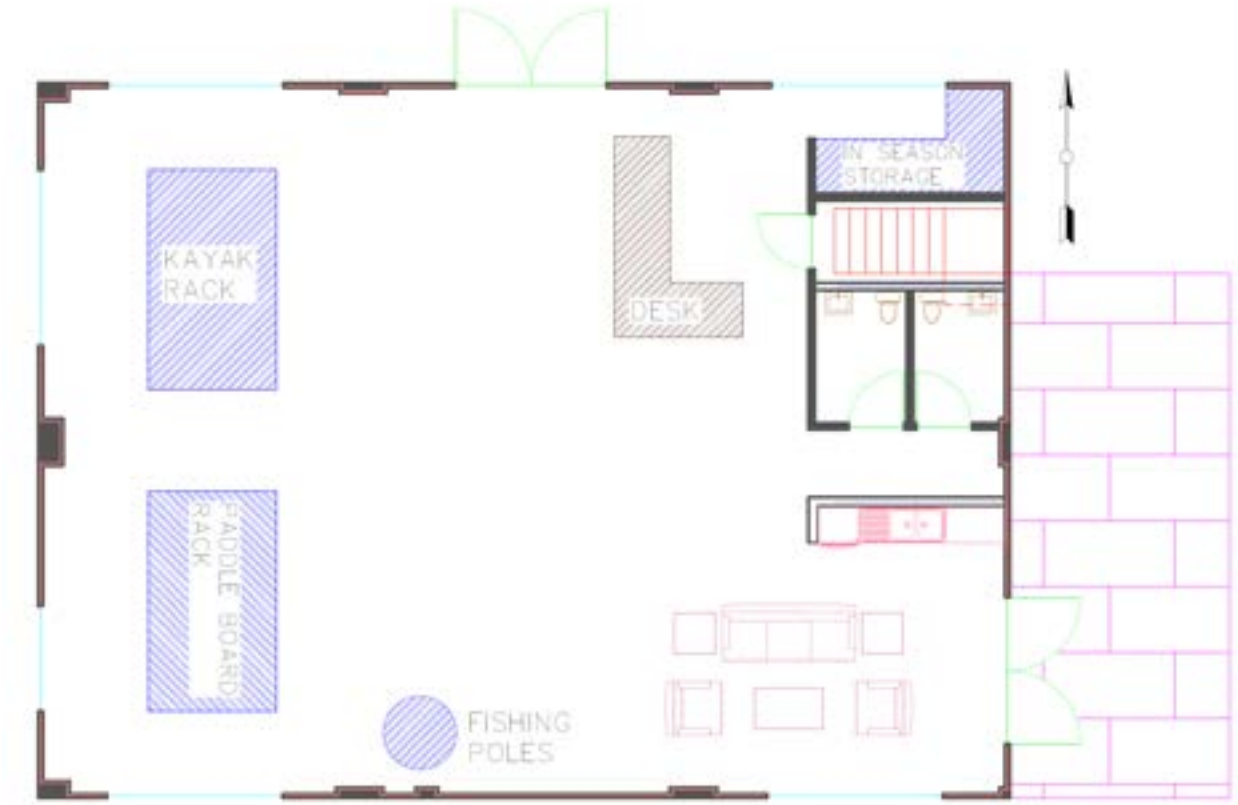
- Skylights for natural light
- A deck for outdoor enjoyment of the scenic location
- Preserved window space for river views and natural light
- New, energy efficient windows that match original design
- Reduce parking lot size from 20,000 to 6,000 square feet to improve the building's environmental footprint
- Handicap parking and accessible entry and egress from the building
- Use of permeable pavements
- Redesigned bathrooms
- Wall and roof insulation

- General maintenance and repairs

Alternative 1: Equipment Rental and Storage

The first design reused the Hydro Power Plant as an equipment rental and storage facility. With this alternative, there will be seasonal equipment rental opportunities so that the community can enjoy the nearby river and environment. With this alternative, large upfront costs are expected due to procuring equipment such as paddle boards, kayaks, bikes, and fishing poles. After this investment, there is an opportunity for financial success through paying for rental equipment although we expect this alternative to break even and then create a small profit. This design ties nicely into the Yahara River walk and bike path and the newly renovated Mandt Park. When weather permits, fishing poles, kayaks, paddle boards, and bikes could be stored and rented out from the facility, utilizing the basement below. In winter months, ice skates can be rented, and a rink will be set up in the nearby parking lot. A 344 square foot deck will be placed on the outside of the building and lounge areas will be provided inside to facilitate community leisure and bonding during all seasons. Bathrooms will be installed as well as a small counter to sell snacks or drinks. This design ties nicely into the outdoors aspect and scenic site location of the Hydro Power Plant and will highlight the historic value of the building by minimally changing its purpose.

Figure 8: Equipment Rental and Storage Proposed Floor Plan (Colored)

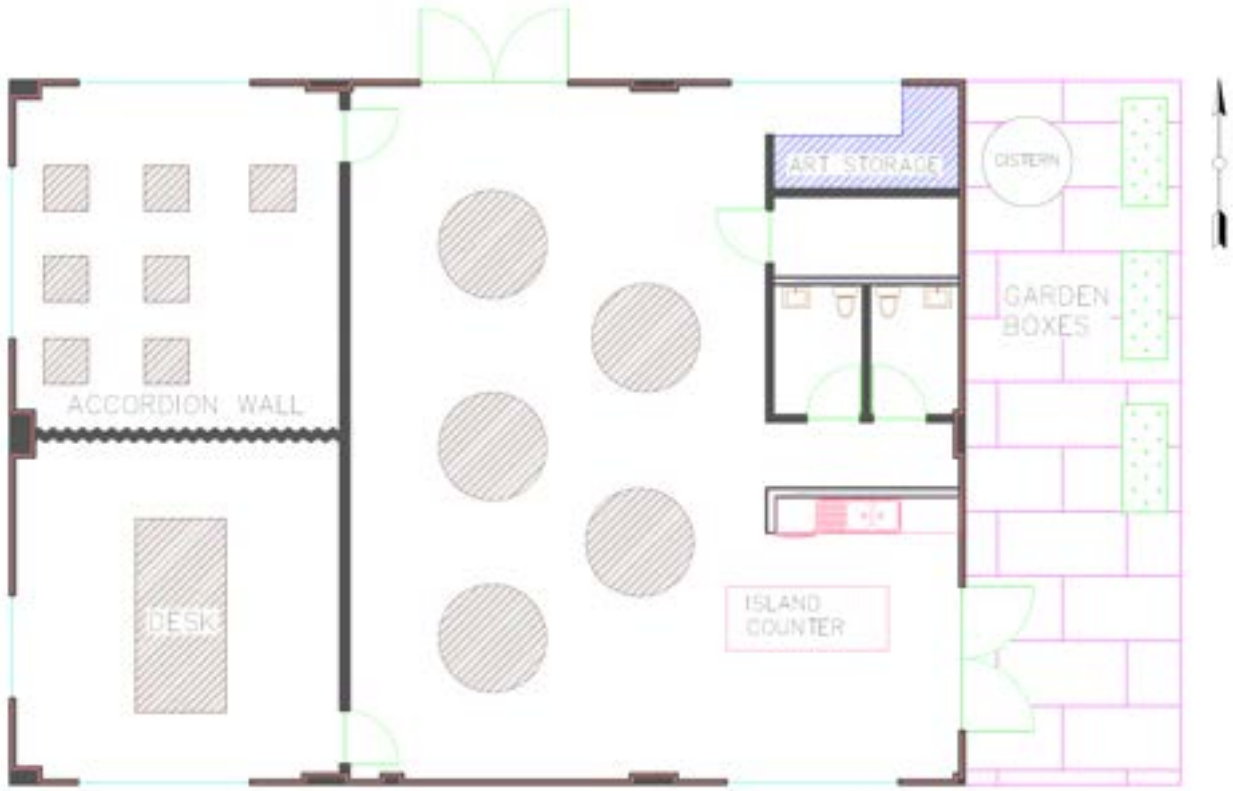


Alternative 2: Community Center with Educational Workshops

The next idea is to repurpose the Hydro Power Plant as a community center that focuses on kids and members of the community through educational classes and workshops. While Stoughton has other community centers and town halls, this alternative provides the unique opportunity to have specified classes and a focus on youth education. The space is reserved for science, math, technology, art, and music classes of all varieties to foster a creative learning environment.

The building will be sectioned to create two rooms and one larger, open space. One room is preserved as a conference style space and the other is a classroom environment with many desks, tables, and chairs. Each room is 340 and 345 square feet respectively. Both rooms will have ample space for collaboration and instructor-led classes. The wall separating the rooms is accordion style and can be removed when needed. The main space will feature a check in counter, open seating, and redesigned bathrooms and it will be 860 square feet. A catering style kitchen with a back counter, small fridge, sink, and serving area will allow for snacks and serving food during workshops. The basement will be used for storage of equipment such as desks, chairs, art supplies, and workshop supplies. An outdoor deck will be reserved for a community garden. A cistern system will be used to collect rainwater from the roof and repurpose the water for use in the garden. There is an opportunity for financial success with this alternative. Memberships to sign up for regular classes or daycare services are potential benefits to the community that this alternative provides. Rooms can also be rented privately for events such as conferences. This alternative promotes community enrichment for all ages but aims to help the city attract families and children.

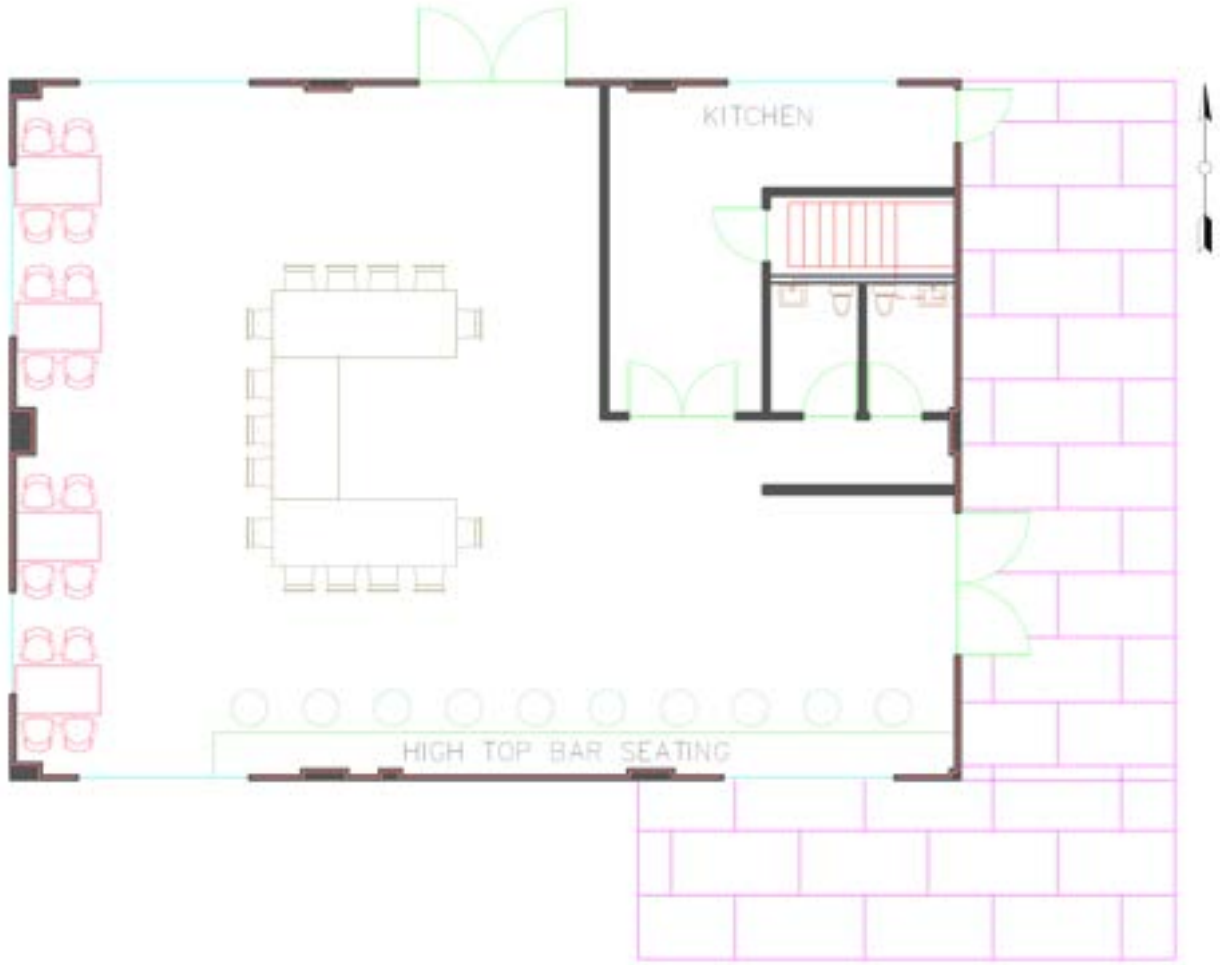
Figure 9: Community Center with Educational Workshops Proposed Floor Plan (Colored)



Alternative 3: Privately Leased Retail Alternative

The final proposal to reuse the Hydro Power Plant is to lease it out to a private vendor as a café or beer garden; however, the City of Stoughton can use this layout for many different types of vendors. A café or beer garden is a suggestion to help envision how the space could be used and is not the only option for use of this space. Privately leasing the building will promote a small business within Stoughton and create a source of revenue. To preserve the historic aspect of the Hydro Power Plant, a rustic, casual aesthetic will be promoted with a central U-Shaped bar with shared seating space. Along the southern wall of the building, high top seating will be provided so that customers can enjoy the view of the river. A large, wrap-round deck for outdoor seating during good weather months is also proposed with this alternative. More private seating will also be available with booths on the side wall, but the goal is to create a community environment within. The kitchen will be placed close to the basement and bathrooms so that utility connections can be concentrated. On the main floor the kitchen is 220 square feet. The 800 square foot basement is closed off by the kitchen and can be an extension for extra space and storage.

Figure 10: Privately Leased Retail Proposed Floor Plan (Colored)



Analysis of the Existing Site Conditions

To assist in understanding the existing building, the overall site was analyzed under various disciplines such as: structural, hydrologic, construction, sustainability, ability for future expansion, and geotechnical. Due to the historic preservation of the building, many of the details are common between

alternatives. Outlining the building's overall strengths and weaknesses in these categories will help the client choose an alternative design that most fits their needs. Further analysis of these disciplines for each separate alternative will be discussed in the next section.

Structural Analysis

The structural analysis performed for the initial building and design alternatives will follow the Wisconsin Existing Building Code of 2015, which adopts amendments of the International Existing Building Code 2015. Specifically, Chapter 12, Historic Buildings 1201-1206, will be followed. Federally, the Secretary of Interior's Standards for the Treatment of Historic Properties will be followed closely for all design alternatives and any additions that will be considered for them. On a more local level, the Municipal Code of the city of Stoughton, Wisconsin will be abided by, for this project Chapter 38: Historical Preservation is important. There are multiple overlaps as well as differences between these standards and they have been considered simultaneously.

