Greenspace Report

School of Urban and Regional Planning

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A PROGRAM OF The University of Iowa Office of Outreach & Engagement

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a program of the Provost's Office of Outreach and Engagement at the University of Iowa that partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and coursework. Through supporting these projects, the IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

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THE DOWNTOWN GREENSPACE PLAN

SIOUX CITY, IOWA

MAY 2016

This plan was created by Master's students in the School of Urban and Regional Planning at the University of Iowa as part of the Iowa Initiative for Sustainable Communities.

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This project began in August of 2015 and culminated in May of 2016. The Greenspace Sioux City Team maintained a blog detailing their progress over time. Visit https://greenspacesc.wordpress.com/ for more information.

GREENSPACE
SIOUX CITY

ACKNOWLEDGEMENTS

The Greenspace Sioux City team would like to thank the following people for their help throughout the planning process. Their insight and expertise greatly assisted the development of this plan.

Downtown Partners Sioux City

- Ragen Cote; *Executive Director*
- Sarah Fish; *Administrative Assistant*

City of Sioux City

- Charlie Cowell; *Planner*
- Matthew Salvatore; *Parks and Recreation Director*

Siouxland Metropolitan Planning Council

- Michelle Bostinelos; *Executive Director*
- Kathryn Pfaffle; *Transportation Modeler/GIS Specialist*

The University of Iowa

- Theresa Blossom; *Administrative Services Coordinator, School of Urban and Regional Planning*
- Dr. Chuck Connerly; *Director and Professor, School of Urban and Regional Planning*
- Dr. Lucie Laurian; *Associate Professor, School of Urban and Regional Planning*
- Dr. Scott Spak; *Assistant Professor, School of Urban and Regional Planning*
- Dr. Christopher Stoakes; *Research Scientist, College of Engineering*

Iowa Initiative for Sustainable Communities

- Nick Benson; *Program Director*
- Sarah SanGiovanni; *Program Coordinator*

Sioux City Public Museum

- Deanna Mayo; *Administrative Assistant*

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

The Downtown Greenspace Plan improves the quantity and quality of greenspaces in order to enhance the social, economic, and environmental vitality of downtown Sioux City. The purpose of this plan is to provide Sioux City with a framework to optimize the development of greenspace in downtown.

This plan proposes strategies to increase social well-being for downtown employees, residents, and visitors by improving the livability and walkability of downtown through the establishment of a dense network of pocket parks, green streetscapes, and greenspace retrofits. Additional greenspace will support the economic health of downtown by creating aesthetically pleasing destinations linking the district's existing attractions. Increasing downtown greenspace will provide ecosystem services and improve the resiliency of downtown Sioux City by improving soil quality and plant health, increasing natural means of handling stormwater runoff, and mitigating heat island effects.

The plan is based on a series of existing conditions assessments, two public engagement opportunities, collaboration with project partners, and conceptual renderings for downtown greenspace and recommends ways to facilitate the development of greenspace in downtown. Greenspace recommendations focus on ensuring that greenspace is of high quality aesthetically, environmentally, and functionally. It promotes the establishment of high quality, healthy, and low-maintenance greenspaces.

Recommendations aim to increase access to greenspaces by current and future residents, workers, and visitors by fostering a network of greenspaces throughout downtown and improving ease of reaching them. The plan will improve biodiversity and environmental resilience by promoting the development of a diverse tree population, enhancing stormwater management by reducing impervious area, and encouraging the planting of a variety of climate-appropriate species within greenspaces.

Funding recommendations in this plan encourage the development of a Greenspace Fund to consolidate intergovernmental greenspace funding resources to facilitate implementation. Recommendations aim to provide additional sources of funding through potential stormwater fees and incentives to private property owners. Education recommendations encourage conservation education in order to foster public interest and support for greenspace and the environmental amenities that greenspace provides. This plan promotes greenspace and environmental education in downtown by encouraging accessible educational opportunities and greenspace programming.