The exterior structure of the building is in good shape and there is minimal freeze/thaw expansion damage of the brick and mortar. The bricks are a combination of cream and red colored with arches around the windows and doors. There are a few areas where the bricks will need to be repointed such as around the windows and on the northeast corner of the building, shown in Figure 11. Although these will need to be fixed, it does not question the building's structural integrity. The repointing will be done using original or like materials and with original methods of construction, per Chapter 12 of Wisconsin Existing Building Code.

Figure 11: Shifting of Bricks Located on the Northeast Corner of the Building

The roof cannot be fixed and will be completely replaced, designed to hold the minimum wind, snow, and rain loadings. There are presently holes in the roof exposing the interior to exterior conditions, causing water damage to the existing ceiling. The roof consists of a steel frame covered with Federal Tile with a lay-in ceiling that is significantly deteriorated.

There are two holes located on the first floor, exposing the basement, and the existing concrete floor is assumed to be 8 inches thick with some minor cracks throughout. There are broken and rusted steel stash windows that will need to be replaced. Presently, there are water passageways in the basement of the building but are assumed to be backfilled by the larger redevelopment project happening along the Yahara River along with the retaining wall being fixed. This is a significant assumption and uncertainty

for the backfill and foundation stabilization, which will require updates and communication with the Stoughton Redevelopment Authority on their project.

There are no original construction documents available; however, the Landmark Nomination Form for the Stoughton City Power Plant #1 contained immense information on the building's original materials, construction practices, and developmental history. The Landmark Nomination Form was used as a reference heavily in the initial structural analysis. One assumption that was is the original minimum design live load. While minimum design loading constraints have changed over time, it is assumed that it was designed with Heavy Equipment Warehouse live load standard (Table 12 Appendix C).

The three alternative buildings will follow the same codes and standards mentioned in the initial structural analysis. The most significant constraint will be the regulation of using original or like materials and original construction operations. The roof is exempt from this regulation as it is irreparable and requires replacement. With the roof being mostly hidden behind the parapet wall, replacement is recommended with a metal roof for ease of maintenance and reduced weight. Other advantages include the ability to locate required ventilation systems and include skylights with an exposed structure above. Design alternatives will include interior and roof insulation, non-load bearing interior walls, an exterior deck, proper fire and corrosion protection, and additional doors to meet egress requirements. The new doors will be placed on the rear of the building where they will not impact the historical nature of the street view of the building.

Loading calculations for the alternatives follow sections 2.3.1 and 2.4.1 of American Society of Civil Engineers Allowable Strength Design (ASD) (Appendix C). ASD is used to satisfy strength and serviceability requirements for the safety of people and the structure through its' lifecycle phases. These take into consideration any combination of loadings that the structure may experience such as dead loads, live loads, and environmental loads. Table 12 in Appendix C includes all currently known and required loadings. Dead loads will be calculated again once design materials and layouts are finalized, which will depend on the minimum design dead loads and materials minimum design densities, leaving the current stated dead loads as knowledge-based uncertainties.

Hydrologic Analysis

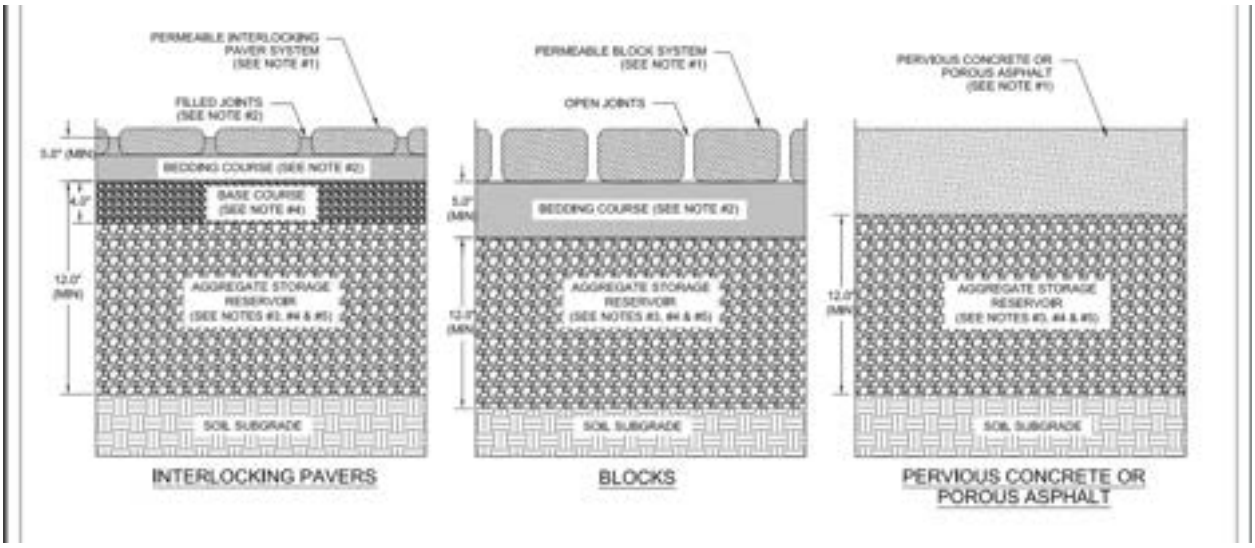
In accordance with the City of Stoughton Municipal Code Section 10-131: Stormwater Management Plan Requirements, an analysis of runoff from the current parking lot versus the proposed parking lot is completed using methodology described in the Natural Resources Conservation Service's Technical Release 55 (NRCS TR-55). The code states that runoff volumes should not increase after changes are made to a site and that practices should be implemented to reduce temperatures of runoff.

The current parking lot is 20,000 square feet of impermeable concrete pavement. In our proposed design we will reduce the size of the parking lot to 6,000 square feet, which is sufficient to provide enough parking for the building's size while addressing the need for handicap spaces to be ADA complaint (Figures 30-32, Appendix A). The excess area will be converted to softscape and bioswales. A minimal amount of hardscape will be provided for ADA compliant access to the building and for bicycle storage in order to promote environmentally friendly transportation to the site.

This parking lot will use pervious pavement to significantly reduce the volume of runoff to the nearby Yahara River. Permeable pavements are one of the Wisconsin Department of Natural Resource's best management practices (BMPs) to reduce impacts of urban water runoff and to improve water quality. The proximity of the parking lot to the Yahara River emphasizes the importance of limiting contamination from the site into water nearby. Permeable pavements slow down peak flows allowing

runoff to cool and therefore reducing impacts on the Yahara River. In the cold climate of Stoughton, permeable pavement reduces the need for salt and promotes melting of snow due to the interlocking structure storing heat. Figure 12 shows the proposed interlocking permeable pavement detail from the Wisconsin Department of Natural Resources.

Figure 12: Wisconsin DNR Permeable Pavement Detail



Permeable pavers can be less durable than traditional paved surfaces and require proper maintenance. In the Construction Administration of the proposed project schedule, operation and maintenance manuals will be provided for the client (Figure 16). In freezing conditions, the subsoil infiltration rates could significantly decline leading to increased runoff volumes. However, permeable pavements provide a unique opportunity to positively impact the building's environmental footprint with this reuse project.

The analysis in Table 2 proves that our proposed parking lot follows the City of Stoughton Municipal Code since our post construction runoff is not greater than predevelopment runoff for the one-, two-, ten-, 100-, and 200-year, 24-hour design storms. 24 Hour Rainfall data was collected for Stoughton, Wisconsin from the National Oceanic and Atmospheric Association (NOAA) point precipitation frequency estimates (Appendix B, Table 9). According to the National Resources Conservation Service's (NRCS) Web Soil Survey, our site in Stoughton has silty loam soil with slopes ranging from 2 to 6 percent (Appendix B, Figure 36). The calculations using this information show that reducing parking lot size and the implementation of permeable pavements will significantly reduce runoff volumes.

Table 2: Summary of Design Storm Parameters and Design Runoff Volumes (Calculated in Appendix B)

Design Storm Frequency (yr)	**1 Year Design Storm**	**2 Year Design Storm**	**10 Year Design Storm**	**100 Year Design Storm**	**200 Year Design Storm**
24 Hour Rainfall (in)	2.48	2.84	4.06	6.48	7.34

Existing Runoff Volume (ft^3)	1,458	1,886	3,486	9,807	11,234
Proposed Runoff Volume (ft^3)	7.38	0.33	39.8	344	507.4
Reduction in Runoff Volume (ft^3)	1451	1885	3,446	9,464	10,726
Percent Reduction	**99.5%**	**99.9%**	**98.8%**	**96.5%**	**95.5%**

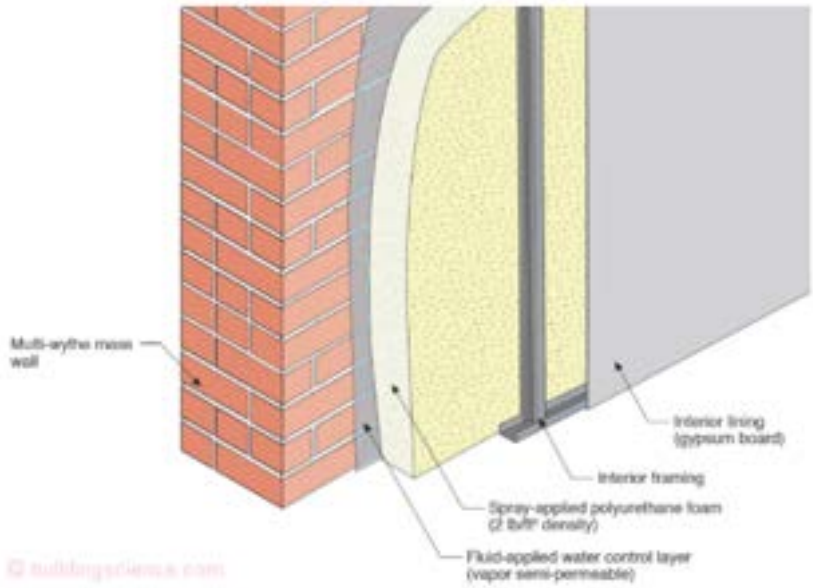
To address uncertainties and to promote conservative calculations, rounding was implemented when necessary. Further solutions to improve upon what is proposed for the parking lot in this report are being considered in the existing Riverfront Redevelopment project and will be evaluated in the future by the City of Stoughton due to budget and funding requirements.

Construction Analysis

The existing site conditions demand meticulous attention to various aspects for a successful transformation. Firstly, the condition of the flooring within the structure has been identified as a priority in restoration. Extensive repairs are necessary to ensure a safe and durable foundation for the building's new reuse. Although foundation repair is not in our scope and is part of the larger redevelopment plan, we will continue to monitor it throughout the construction process.

The introduction of proper insulation is needed to address energy efficiency and climate control, improving the comfort and functionality of the space while conforming to contemporary standards. Mass masonry walls manage moisture in different ways than modern, drained assemblies. Therefore, the balance of moisture into and out of the wall is strongly affected by interior insulation as the wall becomes colder. Moisture flow caused by air leakage into the interface between the masonry and the insulation can result in condensation problems; therefore, excellent airtightness is critical. The primary concern with insulating older load bearing masonry buildings in cold climates is the possibility of freeze-thaw damage of the brickwork due to excess moisture content. In Figure 13 below, a depiction of the proposed insulation is shown, which will be monitored for its performance and whether it is causing damage to the masonry.

Figure 13: Recommended Insulation Installment Method



The existing windows also require a comprehensive replacement, not only for enhanced aesthetics, but also to achieve energy efficiency goals. Their replacement is a strategic step in this restoration process as the replacement windows' muntins and mullions must match the existing per historical structure restoration code. Additionally, abatement procedures must be implemented to address any potential hazardous materials in a controlled and responsible manner, ensuring the safety and health of future occupants.

The building's roof and walls are showing signs of deterioration and wear. Repairing and fortifying these key elements is fundamental to safeguard the structural integrity and protect the interior from natural elements. This comprehensive construction analysis is an essential foundation upon which we will develop a strategy to rejuvenate and repurpose this iconic state landmark. Our goal is to harmonize functionality, safety, and historical preservation while revitalizing the Hydro Power Station for its future role.

Sustainability Analysis

Environmental Sustainability

The Stoughton Hydro Power Station has not been in operation by Stoughton Public Utility since the mid-70s. Today, the building has been deteriorating without usage for over 16 years. The foundation poses concern, exterior brick is shifting but not identified as a structure issue, and assumed lead and asbestos have been exposed to the atmosphere. Originally used for renewable energy generation, the building no longer contributes to the grid and could be a polluter with lead and asbestos to the soil, atmosphere, and nearby Yahara River. While the building is not in a position to currently be sustainable, the history of the building is inspiring towards today’s movement to renewable energy usage.

Reuse of this building should enhance the history while also maintaining a sustainable lifecycle. While LEED or ENVISION certification is not anticipated for the adaptive reuse designs at this time, the

general framework goals will be aimed for by analyzing the project through a Thick Restorative Analysis Framework. This framework focuses on preserving and restoring natural capital such as potable and non-potable water, habitat, energy, and atmosphere. It is graded on a -10 to 10 scale, with positive numbers representing enhancement of the natural capital and negative numbers representing diminishment.

Potable water and energy will be diminished as currently there is no usage by the building. This will require more usage from Stoughton's utilities, leading to a higher consumption of fossil fuels and further withdrawal from Stoughton's wells. Due to the historic nature of the building, the addition of solar panels to complement the buildings energy usage is not recommended due to budget and water consumption is unavoidable.

While potable water and energy will diminish, habitat, non-potable water, and atmosphere capital will not. The atmosphere will end up being maintained through both positive and negative impacts. While there will be more emissions during the construction and operational phase of the project, current pollution into the atmosphere from both the soil and building will be mitigated. This is a similar enhancement to non-potable water runoff into the Yahara River. Controlling size and quality of runoff volumes is a huge priority with this project and its' proximity to the Yahara River. As mentioned in the Hydrologic Analysis, permeable pavement will be replacing the current concrete parking lot, along with a 14,000 sq ft reduction in area. Not only will this reduce runoff into the river, but it will also open a larger area for greenspace, enhancing the surrounding habitat. Native perennial species can be planted with deep root systems that will help with erosion and runoff while providing habitat for surrounding species living around the river.

Table 3: Thick Restorative Natural Capital Analysis

Thick Restorative Natural Capital Analysis				
Resource Impact	Water	Habitat	Energy	Atmosphere
Diminish	-	-	-4	-
Maintain	-	-	-	0
Enhance	2	3	-	-
			Total	1

Table 3 shows the breakdown of scoring for the Thick Restorative Natural Capital Analysis, resulting in a net positive of one. While this project is not significantly restorative, it is a net positive for long-term benefits and impacts on the environment. These long-term benefits include a higher water quality runoff into the Yahara River and enhancement to the surrounding natural habitat and therefore, species for all three alternative designs.

Social Sustainability

One of the goals of the project is to provide a space for the community of Stoughton to come together while appreciating Stoughton's history and natural beauty in hopes of supporting a growing population and economy. There is also a desire to encourage families to move to the area to appreciate what Stoughton has to offer such as recreational opportunities and the buzzing art and music communities. The social sustainability analysis takes into consideration the significant potential long-term impacts the project will have on the community.

Each alternative offers unique long-term impacts that support the social sustainability of Stoughton while also offering experiences that are not fully captured at the Mandt Community Center, Stoughton Area Youth Center, or the Stoughton Area Senior Center. The larger redevelopment plan will promote usage of trails along the river and add an addition of a white-water rapids area along the river.

The equipment rental and storage alternative enhances the recreational aspects along the Yahara River such as kayaking, fishing, and biking. A pedestrian path from the proposed Yahara redevelopment project will follow waters and habitat. The building itself will provide a space to rent and hold recreational equipment, including bikes, fishing poles, kayaks, and paddleboards. Long term, this will promote community engagement with nature by emphasizing the beauty that the Yahara River front has to offer. The community center alternative focuses on a different social aspect of Stoughton community: art, music, education, and gardening. This space provides everything needed for artists, musicians, or teachers and can be used for a variety of educational purposes for people of all ages. The third alternative is a retail option, assuming the renter is specifically interested in a restaurant or bar option. This option provides a scenic location along the riverfront for community members to socialize and is also open to people of all ages. Each alternative provides long-term social impacts on the community in different ways.

Financial Sustainability

The City of Stoughton currently owns the historical building as well as the surrounding land. This property contains a mixture of greenspace and urban areas. As one of the biggest stakeholders, it is important that this building can be financially sustainable for the City of Stoughton and its community members. Financial sustainability analyzes the building's profitability and access to capital through its lifecycle. Money for the adaptive reuse project is still an uncertainty for the project, but the city does already own the property, a good start to having capital.

Re-circulating money into a local economy increases economic activity by encouraging community members to spend their money at local businesses rather than large corporations. This allows the money to stay in the hands of other community members and be spent again in the community. All three alternatives encourage spending and keeping money locally, even directly into the hands of the city. The City of Stoughton can use the money for further benefits to the community members such as decreasing taxes, implementing more greenspaces, or other requests the community may have. In the retail option, it would be most financially beneficial for the city of Stoughton to lease out to a community member and keep the business local. The equipment rental and storage alternative also provides opportunities for the space to be leased and while it may have greater sunken costs due to the costs of equipment, long-term profit is possible.

Financial profitability is possible for each alternative, but it has been determined that the retail space will make the most profit as the space would be leased out for a business. This would take away the city's responsibility to employee people, as well as help pay monthly operation costs. Other alternatives will cost more and it will take a longer amount of time to profit from either design. The city would be responsible for paying employees, monthly costs such as water and electricity, and any maintenance. While these options will cost more initially, they do offer great experiences for community members and is anticipated to be utilized long-term.

Financial sustainability is an uncertainty in the project as it depends on population growth, how much community members utilize the new space, and maintenance and operation costs. However,

considering social sustainability, it is hoped the community of Stoughton will utilize this space to its' full potential.

Analysis of Future Expansion

The City of Stoughton is currently planning the improvement of the Yahara riverfront area through the Stoughton Riverfront Redevelopment Program, which is stated to include the addition of a pedestrian footpath and bridge, removal of a nearby dam, as well as construction of an apartment building neighborhood and power plant (Figure 14). After removal of the dam, this local stretch of the Yahara will be modified to become a kayak whitewater park called the Yahara River Park. This area is expected to be extremely popular and the only park of its kind in Wisconsin.

As a result of the anticipated popularity, the area will see increased attention and economic activity that will create an opportunity to put the historic Hydro Power Station to renewed use, whether it be privately leased or publicly managed. Additionally, community rentals for kayaks and other recreational items will be in high demand in the project area, and increased family presence in the proposed apartments will expand interest in family-oriented public spaces. These key opportunities were all considered in the planning of the three design alternatives presented here. Historic value, community engagement, and financial sustainability were prioritized above all during the design process, resulting in plans that could achieve them by several different means.

Figure 14: Concept Map of the Stoughton Riverfront Redevelopment Project

(Imaged Produced by the Stoughton Redevelopment Authority)

Geotechnical Analysis

The Stoughton Hydro Power Station site is directly located along the Yahara River in south-central Wisconsin, just south of Lake Kegonsa. Soil sediment on the project site is classified as the Kegonsa Silt Loam (KeB), and proximal boring logs show it to be around 68 to 80 feet thick, depending on the location. The underlying bedrock is either the Wonewoc or Eau Claire formations, which are both members of the Elk Mound Group. These formations are medium grained sandstones of about 165 feet in thickness, and outcrops are uncommon in the area due to the presence of thick layers of glacial sediment.

Five soil borings were taken as part of the surrounding Stoughton Riverfront Redevelopment project, with 4 out of 5 selected sites located along the Northern shore of the Yahara River. Locations

were selected for the purpose of constructing a future pedestrian path and bridge, but have been adapted for use in this project, with one boring being located 90 feet from the building. Results from the borings show up to 7 feet of fill comprised of sand, gravel, and cinders overlying 3-7 feet of very loose to medium dense sandy soils. Due to the proximity to the Yahara River, the groundwater table is only 3 to 6 feet deep and fluctuates with the river stages. In addition, the presence of chemical and/or petroleum odors were noted in several soil samples and confirmed by subsequent lab testing. Comprehensive results are available in the project geotechnical report.

The geotechnical analysis for this project is applicable to all three design alternatives due to the small number of new structures planned. Calculations were completed to determine bearing capacity for a planned outdoor deck addition, and highest case loading scenarios were used for each. Foundation design was modeled as drilled pier foundations for calculation purposes. The resulting design includes 5-foot-long piers with 10-inch diameters, each capable of supporting 3.88 tons. A large safety factor of 2.5 was used to limit settlement and provide conservative design parameters.

Recommendation

Decision Matrix

A decision matrix was used to help suggest the best alternative for the Stoughton Hydro Station reuse. The three designs were evaluated based on total project cost, construction duration, financial sustainability, and community impact. After selecting the criteria, the input weight for each one was decided. A larger input weight means the criteria holds more importance. These criteria and the weights were assigned to represent the project goals and client's needs while keeping the community of Stoughton in mind. All criteria were normalized to compare the alternatives fairly. Table 4 shows the final decision matrix. Calculation steps are outlined in Appendix D.

Table 4: Decision Matrix to Recommend Best Alternative

Decision Matrix					
Criteria	**Input Weight**	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**	
Net Present Cost	55%	16.2%	18.3%	20.5%	
Construction Duration	5%	1.7%	1.7%	1.6%	
Self Sustaining Financially	15%	4.4%	1.8%	8.8%	
Lifetime Environmental Impact	10%	3.6%	4.1%	2.3%	
Community Impact	15%	4.2%	7.5%	3.3%	
Total	100%	30.1%	33.3%	36.6%	**Final Score**

Once criteria were selected, the next step was to decide how to measure each one and if a criterion should be minimized or maximized to ensure proper recommendations. Total project cost is measured in dollars and is to be minimized. Project duration is measured in weeks and should be minimized. Financial sustainability and community impact categories were given weights based on client goals and both will be maximized. Lifetime environmental impact was given weight based on how each alternative would impact its surrounding environment throughout the duration of its lifetime and should be minimized. Some factors addressed were contamination of the river from parking lot runoff and the recycling of water with a cistern.

There are uncertainties associated with each criterion. The net present cost and financial sustainability weights were based on rates from similar projects and industry standards in Wisconsin; however, these values are subject to change by the time construction begins. There are also uncertainties for the construction duration as there can be numerous events both environmental and anthropogenic that can affect the schedule. Finally, the uncertainties of assigning weights to community impact stem from the subjective nature of assessing community needs and preferences, as well as the challenge of quantifying and comparing the long-term societal benefits and drawbacks associated with each proposal.

Ultimately, it is recommended that the City of Stoughton moves forward with the privately leased retail alternative. As seen in Table 4, this option was favored by the decision matrix with a percentage of 36.6%. This alternative also has the lowest net present cost when looking at a lifetime of 30 years and an assumed inflation rate of 3%. Overall, the privately leased retail alternative minimizes cost while providing the City of Stoughton with an impactful space for the community, opportunity for financial success, and preservation of the historic character of the Hydro Power Station building. Along with this, the reuse of the building itself will have a net positive environmental impact.

Schedule

Figure 15: Gantt Chart Schedule (Design)

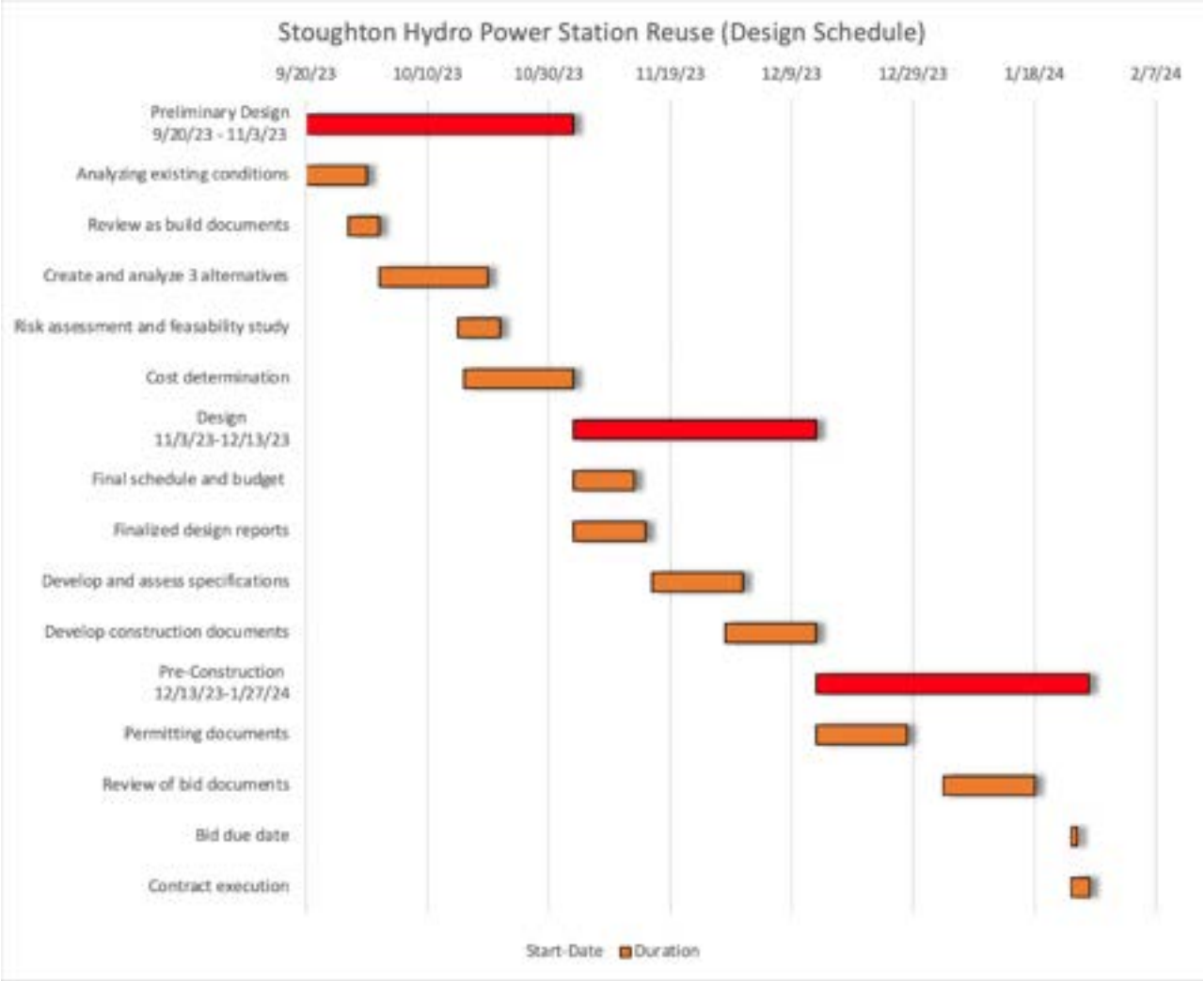
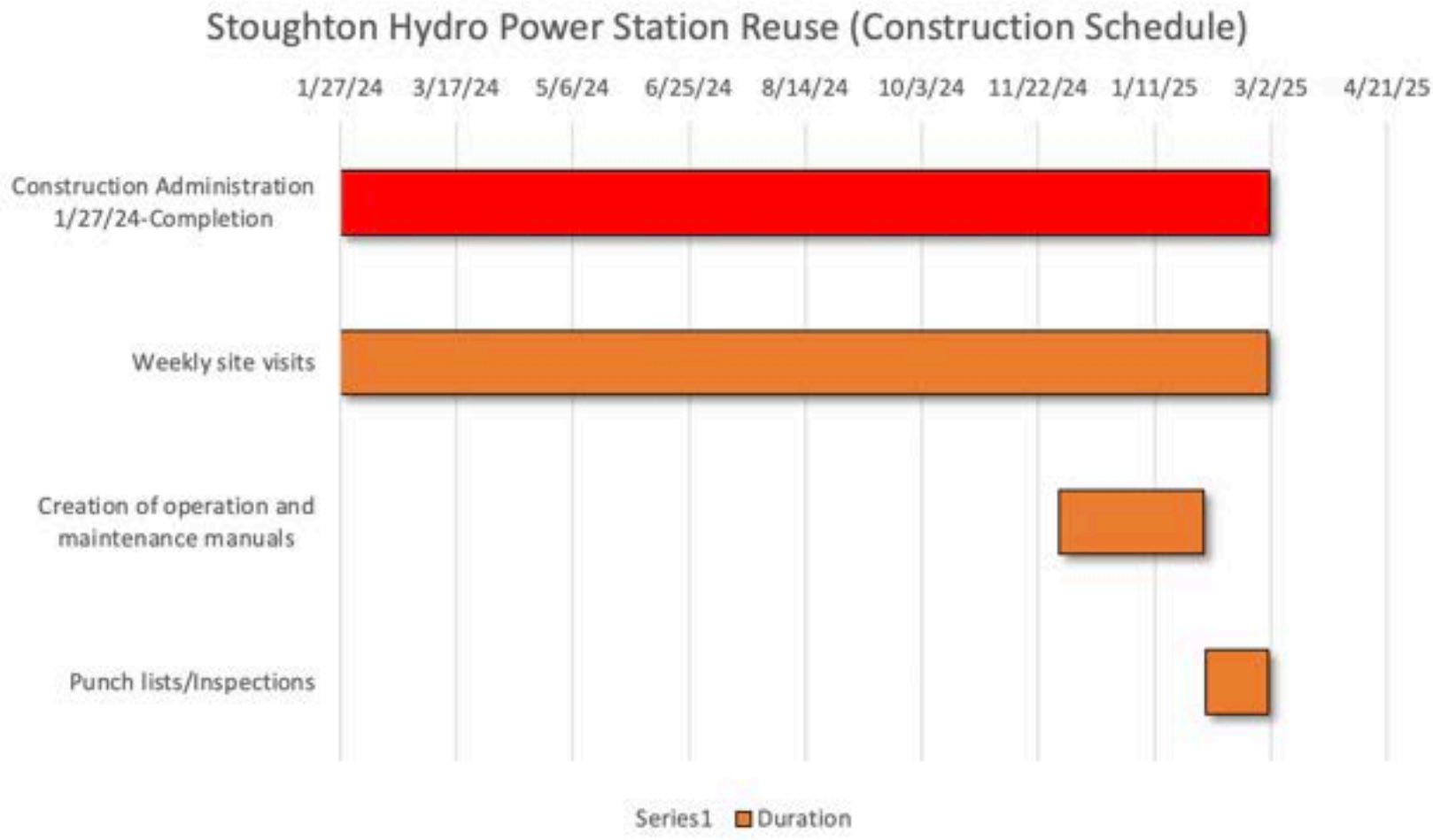


Figure 16: Gantt Chart Schedule (Construction)



Opinion of Probable Cost

An initial opinion of probable cost is provided below for the three alternative solutions for the Stoughton Hydro Power Station Reuse. For each alternative, the estimated capital costs and the annual operational and maintenance costs are provided. A 25% contingency is included in the capital and operational costs due to uncertainties at this stage in the project. Some knowledge-based uncertainties related to the costs include the cost inflation between now and the construction year and the extent of furnishings and equipment that will need to be purchased. The costs are likely to change as more information is gathered on the three alternatives and the contingency percentage will decrease as the project progresses.