The adoption of this plan will improve the social, economic, and environmental quality of downtown Sioux City by creating an attractive and desirable destination for residents, workers, and visitors to enjoy. Implementation of recommendations in this plan will require ongoing effort and monitoring in order for it to achieve maximum effectiveness. Full implementation of this plan will establish downtown as an example of balance between economic and aesthetic success while maintaining Sioux City's status as a regional economic and cultural center.

The Downtown Greenspace Plan for Sioux City is the result of collaboration between the City of Sioux City, the Siouxland Interstate Metropolitan Planning Council, Downtown Partners Sioux City, and the Iowa Initiative for Sustainable Communities. This plan was developed by graduate students from the University of Iowa School of Urban and Regional Planning.

Figure 1. Conceptual rendering of a potential pocket park in downtown Sioux City. Source: authors.

1.1 Why a Greenspace Plan?

Greenspaces mitigate the impacts of the urban environment on human stress and improve quality of life. Greenspaces provide long-term support for the everyday health, safety, and welfare of urban residents and workers (White et. al., 2013, Kaplan, 1995). Access to aesthetically pleasing greenspace increases physical activity and reduces the risk of obesity (Rouse et. al., 2016).

Grassy areas and urban trees moderate temperatures by providing shade and cooling, thus helping reduce the urban heat island effect (Loughner et. al., 2012). Greenspaces have a positive impact on local ecology by providing important ecosystem services (Daniels and Daniels, 2003).

Greenspaces provide a visual relief from the urban landscape and connect urban residents and visitors to the seasonal changes of the natural world. In addition, exposing city residents to local biodiversity can trigger interest in environmental issues. As sites of social interaction, urban parks increase perceptions of identity and belonging, and create a "sense of place" (Lee et. al., 2015).

1.2 Project Area

Sioux City's downtown occupies approximately 0.57 square miles (364.78 acres) and is bounded by the Missouri River to the south, the Floyd River to the east, Perry Creek to the west and commercial and residential developments to the north. Sioux City's downtown links the city and the riverfront.

Figure 2. In this plan, the downtown is defined by the boundaries of the SSMID. Source: authors.

The downtown is the city's civic center and includes City Hall, the Woodbury County Courthouse, and other important institutions. It is Sioux City's main economic and business center, housing a variety of attractions. Downtown is also a cultural and entertainment center, with the Tyson Events Center, Arts Center, Public Museum, Public Library, Orpheum Theatre, Stoney Creek Conference Center and Promenade Cinema all within close proximity. Residential apartments and condominiums are scattered in the northern and western parts of downtown. Downtown is further characterized by many historic buildings with beautiful, iconic prairie style and terracotta architecture.

The project boundaries for this plan match the Self Supporting Municipal Improvement District (SSMID) as shown in Figure 2. This plan focuses on the SSMID area, but it also links to greater Sioux City through trails and streets. For the purpose of this plan, downtown Sioux City is referred to as the SSMID.

1.3 Downtown Sioux City History

Sioux City was founded in 1854. Throughout the twentieth century, it became a regional hub for economic activity with many prominent buildings, industrial warehouses, and cattle stockyards.

As the prominence of the railroad faded, downtown

Figure 3. Pearl Street in 1889. Source: Sioux City History.

Sioux City evolved from a hub of agricultural and manufacturing activity into a center for arts, entertainment, industry, and commerce while maintaining much of its historic character. Like many cities in the United States, downtown Sioux City experienced a period of urban renewal throughout the 1970s that resulted in the loss of many historic buildings (Sioux City History, n.d.). Sioux City has since committed to the preservation of downtown's historic character while continuing to explore means to attract new businesses and opportunities to downtown.