Capital Costs

The capital costs for each alternative solution were calculated based on rates from similar projects and from industry standards in Wisconsin. The cost provided includes construction, furniture, interior finishes, collection of waste, site work, architect and design costs, engineering fees, and project management. The base construction cost in the opinions of probable cost tables below excludes the cost of the deck, the cost of implementing permeable pavement in the parking lot, and contingency and design fees. The permeable pavement costs $7 per square foot and the parking lot for all three alternatives will be 6,000 sq ft; therefore, permeable pavements are estimated to cost $42,000. We have proposed three different deck styles that vary in size and style so that the deck can best suit the needs of each proposed reuse of the Hydro Power Station. All deck alternatives are estimated to cost $25 per square foot.

After the construction costs, contingency, and fees are considered, the total project cost is $1.10 million for the equipment storage and rental alternative, $1.16 million for the center for community engagement alternative, and $1.26 million for the privately leased retail alternative. With the building size being 2800 sq ft, the cost per sq ft for the construction costs for each alternative is $251, $268, $297. The typical industry project cost for a single-story commercial space is about $300 per sq ft, and with our project having a smaller scope than the typical single-story commercial space, our costs align well making it a competitive price.

Operational and Maintenance Costs

The operational and maintenance (O&M) costs for each alternative solution are calculated based on standard unit costs for commercial buildings. All three alternatives vary from each other and require different maintenance and staffing; therefore, there is not a set unit cost to satisfy staff and maintenance needs. For this report, it is assumed that all employees will be paid a base salary of $20 per hour.

The equipment storage and rental alternative will require a part-time staff; however, the number of employees may vary at the time of the year due to the nature of Wisconsin winters. We expect the rentals to be open daily during the summertime and open for an average of 30 hours a week during the winter for ice skating. Our annual maintenance cost includes replacing broken equipment and normal wear and tear on the building and the upkeep of permeable pavements.

The center for community engagement alternative will require a part-time staff throughout the year. We estimate staff hours to be ten hours a week per employee with two employees on staff. The community engagement center is expected to be open daily after school hours and during the summertime. Our annual maintenance cost includes replacing broken equipment and normal wear and tear on the building as well as the upkeep of permeable pavements.

The privately leased retail alternative will require staff and utilities but will be at the discretion of the lessee. There are knowledge-based uncertainties related to these costs because the electricity, gas, and water usage of the building are not known at this time. These costs were not estimated at this time because they will vary greatly on the type of retail that is placed into the building, such as a café, restaurant, or beer garden. Additionally, the costs of cleaning, repairs, and maintenance can vary due to the frequency and quality of services that are required.

Economic Analysis of Three Alternatives

Table 5: Opinion of Probable Cost for Alternative 1 – Equipment Rental and Storage

Alternative 1: Equipment Storage and Rental				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$233	$653,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Medium Deck	344	$/sq foot	$25	$9,000
Subtotal - Construction				$704,000
Construction Contingency	25%	%*Subtotal	$704,000	$176,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,103,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	2	Salary/Year	$20,800	$42,000
Subtotal - Staffing				$42,000
Utilities	2800	$/sq foot	$2.1	$6,000
Repairs and Maintenance	2800	$/sq foot	$2.5	$7,000
Subtotal - Utilities and Services				$13,000
O&M Contingency	20%	%*Subtotal	$55,000	$11,000
Annual O&M Costs				$66,000

The equipment storage and rental alternative is estimated to have a total capital cost of $1.1 million. This alternative is designed to have a 344 sq ft deck and the parking lot is designed to be 6,000 sq ft with permeable pavement. There are estimated to be 2 part-time employees for this alternative and the annual operational and maintenance costs are estimated to be $66k.

Table 6: Opinion of Probable Cost for Alternative 2 – Center for Community Engagement

Alternative 2: Center for Community Engagement				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$249	$696,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Large Deck w/ Cistern	470	$/sq foot	$25	$12,000
Subtotal - Construction				$750,000
Construction Contingency	25%	%*Subtotal	$750,000	$188,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,161,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	2	Salary/Year	$10,400	$21,000
Subtotal - Staffing				$21,000
Utilities	2800	sq / type	$2.1	$6,000
Repairs and Maintenance	2800	$/sq foot	$2.2	$6,000
Subtotal - Utilities and Services				$12,000
O&M Contingency	20%	%/Subtotal	$33,000	$7,000
Annual O&M Costs				$40,000

The center for community engagement alternative is estimated to have a total capital cost of $1.16 million. This alternative is designed to have a 470 sq ft deck with a cistern to collect runoff from the roof for recycling into community gardens. The parking lot is designed to be 6,000 sq ft with permeable pavement. It is estimated that two part-time employees will be on staff for this alternative and the annual operational and maintenance costs are estimated to be $40k.

Table 7: Opinion of Probable Cost for Alternative 3 – Privately Leased Café

Alternative 3: Privately Leased Café				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$275	$771,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Large w/ Wrap Deck	770	$/sq foot	$25	$19,000
Subtotal - Construction				$832,000
Construction Contingency	25%	%*Subtotal	$832,000	$208,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,263,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	N/A	N/A	N/A	N/A
Subtotal - Staffing				N/A
Utilities	N/A	N/A	N/A	N/A
Repairs and Maintenance	2800	$/sq foot	$3	$8,000
Subtotal - Utilities and Services				$8,000
O&M Contingency	20%	%/Subtotal	$8,000	$2,000
Annual O&M Costs				$10,000

The privately leased retail alternative is estimated to have a total capital cost of $1.26 million. This alternative is designed to have a 770 sq ft deck that wraps around to the south of the building and the parking lot is designed to be 6,000 sq ft with permeable pavement. There is no cost estimate for staffing or utilities as this will be covered by the lessee. Therefore, the annual operational and maintenance costs are estimated to be much lower than the other alternatives at $10k.

Life Cycle Cost Analysis

Table 8 summarizes the life cycle cost analysis for the three alternatives. The lifetime of the Hydro Power Station Reuse is set at 30 years for this analysis. The net present cost is found by converting the annual O&M cost into a present cost using a 3% interest rate for a 30-year life cycle. That present O&M cost was then added to the capital cost to give a net present cost for each alternative. As seen in Table 8, the equipment storage and rental alternative had the highest net present cost due to a higher annual O&M cost. The reason for just costs and no benefits for each alternative is because of the uncertainty of how each will be operated in the future by the client, and whether they plan on changing from our recommendation.

Table 8: 30 Year Life Cycle Cost Analysis

30 Year Life Cycle Cost Analysis			
Description	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Capital Cost	$1,103,000	$1,161,000	$1,263,000
Annual O&M Cost	$66,000	$40,000	$10,000
Net Present Cost	**$2,397,000**	**$1,945,000**	**$1,459,000**

Project Financing

The funding for the Stoughton Hydro Power Station Reuse project is still unknown at this time. It is expected that the funding will come from taxpayer money, grants, and private funding. The source of funding may vary based on the selected alternative and community support

Appendix A: General Site Information

Figure 17: Existing Interior of the Building - View of the South and Partition Walls (Direction: SW)

Figure 18: Existing Interior of the Building - View of the North Wall and Entrance (Direction: NW)

Figure 19: Existing Basement Condition (Direction: SW)

Figure 20: East Exterior Wall Condition and Tile Roof Side View (Direction: W)

Figure 21: West and South Existing Exterior Wall Conditions (Direction: NE)

Figure 22: Existing Retaining Wall (Direction: E)

Figure 23: Existing Retaining Wall (Direction: N)

Figure 24: Existing Dam that is Proposed to be Removed (Direction: W)

Figure 25: Existing Building Floor Plan (Colored) with Existing Basement Overlay (Dashed - Blue)

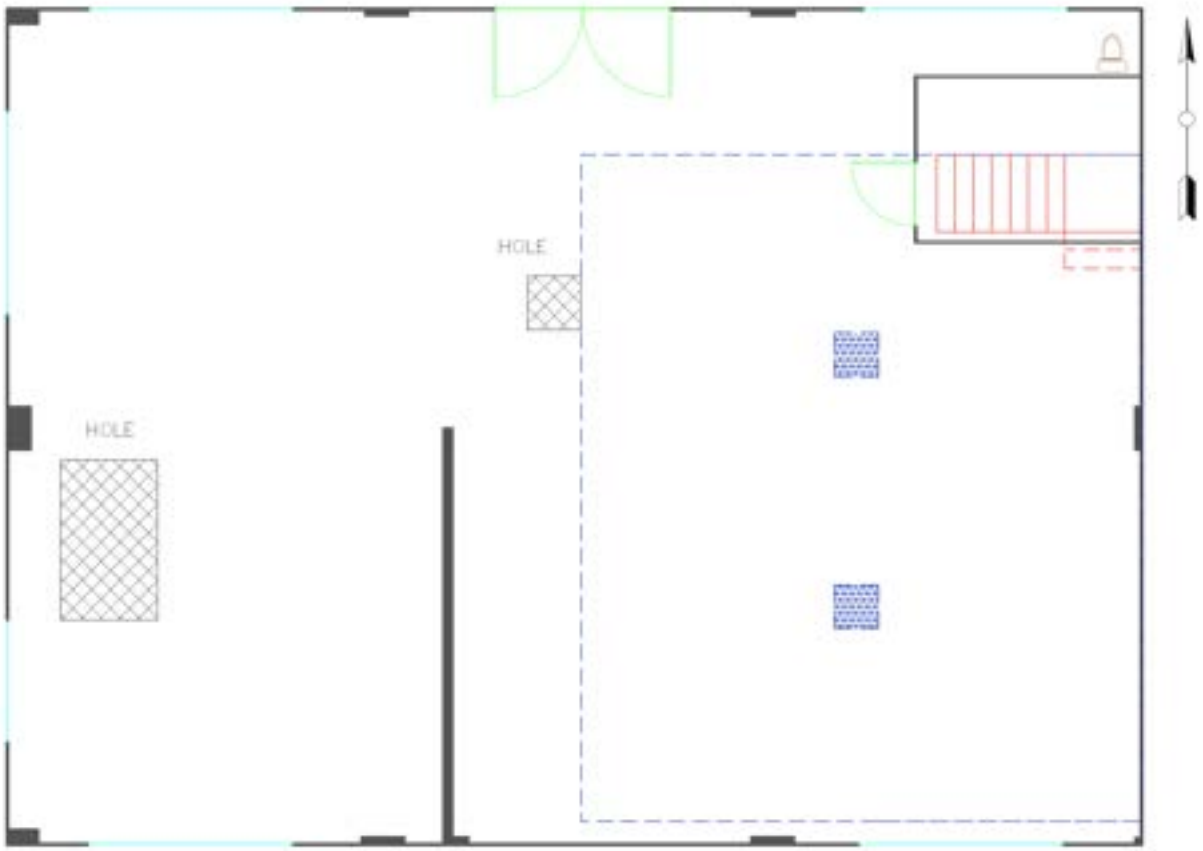


Figure 26: Equipment Rental and Storage Proposed Basement Floor Plan (Dashed - Blue) with Existing Floor Plan Overlay (Gray)

Figure 27: Community Center Proposed Basement Floor Plan (Dashed – Blue) with Existing Floor Plan Overlay (Gray)

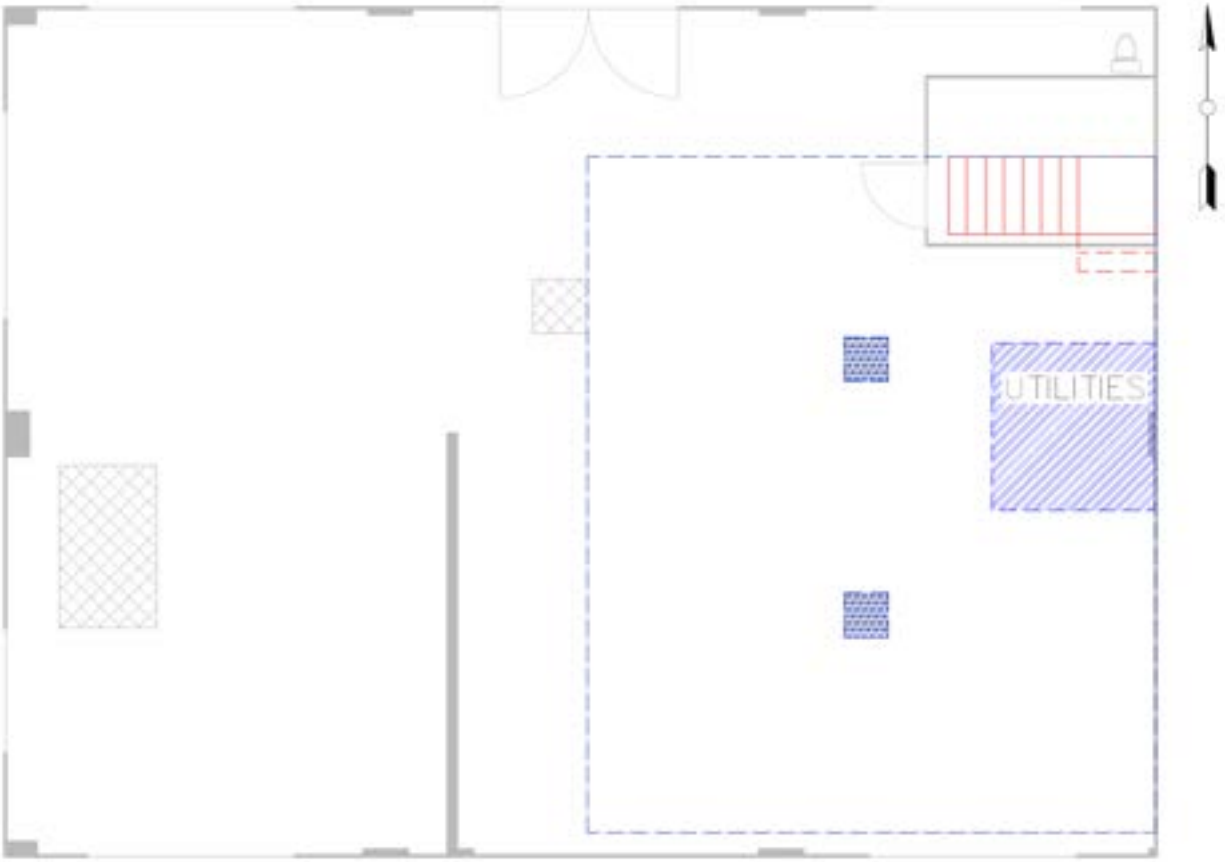
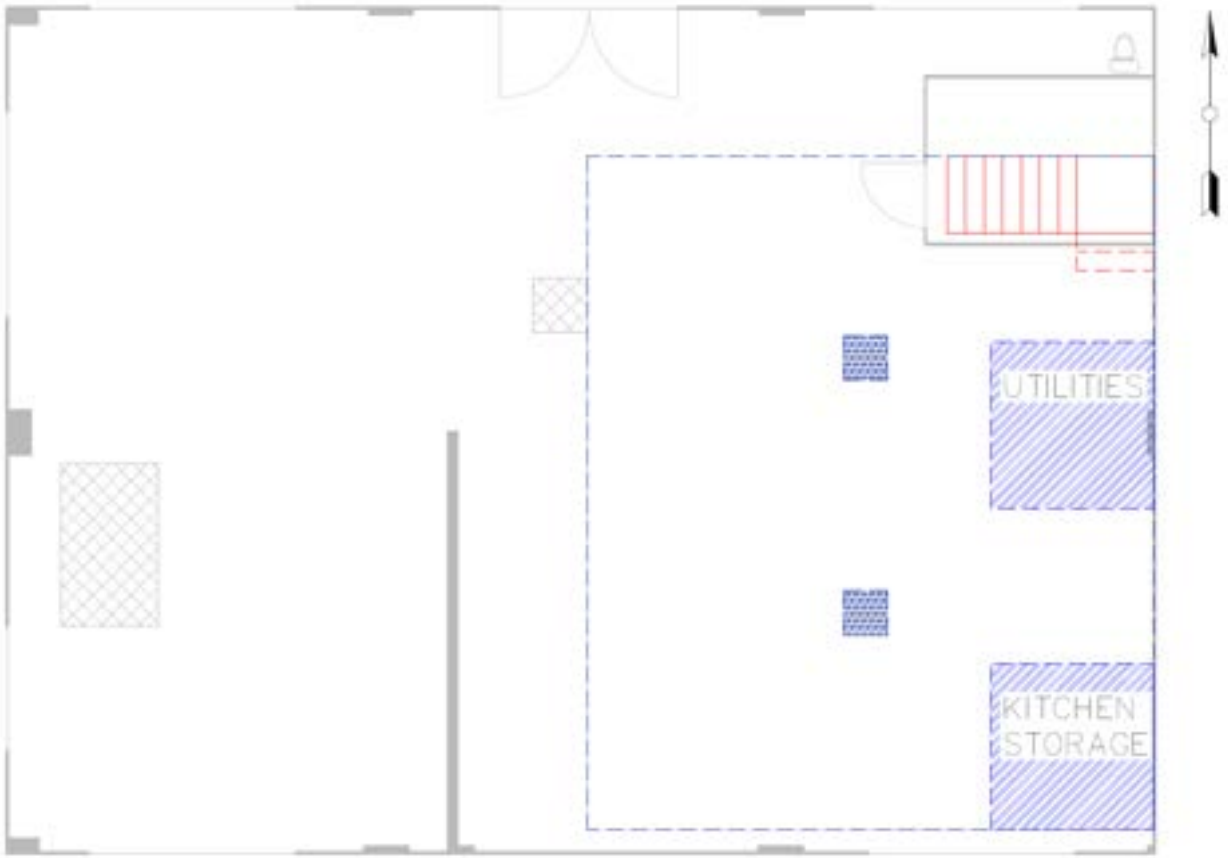


Figure 28: Cafe or Beer Garden Basement Floor Plan (Dashed – Blue) with Existing Floor Plan Overlay (Gray)



For Figures 26 - 28, the existing floor plan was overlayed to show the new basement floor plan because the basement. It was not overlayed with the proposed floor plans due to the addition of new walls that would cover parts of the basement.

Figure 29: Existing Site Conditions (Colored)

Figure 30: Equipment Rental and Storage Proposed Site Plan

(Green = Green Space Added, Blue = River Alterations and Dam Removal, Gray = Existing and No Change)

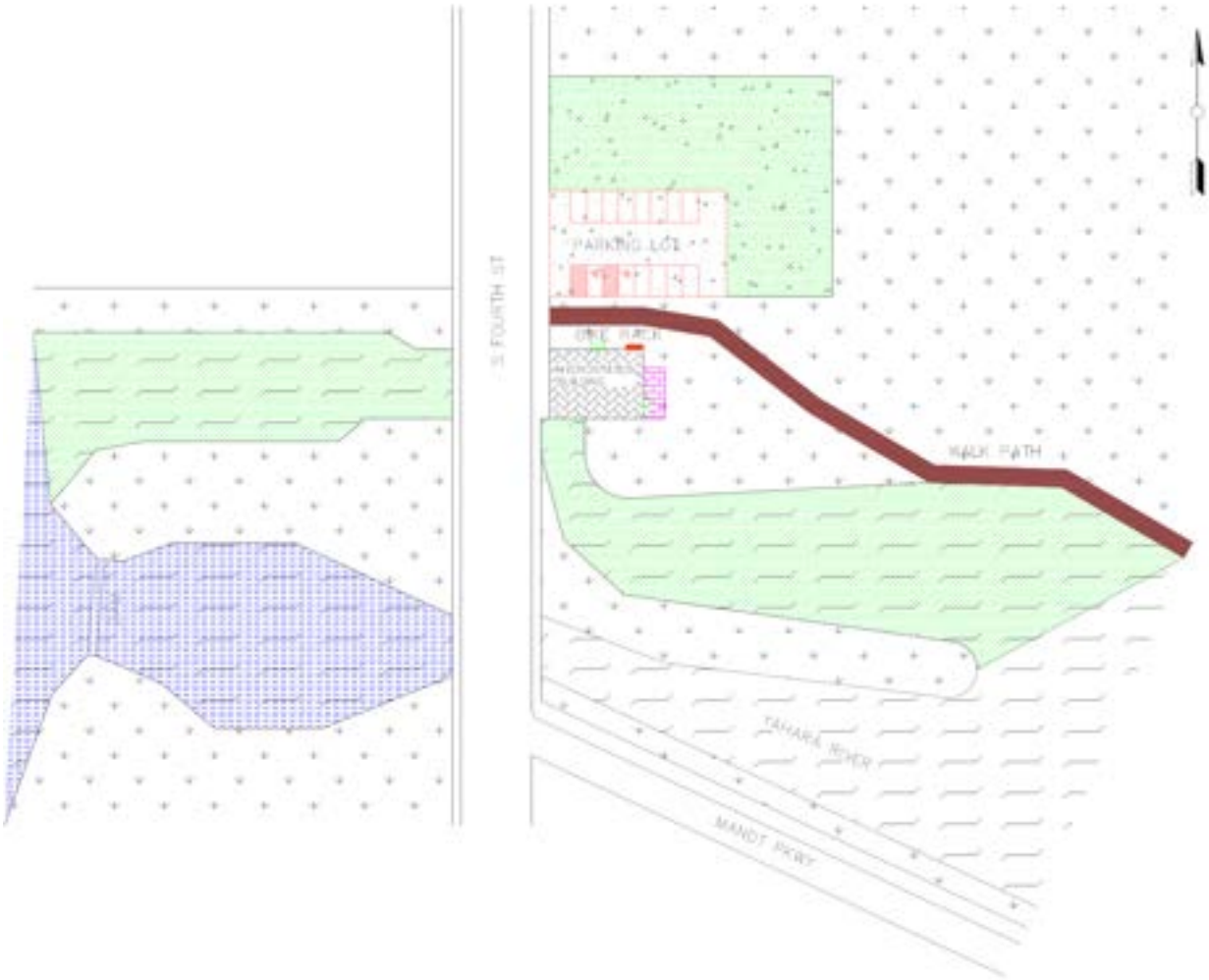


Figure 31: Community Center Proposed Site Conditions

(Green = Green Space Added, Blue = River Alterations and Dam Removal, Gray = Existing and No Change)

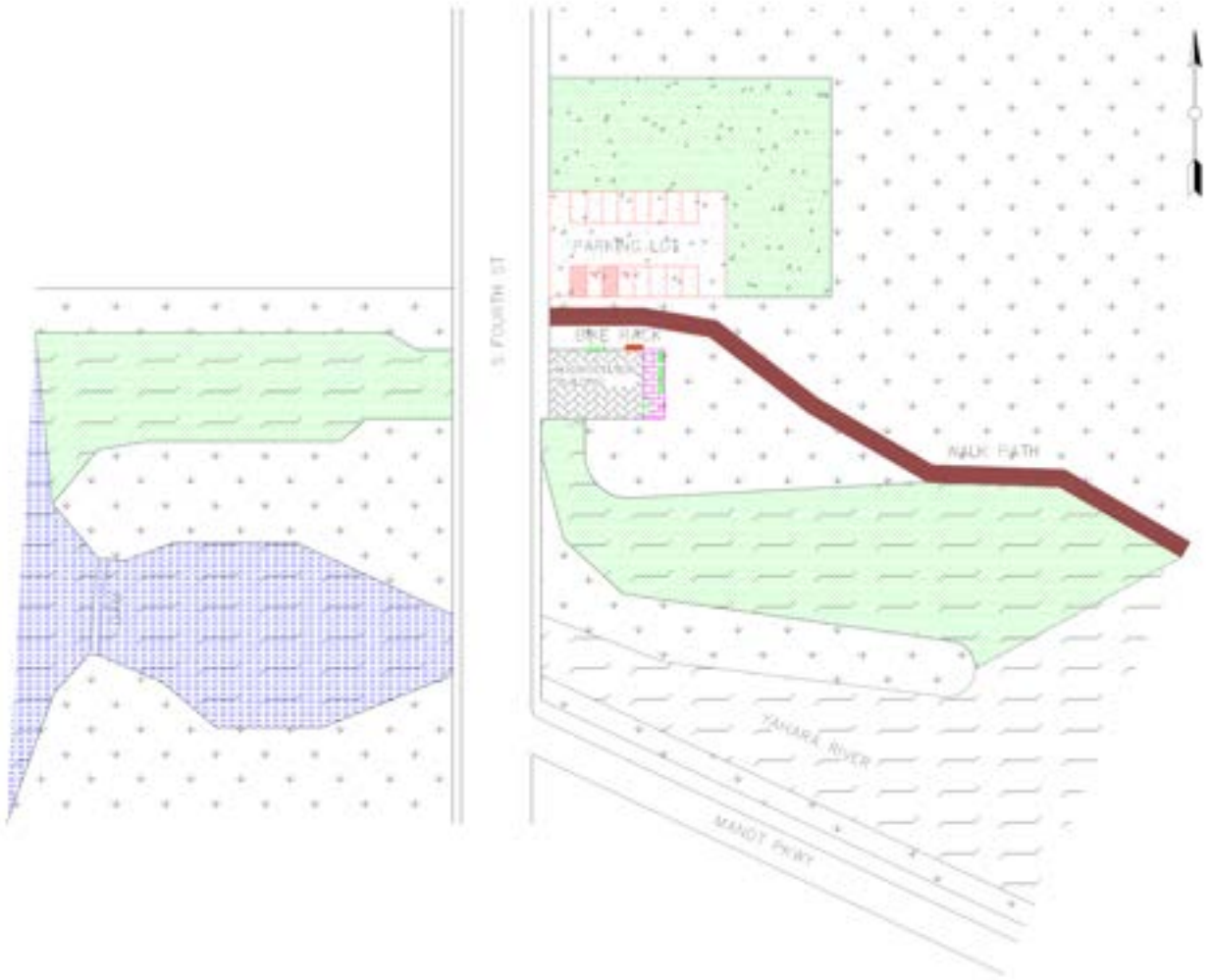


Figure 32: Privately Leased Café or Beer Garden Proposed Site Conditions

(Green = Green Space Added, Blue = River Alterations and Dam Removal, Gray = Existing and No Change)

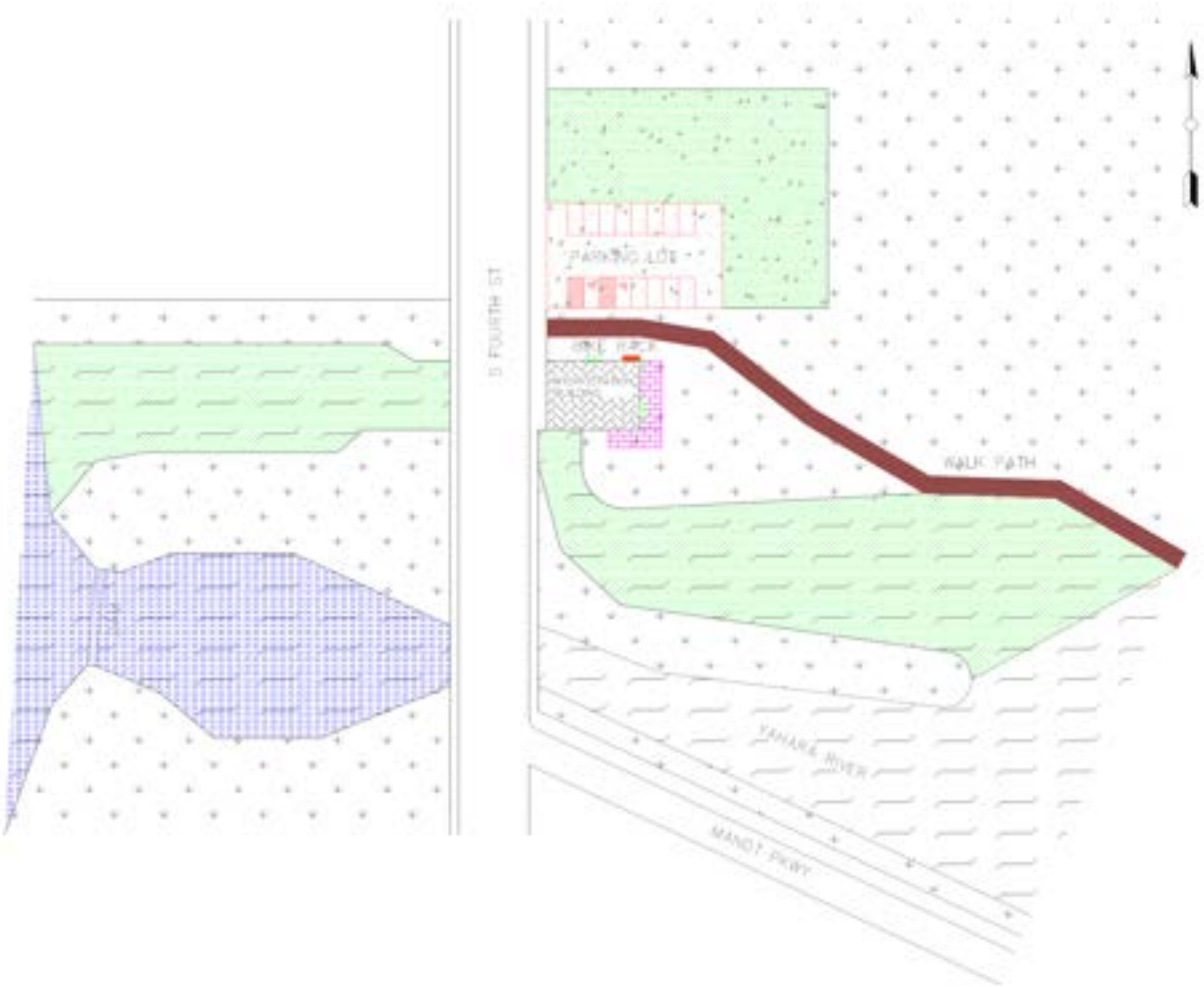


Figure 33: Topographic Map of Stoughton Area

Figure 34: Concept Map of the Yahara River Redevelopment Project

Appendix B: Hydrologic Analysis

Runoff Volume Calculations

Purpose:

To calculate the total runoff volume from the existing parking lot and the proposed parking lot on the Hydro Power Station site for the 1, 2-, 10-, 100-, and 200-year design storms. These runoff volume values will be compared to prove that the changes made to the parking lot will not cause excess runoff into the Yahara River.