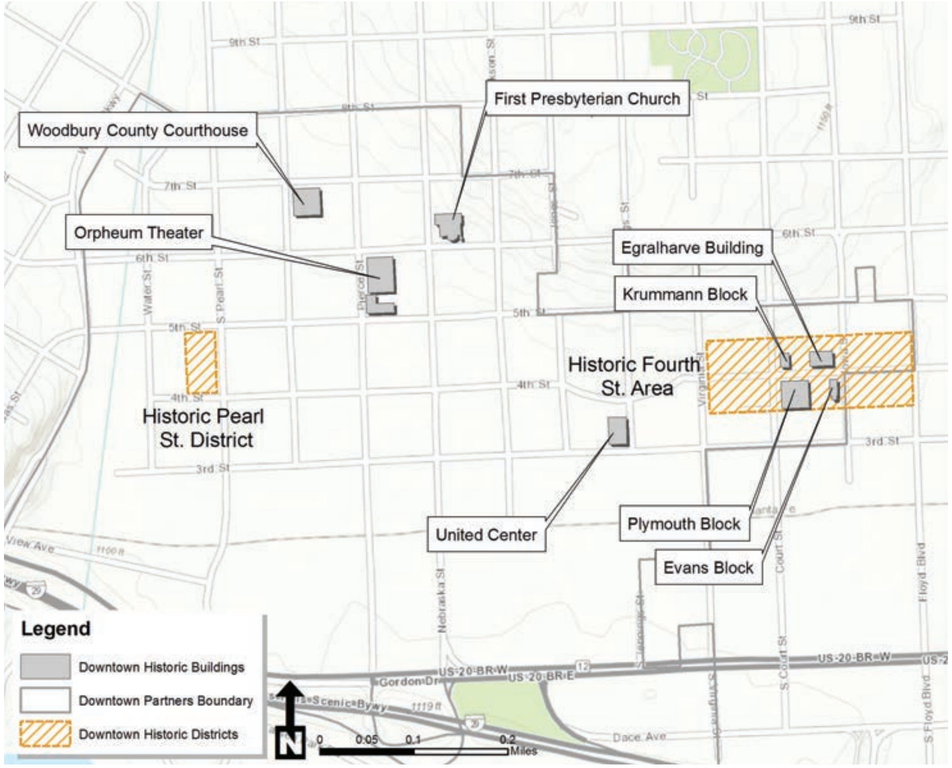

Figure 4. Historic districts and buildings downtown. Source: authors.

Sioux City has been recognized for its successes by being named an All-America City twice by the National Civil League in 1961 and 1990, one of only three cities in Iowa to receive this designation multiple times (National Civic League, 2014).

Buildings of historic architectural significance in downtown Sioux City include the Orpheum Theatre, the Frances Building, the First National Bank Building, the Woodbury County Courthouse, the First Presbyterian Church, and the United Center.

Historic streets include Pearl Street and Fourth Street. Pearl Street has been an important part of downtown's history and is pictured in Figure 3. Fourth Street contains many historic buildings notable for their 1890s Richardsonian Romanesque style. Boston Block and Evans Block are on the National Register of Historic places. Other historic blocks and buildings are the Krummann Block, Plymouth Block, and the Egralharve building (Sioux City History, n.d.). Historic districts and buildings are depicted on Figure 4.

The SSMID of downtown Sioux City originated in 1993 as a funding mechanism for the Sioux City Main Street District in a concerted effort to encourage economic development, historic preservation, streetscape maintenance, and beautification of downtown. The original Main Street District was succeeded by Downtown Partners, who continues to carry out and expand the original mission of the SSMID. Currently, the SSMID operates within a levy term of five years and has enjoyed support from downtown business as evidenced by continuous renewal of the SSMID (Iowa Initiative for Sustainable Communities, 2014). Currently, the SSMID devotes most of its greenspace-related funding to tree planters, trees, and holiday decorations and has budgeted for an increase in funding for tree planters and general greenspace over FY15 and FY16.

1.4 Problem Statement

Despite major assets, downtown Sioux City severely lacks greenspaces and natural features. Most of the downtown consists of buildings or paved surfaces. The total existing greenspace is about 8 acres, excluding the Riverfront Park.

The lack of adequate greenspace in downtown Sioux City results in untapped potential benefits and leads to environmental and ecological problems. Extensive impervious surfaces are not conducive to healthy tree growth, increase stormwater ponding and runoff, and add to the downtown urban heat island effect. These factors also reduce the appeal of downtown for walking, relaxing, interacting, or spending time outdoors and hinders the quality of life for residents, employees, and visitors in downtown. Although downtown Sioux City is a regional destination, the lack of greenspace reduces the potential for downtown to be utilized to its full potential.