Methodology:

Calculations are made using the TR-55 runoff analysis method in accordance with the City of Stoughton Municipal Code 10-131.

Assumptions:

- The existing parking lot is concrete
- 6,000 square feet provides sufficient parking lot space for the building's use
- The proposed parking lot is pervious pavements and an estimate "C" Value of 40.5 is used
    - This value is calculated based on National Resources Conservation Service's (NRCS) Web Soil Survey categorization of the soil as "silt loam" in Hydrologic Soil Group B
    - Calculations assume knowledge-based uncertainty in accordance with the Minnesota Stormwater Manual and United States Department of Agriculture's Soil Quality Indicators report that the silt loam soil infiltrates at a rate of $0.3\ \frac{in}{hr} = 0.76\ \frac{cm}{hr}$
    - A value of 40.5 is achieved from the American Society of Civil Engineer's (ASCE) Journal of Hydrologic Engineering
- The lower end of the "C" value range from Table 9 is used to analyze runoff volumes for the 1-, 2-, and 10-year storms
- The higher end of the "C" value range from Table 9 is used to analyze runoff volumes for the 100- and 200-year storms
- The parking lot is unconnected from any stormwater system and therefore the runoff will be sheet flow until absorbed into a pervious surface or the Yahara River.

Calculation Step 1: Determine 24 Hour rainfall intensities for the required design storms

24 Hour Rainfall data was collected for Stoughton, Wisconsin from the National Oceanic and Atmospheric Association (NOAA) point precipitation frequency estimates. The City of Stoughton requires runoff analysis for the one-, two-, ten-, 100-, and 200-year, 24-hour design storms. The rainfall intensities for these storms are below in Table 9.

Table 9: NOAA 24 Hour Design Storm Precipitation Values

10/16/23, 5:11 PM

Precipitation Frequency Data Server

NOAA Atlas 14, Volume 8, Version 2
Location name: Stoughton, Wisconsin, USA*
Latitude: 42.9168°, Longitude: -89.2173°
Elevation: 880 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF tabular | PF graphical | Maps & aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.366 (0.292-0.462)	0.422 (0.336-0.532)	0.516 (0.410-0.652)	0.596 (0.472-0.754)	0.710 (0.550-0.916)	0.801 (0.609-1.04)	0.894 (0.663-1.17)	0.991 (0.713-1.31)	1.12 (0.785-1.51)	1.22 (0.840-1.66)
10-min	0.537 (0.428-0.676)	0.618 (0.492-0.780)	0.756 (0.600-0.954)	0.873 (0.691-1.10)	1.04 (0.806-1.34)	1.17 (0.892-1.52)	1.31 (0.972-1.72)	1.45 (1.04-1.92)	1.64 (1.15-2.21)	1.79 (1.23-2.42)
15-min	0.654 (0.521-0.825)	0.754 (0.601-0.951)	0.922 (0.732-1.16)	1.06 (0.843-1.35)	1.27 (0.982-1.64)	1.43 (1.09-1.85)	1.60 (1.18-2.09)	1.77 (1.27-2.35)	2.00 (1.40-2.69)	2.19 (1.50-2.96)
30-min	0.920 (0.733-1.16)	1.06 (0.846-1.34)	1.30 (1.03-1.64)	1.50 (1.19-1.90)	1.79 (1.39-2.31)	2.02 (1.54-2.62)	2.26 (1.68-2.96)	2.50 (1.80-3.32)	2.84 (1.98-3.81)	3.09 (2.12-4.18)
60-min	1.17 (0.932-1.47)	1.37 (1.09-1.72)	1.70 (1.35-2.15)	1.99 (1.57-2.52)	2.40 (1.86-3.09)	2.72 (2.07-3.52)	3.05 (2.26-4.00)	3.40 (2.45-4.51)	3.87 (2.71-5.20)	4.24 (2.90-5.72)
2-hr	1.42 (1.14-1.76)	1.67 (1.35-2.08)	2.11 (1.69-2.62)	2.48 (1.98-3.09)	3.00 (2.35-3.82)	3.42 (2.63-4.38)	3.85 (2.89-4.99)	4.30 (3.13-5.64)	4.90 (3.47-6.52)	5.38 (3.73-7.20)
3-hr	1.56 (1.27-1.93)	1.85 (1.50-2.29)	2.35 (1.90-2.91)	2.78 (2.24-3.44)	3.39 (2.68-4.30)	3.88 (3.01-4.94)	4.39 (3.32-5.65)	4.92 (3.61-6.42)	5.64 (4.02-7.48)	6.21 (4.34-8.25)
6-hr	1.84 (1.51-2.24)	2.16 (1.78-2.64)	2.73 (2.24-3.34)	3.23 (2.64-3.96)	3.96 (3.18-4.98)	4.56 (3.59-5.75)	5.18 (3.98-6.62)	5.84 (4.35-7.56)	6.76 (4.89-8.87)	7.50 (5.30-9.86)
12-hr	2.16 (1.80-2.60)	2.49 (2.07-3.00)	3.07 (2.55-3.71)	3.60 (2.98-4.36)	4.40 (3.59-5.48)	5.06 (4.05-6.33)	5.78 (4.50-7.32)	6.55 (4.95-8.40)	7.64 (5.60-9.94)	8.52 (6.10-11.1)
24-hr	2.48 (2.09-2.94)	2.84 (2.39-3.37)	3.48 (2.93-4.14)	4.06 (3.40-4.85)	4.94 (4.09-6.09)	5.68 (4.60-7.02)	6.48 (5.11-8.11)	7.34 (5.61-9.31)	8.56 (6.35-11.0)	9.54 (6.91-12.3)
2-day	2.78 (2.38-3.26)	3.23 (2.76-3.79)	4.02 (3.42-4.72)	4.71 (4.00-5.55)	5.73 (4.78-6.94)	6.56 (5.37-7.99)	7.44 (5.93-9.17)	8.37 (6.47-10.5)	9.67 (7.26-12.3)	10.7 (7.86-13.7)
3-day	3.04 (2.62-3.54)	3.51 (3.02-4.09)	4.33 (3.72-5.05)	5.05 (4.32-5.90)	6.11 (5.13-7.34)	6.98 (5.75-8.43)	7.89 (6.34-9.68)	8.86 (6.90-11.0)	10.2 (7.73-12.9)	11.3 (8.36-14.3)

Calculation Step 2: Determine the appropriate curve numbers

For the existing concrete parking lot, a curve number of 80 will be used for the one-, two-, and 10-year design storms. A curve number of 95 will be used to calculate runoff volumes for the 100- and 200-year design storms as shown in Table 10. This is in accordance with the Wisconsin State Legislature Safety and Professional Services Detail B under Appendix 382.36 (4)-2 (Table 10).

Table 10: Wisconsin State Legislature SPS 382 Appendix Runoff Coefficients by Land Use

Land Use	Design Storm 24-Hour Event	Hydrologic Soil Group											
		A			B			C			D		
		Slope Range (%)			Slope Range (%)			Slope Range (%)			Slope Range (%)		
		0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6	0–2	2–6	> 6
Row Crops	2- and 10-year	0.08	0.16	0.22	0.12	0.20	0.27	0.15	0.24	0.33	0.19	0.28	0.38
	25-, 50-, and 100-year	0.22	0.30	0.38	0.16	0.34	0.44	0.30	0.37	0.50	0.34	0.41	0.56
Median Strip, turf	2- and 10-year	0.19	0.20	0.24	0.19	0.22	0.26	0.20	0.23	0.30	0.20	0.25	0.30
	25-, 50-, and 100-year	0.24	0.26	0.30	0.25	0.28	0.33	0.26	0.30	0.37	0.27	0.32	0.40
Slide Slope, turf	2- and 10-year	—	—	0.25	—	—	0.27	—	—	0.28	—	—	0.30
	25-, 50-, and 100-year	—	—	0.32	—	—	0.34	—	—	0.36	—	—	0.38
Pavement:													
Asphalt		0.70–0.95											
Brick		0.70–0.80											
Concrete		0.80–0.95											
Drives and Walks		0.75–0.85											
Roofs		0.75–0.95											
Gravel Roads Shoulders		0.40–0.60											

Source: Wisconsin department of transportation (WDOT), Facilities Development Manual (July 2, 1979), Procedure 13-10-5.

Note: The lower "C" values in each range should be used with the relatively low intensities associated with 2- to 10-year design recurrence intervals whereas the higher "C" values should be used for intensities associated with the longer 25- to 100-year design recurrence intervals.

Note: In parking lot runoff, visible sheen has been accepted as having an oil concentration of 15 mg/L.

The proposed parking lot will use permeable pavements and an estimated curve number of 40.5. Pervious pavements are designed to account for the native subsoil infiltration rate. This is because the water will drain through the pavement and infiltrate into the soil below. According to the National Resources Conservation Service's (NRCS) Web Soil Survey, the soil is a "silt loam" in Hydrologic Soil Group B with a 2 – 6% slope (Figure 36). The Minnesota Stormwater Manual (Figure 37) places the infiltration rate of silt loam soil at $0.3\ \frac{in}{hr} = 0.76\ \frac{cm}{hr}$. This is in accordance with the United States Department of Agriculture's Soil Quality Indicators report where they provided the range of $0.2 – 0.4\ \frac{in}{hr}$ for loam infiltrations (Figure 38). With further research from the American Society of Civil Engineer's Journal of Hydrologic Engineering, an expected curve number for permeable pavements is found to be 40.5 (Figure 39).

Figure 35: NRCS Web Soil Survey Area of Interest

Figure 36: Classification of Soil in Area of Interest as Silt Loam

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
KeB	Kegonsa silt loam, 2 to 6 percent slopes	5.6	98.0%
W	Water	0.1	2.0%
Totals for Area of Interest		**5.7**	**100.0%**

Figure 37: Minnesota Stormwater Manual Infiltration Rates by Soil Type

Hydrologic soil group	Infiltration rate (inches/hour)	Infiltration rate (centimeters/hour)	Soil textures	Corresponding Unified Soil Classification[hyperscript text]
A	Although a value of 1.63 inches per hour (4.14 centimeters per hour) may be used, it is ***Highly recommended*** that you conduct field infiltration tests or amend soils.[b] See Guidance for amending soils with rapid or high infiltration rates and Determining soil infiltration rates.		gravel sandy gravel	GW - Well-graded gravels, fine to coarse gravel GP - Poorly graded gravel
	1.63[a]	4.14	silty gravels gravelly sands sand	GM - Silty gravel SW - Well-graded sand, fine to coarse sand
	0.8	2.03	sand loamy sand sandy loam	SP - Poorly graded sand
B	0.45	1.14	silty sands	SM - Silty sand
	0.3	0.76	loam, silt loam	MH - Elastic silt
C	0.2	0.51	Sandy clay loam, silts	ML - Silt
D	0.06	0.15	clay loam silty clay loam sandy clay silty clay clay	GC - Clayey gravel SC - Clayey sand CL - Lean clay OL - Organic silt CH - Fat clay OH - Organic clay, organic silt

Figure 38: United States Department of Agriculture's Soil Quality Indicator Report for Infiltration Rates by Soil

Soil Type	Steady Infiltration Rate (in/hr)
Sands	> 0.8
Loams	0.2 - 0.4
Clays	0.04 - 0.2

Figure 39: ASCE Expected Curve Number for Permeable Pavement by Infiltration Rate

(1)	(2)		(3)		(4)		(5)		(6)	
Subsoil infiltration rate	0.13 cm/h (0.05 in./h)		0.38 cm/h (0.15 in./h)		0.76 cm/h (0.3 in./h)		1.27 cm/h (0.5 in./h)		2.54 cm/h (1.0 in./h)	
Subbase thickness										
Drained *Undrained*	29.9 cm (11.8 in.)	38.4 cm (15.1 in.)	31.1 cm (12.2 in.)	33.2 cm (13.1 in.)	na	27.1 cm (10.7 in.)	na	23.2 cm (9.1 in.)	na	18.3 cm (7.2 in.)
Drawdown time										
Drained *Undrained*	63 h[a]	305 h	71.5 h[b]	93 h	na	43 h	na	23.3 h	na	12 h
Drains	9–2.54 cm UD[c]		2–2.54 cm UD[c]		None		None		None	
ECN	87.3		60.6		40.5		36.7		28	
10-year storm, percent infiltrated	23.2		76.7		100		100		100	

Note: na=not applicable.

[a]Includes nine 2.54-cm underdrains.

[b]Includes two 2.54-cm underdrains.

[c]UD—underdrain.

Calculation Step 3: TR-55 Runoff Analysis

The necessary equations from the TR-55 are listed below:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{Equation 1}$$

$$S = \frac{1000}{CN} - 10 \qquad \text{Equation 2}$$

$$V = QA \qquad \text{Equation 3}$$

Q = Runoff depth (in)

P = Precipitation from 24 Hour Design Storm (in)

S = Maximum storage potential after runoff begins (in)

CN = Expected curve number

V = Volume of runoff (ft^3)

A = Area of parking lot (ft^2)

For the existing parking lot:

$S = \frac{1000}{80} - 10$ = 2.5 for the 1-, 2-, and 10-year design storms

$S = \frac{1000}{95} - 10$ = 0.53 for the 100- and 200-year design storms

Example calculations are shown for the 100-year design storm, P = 6.48 in

$Q = \frac{(6.48-0.2*0.53)^2}{(6.48+0.8*0.53)}$ = 5.89 in = 0.49 ft

The parking lot is 20,000 ft^2; therefore, the total runoff volume is:

V = (0.491 ft)*(20,000 ft^2) = **9,807 ft^3**

For the proposed parking lot:

$S = \frac{1000}{40.5} - 10$ = 14.69 for all design storms

Example calculations are shown for the 100-year design storm, P = 6.48 in

$Q = \frac{(6.48-0.2*14.69)^2}{(6.48+0.8*14.69)}$ = 0.68 in = 0.057 ft

The parking lot is 6,000 ft^2; therefore, the total runoff volume is:

V = (0.057 ft)*(6,000 ft^2) = 344 ft^3

Total runoff reduction for the 100-year storm

V = 9,807ft^3 – 344 ft^3 = **9,464 ft^3**

$$\text{Percent runoff reduced} = \frac{9{,}464\ ft^3}{9{,}807\ ft^3} * 100\% = \mathbf{96.5\%}$$

Results

Reducing the parking lot size and implementing permeable pavements will significantly decrease runoff volumes for all design storm events. In fact, for the 100-year design storm, there will be a 96.5% reduction in runoff from the parking lot. A detailed chart of all runoff values and percent reductions is provided in the Hydrologic Analysis section.