1.5 Vision Statement

Our vision for downtown greenspace is a cohesive network of high quality greenspaces that supports and promotes quality of life and community health, provides ecosystem services, and fosters a vibrant downtown environment.

This plan supports Sioux City's vision of downtown as a hub of hometown pride, discovery, adventure, comfort, and prosperity. This plan helps foster downtown's status as a beautiful, welcoming community space that attracts economic opportunity.

The Downtown Greenspace Plan is meant to inform the City of Sioux City, SIMPCO, and Downtown Partners as they move forward in partnership to address greenspace needs in downtown Sioux City. In order to implement this plan, cooperation and partnership from public and private agencies across Sioux City are needed. Although the City of Sioux City, SIMPCO, and Downtown Partners already have strong relationships with their community, this plan helps illuminate additional, currently unknown potential greenspace-specific partnerships through information gained in the survey and community input phase of this project. This strengthens the financial and relational commitment of Sioux City to downtown greenspace development and makes this a true, sustainable community effort.

1.6 Project Goals & Objectives

1.6.1 Goals

The Downtown Greenspace Plan's goals for downtown Sioux City are threefold: it seeks to augment social, economic, and environmental benefits.

Figure 5. The Shepherd's Sensory Garden, located east of the First Presbyterian Church, is a popular greenspace in downtown. Source: authors.

Each of these broad goals drives the decisions and recommendations in this plan.

The first goal is to increase social well-being for employees and residents. Our mission is to increase the general livability, walkability, aesthetics, and increase shade and cooling of the downtown area. The second goal is to improve and increase the resiliency of the built and natural environment. Adding greenspace will improve the quality of soil and the land's ability to naturally handle stormwater runoff and mitigate the urban heat island effect. This goal drives recommendations for greenspace design since the ability of Sioux City to respond to environmental stressors depends on having a diverse selection of climate-appropriate species growing in healthy, moist soil.

The third goal is to improve the local economy. We expect economic benefit to occur with improved social well-being and downtown livability. In other words, people who enjoy spending time downtown will spend more money downtown and will have a greater incentive to visit and live downtown.

1.6.2 Objectives

Each of the greenspace goals can be qualitatively and quantitatively measured through the accomplishment of multiple objectives. The 15 objectives are represented in Figure 6 and detailed below. In the Greenspace Design Strategies section of this plan, each objective icon indicates how proposed designs and policies contribute to the achievement of each goal in downtown Sioux City.

Objectives related to social well-being aim to increase greenspace accessibility, increase opportunities for active recreation, improve environmental education, improve downtown aesthetics, increase shading on sidewalks, increase local foods availability, and increase public space.

This plan also identifies 4 objectives directly related to the natural environment. This plan seeks to increase water infiltration, improve soil health, increase species diversity, and improve stormwater management. Finally, this plan recognizes 4 objectives related to economic growth: improve the livability for living and working downtown, increase local spending, increase time spent downtown, and attract visitors to downtown.

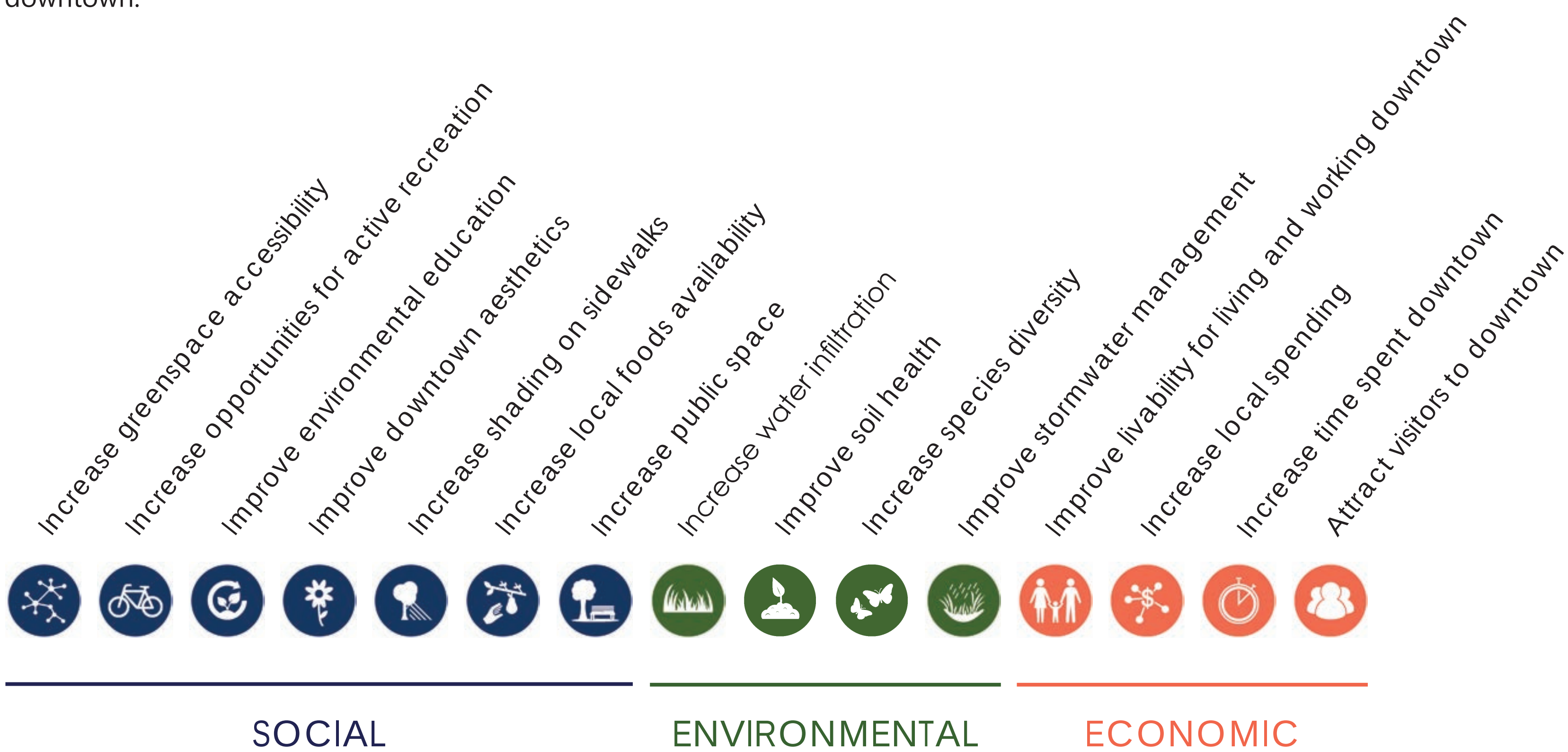

Figure 6. Greenspace planning objectives. Source: authors.

2.1 The Planning Process

The Planning Process, shown in Figure 7, describes the methods and actions used to complete the Downtown Greenspace Plan. The creation of this plan involved a number of steps extending over a nine-month timeline. Specific details on how the planning process fits into the designated timeline for this project can be found in Appendix A.

This process was developed based on the principles of rational and communicative planning. Rational planning directs us to develop, evaluate, and recommend a variety of alternatives in response to a problem. The use of communicative planning reflects the goal to seek the input and public approval of downtown stakeholders and the larger Sioux City community.

Greenspace Assessment

Our team performed a variety of assessments of existing social, economic, and environmental trends in downtown Sioux City to examine the strengths

1	Greenspace Assessment
2	Usage and Interest Survey
3	Need-based Evaluation Model
4	Designing Greenspace Strategies
5	Community Open House
6	The Downtown Greenspace Plan