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Appendix C: Structural Analysis

Structural Figures

Figure 40: White Model of Initial Condition (Revit)

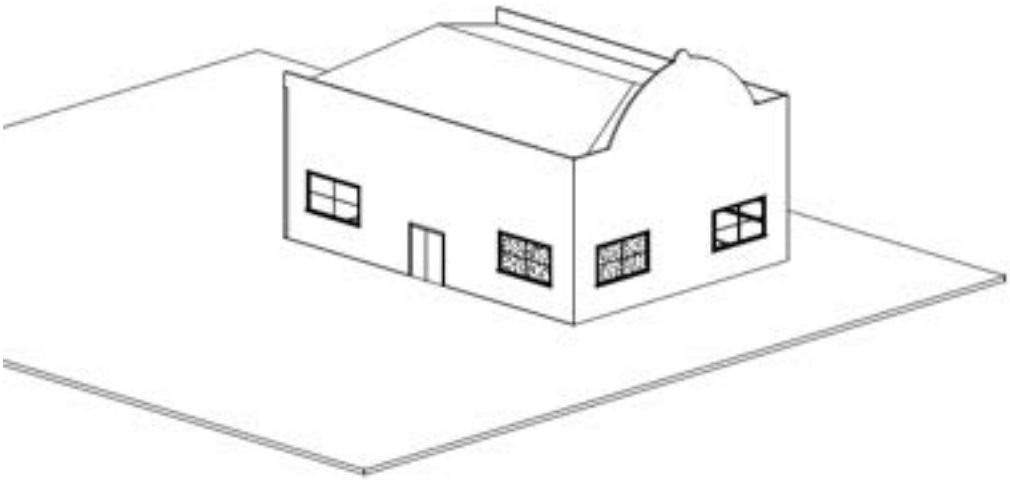

Figure 41: Simple White Model Rendering Intended to Indicate Scale and Form, Not Historical Information (Revit)

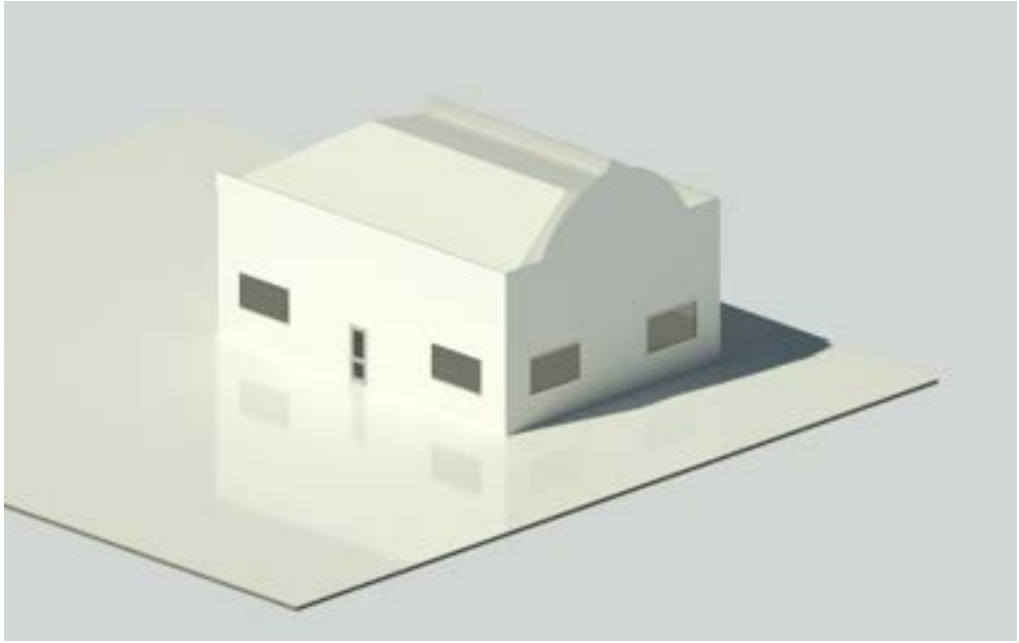

Figure 42: Snow load in psf for the State of Wisconsin from Trusses and Lumber, Inc Adapted from Wisconsin Legislature SPS 321.02 Loads and Materials

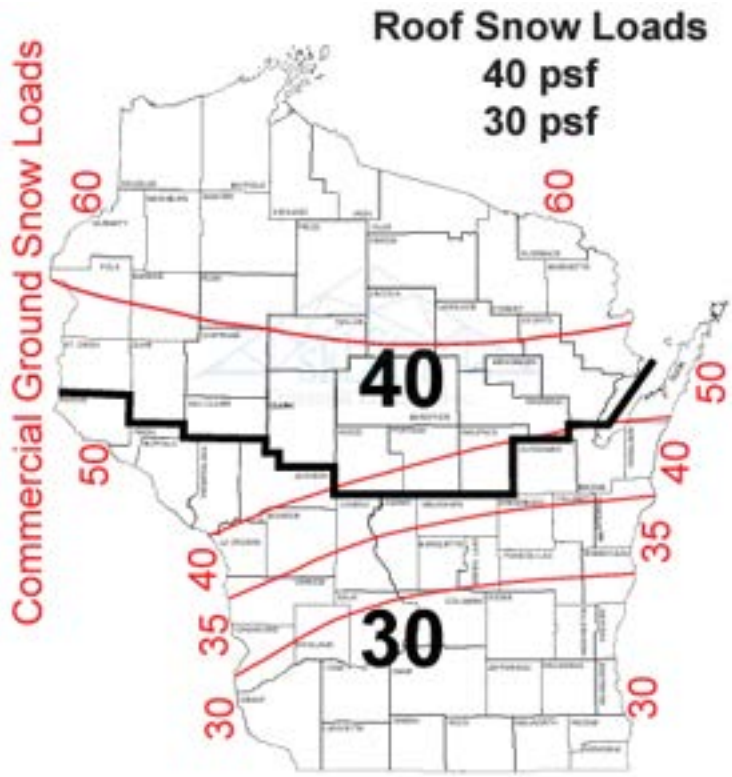

Figure 43: NOAA Atlas Depth-Duration-Frequency Estimates from Station 47-8229 located in Stoughton, WI used for Rain Loading Calculations

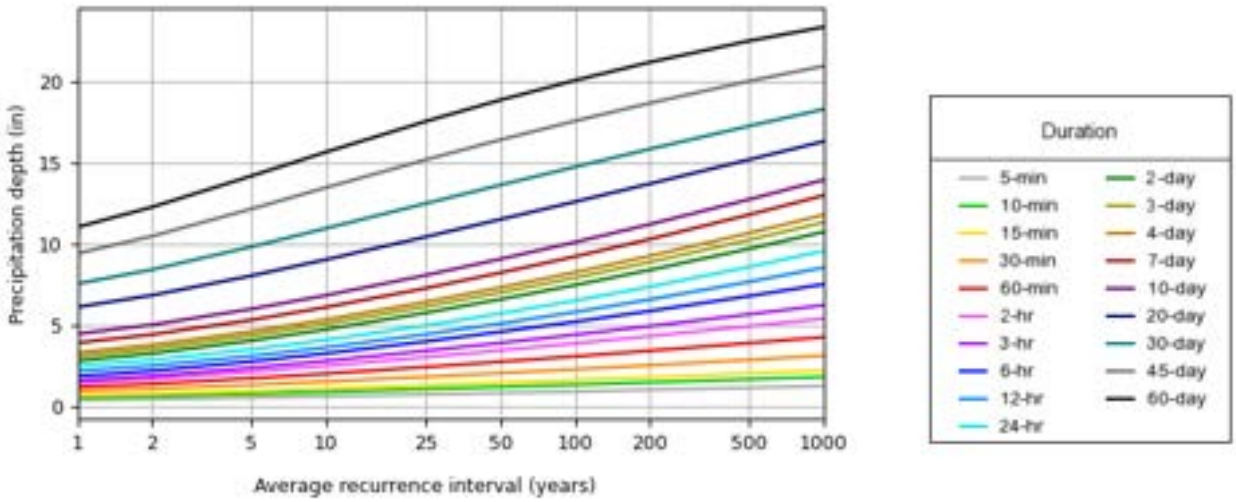

Figure 44: Ultimate Design Wind Speeds for the United States from the Wisconsin Building Code: Chapter 16 Structural Design

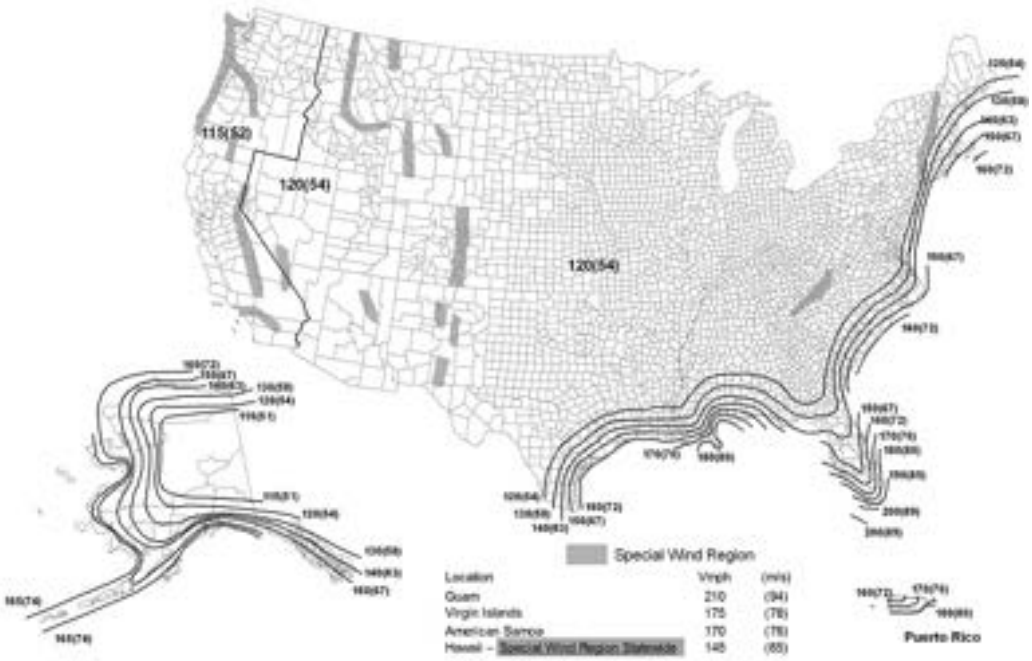

Figure 45: Risk Category of Buildings and Other Structures from the International Building Code Chapter 16: Section 1604.5

Risk Category	Nature of Occupancy
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities
II	Buildings and other structures except those listed in Risk Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident care recipients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5000[a] • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1 (2) or per outdoor control area in accordance with the International Fire Code, and Are sufficient to pose a threat to the public if released[b]
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response • Power generating stations and other public utility facilities required as emergency back up facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: Exceed maximum allowable quantities per control area given in Table 307.1(2) or per outdoor control area in accordance with the International Fire Code Are sufficient to pose a threat to the public if released[b] • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions • Water storage facilities and pump structures required to maintain water pressure for fire suppression

Structural Calculations

Table 11 shows common units used in structural calculations and what they stand for.

Table 11: Summary of Units seen in Calculations

Unit	Numerical Unit
lbs	pounds
psf	Pounds per square foot
sf	Square foot
in	inches
pcf	Pounds per cubic foot
mph	Miles per hour
ft	feet
gal	gallons

Rain, Wind and Snow Loading Calculations

Purpose:

To calculate rain, wind, and snow loadings that will act on the building throughout its lifecycle to be used in final loading calculations of ASD to satisfy strength requirements for the safety of people and the structure.

Methodologies:

Following the Wisconsin Administrative Code: Construction Standards Chapter SPS 321, wind and roof minimum live loadings were found. In Stoughton WI, there is a minimum roof design loading of 30 psf for snow loadings (Figure 42) and a minimum wind speed design of 125 mph (Figure 44). The International Building Code (IBC) states that for design rain loads, the design rainfall shall be based on the 100-year, 15-minute duration event found in Table 9.

Assumptions:

- ds was estimated based on the duration event number and drainage.
    - This is a data-based uncertainty as there seems to be only two exit points for the rain off the east facing side of the building. It was also assumed that it would be immensely difficult for the primary drainage system to be blocked as there is no gutter system and the rain flows directly off the roof.
- The roof is assumed not to be susceptible to ponding

Calculations:

Part 1 - Snow Calculations:

The snow loading was given as a minimum roof design load, so no further calculations were needed.

S = **30 psf**

Part 2 - Rain Calculations:

As mentioned, the IBC has rain load calculation criteria and Section 1611.1 was followed. The equation for rain load calculation is shown below:

$$R = 5.2(ds+dh) \qquad \text{Equation 4}$$

where:

dh = Additional depth of water of the undeflected roof above the inlet of secondary drainage system at its design flow [in]

- dh = 1.6 in obtained from NOAAs average 100-year 15-minute duration event for Stoughton, WI

ds = Depth of water on the undeflected roof up to the unlet of secondary drainage system when the primary drainage system is blocked [in]

- ds = 2.0 in

R = Rain load on the undeflected roof [psf]

$$R = 5.2(2.0 + 1.6) = \mathbf{18.72\ psf}$$

Part 3 - Wind Calculations:

As mentioned in methodologies, construction standards call for a minimum wind speed design of 125 mph. To calculate the loading, or pressure, in psf, a conversion factor was used.

$$W = ws^2 * 0.00256 \qquad \text{Equation 5}$$

where:

W = wind load [psf]

ws = minimum wind speed design [mph]

$$W = 125^2 * 0.00256 = \mathbf{40\ psf}$$

Results:

Table 12 includes the environmental loadings that were calculated and minimum design loading requirements. These will be used in further calculations for combinational loading in the loading calculation section. The rain load will not play a significant role in final calculations and structural design as the minimum snow load is greater than the calculated rain load.

Loading Calculations

Purpose:

To design for structural strength, dead loads and live loads need to be considered and calculated to satisfy safety and strength requirements. Combination loading is used to check that stresses imposed on structures will be able to handle the loadings without exceeding elastic limits of the materials.

Methodologies:

Dead loads are calculated following American Society of Civil Engineers (ASCE) 7 Standards and consider gravity loads that depend on material densities. An Allowable Stress Design (ASD) methodology from Section 2.3.1 and 2.4.1 of the ASCE 7-16 is used in the combination loadings. These will use minimum material densities, live loads are taken from minimum live load standards, and environmental loadings calculated or taken from national and local weather data.

For ASD, the load combinations are as follows:

1. D
2. (D + L)
3. D + (L_r or S or R)
4. D + 0.75L + 0.75(Lr or S or R)
5. D + (0.6W)

Where:

D = Dead Load

L = Live Load due to minimum design load occupancy

Lr = Roof Live Load

S = Snow Load

R = Nominal loading due to initial rainwater or ice

W = Wind Load

Assumptions:

- Minimum design live loads and dead loads used are in Table 12
- ASD assumes all materials satisfy applicable conditions of equilibrium and compatibility of constraints
- The deck will be made of plywood with a density of 36 $\frac{lb}{ft^3}$ with a thickness of 0.333 feet
- Existing materials such as I-beams, bricks, and concrete are assumed for dead load approximations
- Thickness of the floor is assumed to be 8 inches
- Thickness of insulation is assumed to be 3 inches
- Deck will be built around the cistern for the community center alternative

Live loads include any moveable objects such as tables, chairs, or garden beds.

Calculations:

Part 1: Roof Combination Loading

$$D = \sum \text{(dead load of materials included in system)} \qquad \text{Equation 6}$$

$$\text{Gravity Load} = D + (L_r \text{ or } S \text{ or } R) \qquad \text{Equation 7}$$

Where:

D = Dead Load [psf]

Lr = Live Load from Roof [psf]

S = Snow Load [psf]

- S = 30 psf

R = Nominal loading due to initial rainwater or ice [psf]

D = Aluminum Alloy + Insulation + Suspended Steel Channel System + Skylight

D = 3 + 8 + 2 + 0.5*3 = **14.5 psf**

Gravity Load = 14.5 + 30 = **44.5 psf**

Part 2: Floor Combination Loading

D = Cinder Concrete Fill*t + Interior Beams + Insulation Equation 8

Gravity Load = D + L Equation 9

Where:

D = Dead Load calculated using Equation 6 [psf]

L = Minimum Live Load [psf]

- L = 40 psf

t = Thickness of concrete [in]

- t = 3 inches

D = 9*8 + 40 + 0.5*3 = **113.5 psf**

Gravity Load = 113.5 + 40 = **153.5 psf**

Part 3: Deck Loadings

$D = \rho * t$ Equation 10

Where:

D = Dead Load [psf]

ρ = Density of material [pcf]

- ρ = 36 pcf

t = thickness of material [ft]

- t = 0.333 ft

D = 36 * 0.333 = **12 psf**

Results:

All calculated loadings are included in Table 12. The floor combination loading is under the assumed live load design of 250 psf and therefore will be structurally stable. The deck dead load can be used in combination with the design areas to determine footing and stabilization in the geotechnical analysis.

Cistern Size Calculations

Purpose:

The community center alternative has a unique aspect to its' design that includes a cistern for non-potable water use and a mechanism for rainwater capture. This will be used for the garden beds on the deck as well as educational purposes.

Methodologies:

Cistern sizes depend on multiple variables such as rainwater frequency, what the captured water will be used for, and how often the water will be used. A cistern guide from the City of Chicago Department of Environment was used for Part 1 calculations in combination with qualitative analysis to determine a sufficient cistern size needed for the community center garden.

Assumptions:

- There will be an overflow outlet
- Run off coefficient was assumed to be 0.90 for metal roofing
- Cistern will not be utilized in the winter (9 months / year)
- Stoughton experiences 36 inches of rain on average annually
- Three garden beds will be located on or near the medium sized deck
- 0.623 $\frac{gallons}{ft^2}$ a week are assumed to be needed for garden beds according to the University of California School of Agriculture and Natural Resource

Calculations:

Part 1: Amount of water that can be captured in a 1-inch rain event

$$G = A * 1/12 * RC * 7.48 \qquad \text{Equation 11}$$

Where:

G = Rainwater captured in a 1-inch rain event [gal]

A = Collection area [sf]

- Area of the Roof = 2000 sf

RC = Runoff Coefficient

- RC = 0.90

7.48 = conversion factor cf to gal

$$G = 2000 * (1/12) * 0.90 * 7.48 = \mathbf{1122\ gallons}$$

Part 2: Estimated amount of water used monthly

$$W = 0.623*A*N*K \qquad \text{Equation 12}$$

Where:

W = water needed for nine-month usage [gallons]

A = Area of garden bed [sf]

- A = 4ft x 3ft = 12 sq. ft

N = Number of garden beds

- N = 3

K = Weeks of usage

- K = 36

W = 0.623 * 12 * 3 * 36 = **807 gallons**

Part 3: Final Calculation

In a one-inch rain event, about 1,120 gallons can be captured from roof runoff and over the course of nine months it is estimated that 807 gallons will be needed for proper watering of garden beds. Taking into consideration that the water may be used for other non-potable usages, a cistern that holds 1,000 gallons would be sufficient for needs.

Results:

Using both qualitative and quantitative metrics, a 1,000-gallon cistern is recommended with an overflow outlet. Stoughton annually receives 36 inches of rain on average and therefore the cistern is expected to have enough water throughout the months of its usage for watering plants. The dimensions are anticipated to be 8ft tall and 5ft wide in diameter and rain will be collected from runoff from the roof.

Table 12: Known and Calculated Loadings

Structure/Materials	Design Load (psf)
Initial Assumed Design Live Loading – Heavy Equipment Warehouse	250
Alternative 1 – Minimum Live Load	40
Alternative 2 – Minimum Live Load	40
Alterative 3 - Minimum Live Load	40
Roof – Minimum Live Load	30
Deck – Minimum Live Load	40
Snow Load [S]	30
Rain Load [R]	18.72
Wind Load [W]	40
Deck – Dead Load	12
First Floor –Dead Load	153.5
Roof – Dead Load	44.5
8 – inch Clay Brick Wythes – Dead Load	79
Windows, glass, frames, and sash- Dead Load	8
Suspended steel channel system	2
Deck, metal 18 Gauge – Dead Load	3
Skylight, metal frame, 3/8-in. wire glass	8

Table 13: Assumed Materials to be Used that are Subject to Change with Design Finalization

Materials and Planned Usage	Design Densities (psf/inch)
Plywood – Deck	3
Cinder Concrete Fill – First Floor	9
Concrete Finish – First Floor	12
Steel – I-Beam Frames	41
Urethane Insulation Foam – First floor and roof	0.5

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Appendix D: Decision Matrices and Cost Analysis:

Table 14: Weighted Entries for Decision Making Criteria

Matrix 1 - Project Specific Data Entry						
Input	Input	Input	Input	Input	Input	
Goal: Max or Min?	*Criteria*	*Units*	Equipment Storage and Rental	Center for Community Engagement	Privately Leased Café	Total
Min	Net Present Cost	$	2,383,560	1,932,274	1,459,946	5,775,779
Min	Construction Duration	Weeks	61	63	67	191
Max	Self Sustaining Financially	0 - 1	0.5	0.2	1	1.7
Min	Lifetime Environmental Impact	0 - 1	0.3	0.2	0.6	1.1
Max	Community Impact	0 - 1	0.5	0.9	0.4	1.8

Table 15: Automatic Calculation for Decision Matrix

Matrix 2 - Automatic Calculation to Normalize Alternatives				
Normalized Matrix	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**	
Criteria	**Criteria / Total**	**Criteria / Total**	**Criteria / Total**	**Total**
Net Present Cost	0.4127	0.3345	0.2528	1.0
Construction Duration	0.3194	0.3298	0.3508	1.0
Self Sustaining Financially	0.2941	0.1176	0.5882	1.0
Lifetime Environmental Impact	0.2727	0.1818	0.5455	1.0
Community Impact	0.2778	0.5000	0.2222	1.0

Table 16: Automatic Calculation for Decision Matrix

Matrix 3 - Automatic Calculation					
Goal	***Max Matrix***	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**	**Total**
Min	Net Present Cost	0.5873	0.6655	0.7472	2.0
Min	Construction Duration	0.6806	0.6702	0.6492	2.0
Max	Self Sustaining Financially	0.2941	0.1176	0.5882	1.0
Min	Lifetime Environmental Impact	0.7273	0.8182	0.4545	2.0
Max	Community Impact	0.2778	0.5000	0.2222	1.0

Table 17: Automatic Calculation for Decision Matrix

Matrix 4 - Automatic Calculation				
Normalized Max Matrix Adjusted	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**	**Total**
Net Present Cost	0.2937	0.3327	0.3736	1.00
Construction Duration	0.3403	0.3351	0.3246	1.00
Self Sustaining Financially	0.2941	0.1176	0.5882	1.00
Lifetime Environmental Impact	0.3636	0.4091	0.2273	1.00
Community Impact	0.2778	0.5000	0.2222	1.00

Table 18: Matrix for Criteria Weight

Matrix 5 - Input Criteria Weight					
Weighting Matrix	**Input Weight**	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**	
Net Present Cost	0.55	0.1615	0.1830	0.2055	
Construction Duration	0.05	0.0170	0.0168	0.0162	
Self Sustaining Financially	0.15	0.0441	0.0176	0.0882	
Lifetime Environmental Impact	0.1	0.0364	0.0409	0.0227	
Community Impact	0.15	0.0417	0.0750	0.0333	
Total	1.0	0.3007	0.3333	**0.3660**	Final Score

Table 19: Final Decision Matrix

Matrix 6 - Presentation Matrix					
Criteria	Input Weight	Equipment Storage and Rental	Center for Community Engagement	Privately Leased Café	
Net Present Cost	55%	16.2%	18.3%	20.5%	
Construction Duration	5%	1.7%	1.7%	1.6%	
Self Sustaining Financially	15%	4.4%	1.8%	8.8%	
Lifetime Environmental Impact	10%	3.6%	4.1%	2.3%	
Community Impact	15%	4.2%	7.5%	3.3%	
Total	100%	30.1%	33.3%	36.6%	Final Score

Table 20: Individual Costs for All Alternatives

Equipment Storage and Rental		Center for Community Engagement		Privately Leased Café	
Item	Cost	Item	Cost	Item	Cost
General Conditions		General Conditions		General Conditions	
Permitting	$5,000	Permitting	$5,000	Permitting	$8,000
Site Work		Site Work		Site Work	
Permeable Paving	$42,000	Permeable Paving	$42,000	Permeable Paving	$42,000
Landscaping	$10,000	Landscaping	$10,000	Landscaping	$10,000
Exterior Deck	$9,000	Exterior Deck	$12,000	Exterior Deck	$19,000
Selective Building Demo	$45,000	Selective Building Demo	$45,000	Selective Building Demo	$45,000
Abatement	$20,000	Abatement	$20,000	Abatement	$20,000
Masonry/Structural Repair	$125,000	Masonry/Structural Repair	$125,000	Masonry/Structural Repair	$125,000
Floor Repairs	$18,000	Floor Repairs	$18,000	Floor Repairs	$18,000
Roofing/Skylight	$55,000	Roofing/Skylight	$55,000	Roofing/Skylight	$55,000
Insulation	$35,000	Insulation	$35,000	Insulation	$35,000
Exterior Door/Window	$100,000	Exterior Door/Window	$100,000	Exterior Door/Window	$100,000
Interior Doors/Walls	$30,000	Interior Doors/Walls	$38,000	Interior Doors/Walls	$45,000
Painting	$15,000	Painting	$15,000	Painting	$15,000
Mechanical	$40,000	Mechanical	$40,000	Mechanical	$60,000
Electrical	$70,000	Electrical	$80,000	Electrical	$90,000
Plumbing	$40,000	Plumbing	$55,000	Plumbing	$70,000
FFE	$45,000	FFE	$55,000	FFE	$75,000
Total Construction Cost = $704,000 Cost per sq foot = $251		**Total Construction Cost = $750,000 Cost per sq foot = $268**		**Total Construction Cost = $832,000 Cost per sq foot = $297**	
Contingency (25%)	$176,000	Contingency (25%)	$188,000	Contingency (25%)	$208,000
Architect/Engineering Fee	$223,000	Architect/Engineering Fee	$223,000	Architect/Engineering Fee	$223,000
Total Project Cost = $1,103,000		**Total Project Cost = $1,161,000**		**Total Project Cost = $1,263,000**	

Table 21: 30 Year Life Cycle Analysis

30 Year Life Cycle Cost Analysis			
Description	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Capital Cost	$1,103,000	$1,161,000	$1,263,000
Annual O&M Cost	$66,000	$40,000	$10,000
Net Present Cost	**$2,397,000**	**$1,945,000**	**$1,459,000**

Table 22: Alternative 1 – Equipment Storage and Rental Project Costs

Alternative 1: Equipment Storage and Rental				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$233	$653,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Medium Deck	344	$/sq foot	$25	$9,000
Subtotal - Construction				$704,000
Construction Contingency	25%	%*Subtotal	$704,000	$176,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,103,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	2	Salary/Year	$20,800	$42,000
Subtotal - Staffing				$42,000
Utilities	2800	$/sq foot	$2.1	$6,000
Repairs and Maintenance	2800	$/sq foot	$2.5	$7,000
Subtotal - Utilities and Services				$13,000
O&M Contingency	20%	%*Subtotal	$55,000	$11,000
Annual O&M Costs				$66,000

Table 23: Alternative 2 – Center for Community Engagement Project Costs

Alternative 2: Center for Community Engagement				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$249	$696,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Large Deck w/ Cistern	470	$/sq foot	$25	$12,000
Subtotal - Construction				$750,000
Construction Contingency	25%	%*Subtotal	$750,000	$188,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,161,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	2	Salary/Year	$10,400	$21,000
Subtotal - Staffing				$21,000
Utilities	2800	sq / type	$2.1	$6,000
Repairs and Maintenance	2800	$/sq foot	$2.2	$6,000
Subtotal - Utilities and Services				$12,000
O&M Contingency	20%	%/Subtotal	$33,000	$7,000
Annual O&M Costs				$40,000

Table 24: Alternative 3 – Privately Leased Café Project Costs

Alternative 3: Privately Leased Café				
Capital Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Base Construction Cost	2800	$/sq foot	$275	$771,000
Permeable Pavement	6000	$/sq foot	$7	$42,000
Large w/ Wrap Deck	770	$/sq foot	$25	$19,000
Subtotal - Construction				$832,000
Construction Contingency	25%	%*Subtotal	$832,000	$208,000
Architect/Engineering Fee				$223,000
Total Project Cost				$1,263,000

Annual Operational and Maintenance Costs				
Description	**Quantity**	**Unit Type**	**Unit Cost**	**Total Cost**
Staffing Salary	N/A	N/A	N/A	N/A
Subtotal - Staffing				N/A
Utilities	N/A	N/A	N/A	N/A
Repairs and Maintenance	2800	$/sq foot	$3	$8,000
Subtotal - Utilities and Services				$8,000
O&M Contingency	20%	%/Subtotal	$8,000	$2,000
Annual O&M Costs				$10,000

Table 25: Summary of Probable Costs

Summary of Opinions of Probable Cost			
Cost Type	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Capital Cost	$1,103,000	$1,161,000	$1,263,000
Annual O&M Cost	$66,000	$40,000	$10,000

Table 26: Summary of Capital Costs for All Alternatives

Capital Costs			
Cost Item	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Base Construction Cost	$653,000	$696,000	$771,000
Permeable Pavement	$42,000	$42,000	$42,000
Deck Option	$9,000	$12,000	$19,000
Construction Contingency	$176,000	$188,000	$208,000
Architect/Engineering Fee	$223,000	$223,000	$223,000
Total Project Cost	**$1,103,000**	**$1,161,000**	**$1,263,000**

Table 27: Summary of Annual O&M Costs for All Alternatives

Annual Operation and Maintenance Costs			
Cost Item	**Equipment Storage and Rental**	**Center for Community Engagement**	**Privately Leased Café**
Staffing Salary	$42,000	$21,000	N/A
Utilities	$6,000	$6,000	N/A
Repairs/Maintenance	$7,000	$6,000	$8,000
O&M Contingency	$11,000	$7,000	$2,000
Annual O&M Cost	**$66,000**	**$40,000**	**$10,000**

Appendix E: References

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