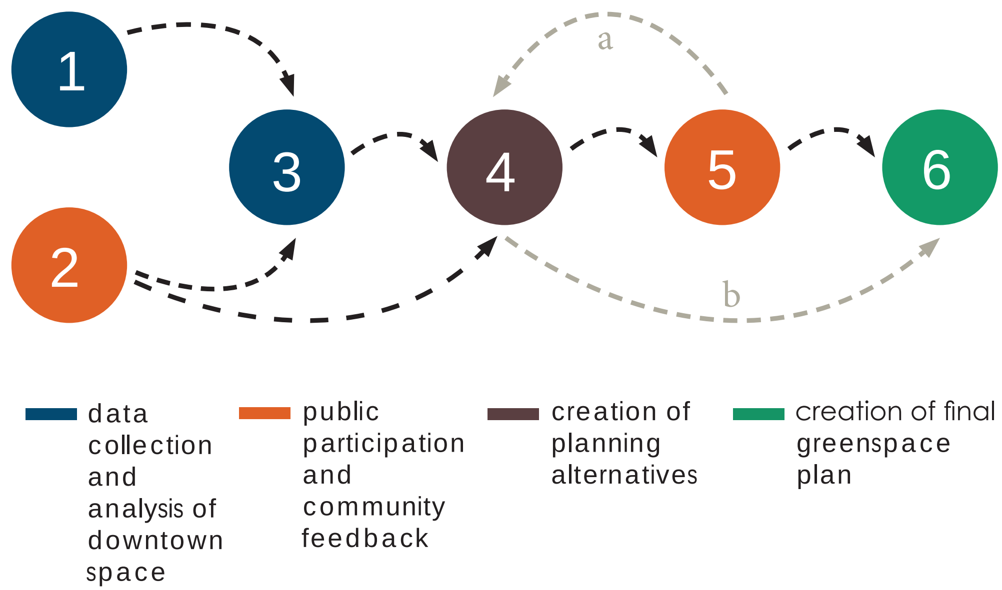

Figure 7. Greenspace planning process. Source: authors.

and weaknesses of the study area. Assessment criteria were chosen based on the project objectives and the results from each assessment supported the evaluation and recommendation process. The following components, which are further detailed in the Greenspace Assessment section of this plan, were analyzed:

- Existing greenspace inventory
- Ecological conditions such as soils and tree cover
- Impervious surface area
- Hydrology and slopes
- Demographics
- Access to existing greenspaces
- Public and project partner input

Best Practices in Planning

When developing alternatives for downtown greenspace, this plan draws inspiration from best practices in other cities. While lessons from comparable research from cities of a similar size and climate as Sioux City are most relevant, we also explored cities with land use constraints similar to Sioux City. For example, large and dense cities such as Copenhagen, Denmark also have limited space to devote to large greenspaces and must rely on creative deployment of pocket parks. Throughout this project, we consulted a variety of urban streetscape, open space, and greenspace plans, which provided a template to set target goals for the implementation of the Downtown Greenspace Plan.

Community Input via Greenspace Usage and Interest Survey

The first round of public input involved collecting information from downtown business owners, employees, and residents through a survey. The primary goal of this survey was to identify (1) existing greenspace used by downtown residents and employees, (2) vegetation and design preferences, (3) desire for additional greenspace amenities in downtown, and (4) landowner interest for incorporating green features on their property.

We collected these data via 2 surveys. The first survey targeted downtown business owners. 23 questionnaires were distributed to downtown business owners that attended a regular meeting of the Downtown Livability Task Force. The second survey targeted downtown residents and employees. An electronic survey link was sent to an email list of over 1,200 downtown employees and residents. The surveys were conducted between the months of November (2015) and March (2016). Results from both surveys are detailed in Section 4.2.

We received 126 electronic survey responses and 9 responses from business owners. In order to determine if the data received were representative of the actual population living and working downtown, we compared various demographics of the survey sample to demographics of the actual population, according to the 2013 Economic Census and the 2013 American Community Survey.

Overall Greenspace Needs

Based on our objectives, the results from our Greenspace Assessment, survey of downtown residents and employees, and discussions with our project partners, we generated criteria for the Need-Based Evaluation model. The model ranked each Census block according to public input, demographic, and environmental components, which are detailed later in Section 3.3. Census blocks were utilized because they are the finest level of analysis that we could obtain publicly available data regarding demographics. Other criteria were normalized to the same spatial level.

Blocks that scored highest on the Need-Based Evaluation are suggested starting places for Sioux City to address greenspace deficiencies. These spaces received the highest priority for implementation and the most attention regarding design and implementation methods. Parcels, streetscapes, and sidewalks were considered for improvement and development.

Create Design Alternatives

Our team produced design alternatives for selected potential greenspaces. These designs present detailed visual representations in the form of computer generated renderings and graphics. Design characteristics were selected based on results from the Greenspace Assessment, the Usage and Interest Survey, and project objectives. These alternatives, as well as estimated costs of construction, are shown in Chapter 5.

Community Open House

The second round of community engagement gathered public input on the aforementioned greenspace design alternatives and potential design guidelines. Information was collected through a Community Open House on March 5th, 2016 at the Sioux City Public Museum. This event was advertised on radio, television, Facebook, and through email newsletters provided by Downtown Partners. The Community Open House attracted the input of over 100 business owners, downtown residents and employees, and residents from all of Sioux City as well as visitors from outside the city.

At the Community Open House, a vision for the general design, placement, and connectivity of greenspaces in downtown Sioux City was presented. Specific design alternatives for selected potential greenspaces were showcased and explained to participants. We also gathered opinions on greenspace designs and policies throughout

Figure 8. An example of a public greenspace, shown here outside of the Sioux City Public Museum. Source: authors.

downtown via open-ended exercises including a "design your own pocket park" activity and by having participants place sticky notes with comments on a large aerial map of downtown. In addition, the Greenspace Team provided expertise to the community regarding the positive environmental and social impacts of increased greenspaces in downtown Sioux City. More information about the Community Open House can be found in Section 4.3.

Final Analysis & Creation of Greenspace Plan

The results from both the survey and the community open house helped shape the final Downtown Greenspace Plan. The implementation framework of the Downtown Greenspace Plan was finalized by creating a system of prioritization for all possible greenspace features, designs, policies, and programs.

3.1 Introduction

A crucial component of the planning process involves assessing the current socio-economic and biophysical characteristics of the SSMID as well as potential locations for future greenspaces. The Greenspace Assessment identifies the stock of existing and potential greenspaces within the district and prioritization criteria. The maps and analyses presented in this section serve as the basis for site selection, site-specific design, and policy recommendations.

This assessment presents the existing stock of greenspace in downtown Sioux City as well as potential sites identified by the Greenspace Team and project partners. In addition, feasibility criteria are applied to identify potential greenspaces. Initial environmental conditions examined in this assessment include soils and contamination, tree cover, impervious surface area, and the hydrology and slopes within the SSMID area. These were developed in an effort to identify areas of environmental concern within the district and are factored into the Need-Based Evaluation model.

Socio-economic, demographic, and land-ownership characteristics within the SSMID are another crucial component of the assessment because this plan seeks to maximize residents and workers access to greenspace. Characteristics examined include trends in employee and residential populations, the distribution of employment and housing populations, employee age trends and distribution, working resident age distribution, and derived measurements of access to greenspaces for these populations. We examined the potential use of greenspace by employees and residents to evaluate areas where the current greenspace network may be deficient and where additions can be most beneficial to the Sioux City population.

3.2 Greenspace Inventory

Greenspaces are important parts of any downtown as they create small oases among vast expanses of concrete. In addition, downtown parks have positive economic impacts and businesses value proximity to parks and greenways. Greenspaces encourage interactions and are vital to a vibrant downtown (Grabow, 2005).

We first inventoried the existing greenspaces in downtown Sioux City. Existing greenspaces cover 39 acres, which includes the Riverfront Park (31 acres). Excluding the Riverfront Park, existing greenspaces in downtown consist of about 8 acres. This accounts for about 4 percent of the total downtown space.

We also inventoried all other spaces in downtown based on existing, potential, parking and non-parking use, and public and private ownership. Figure 12 on page 24 shows a comprehensive map of the existing greenspace as well as potential greenspaces.

3.3 Greenspace Spatial Assessment & Needs Analysis

In order to guide the site selection of future greenspace, a geographic information system (GIS) model was created that takes into account variables that can be categorized into three groups: (1) environmental constraints, (2) demographic distribution, and (3) public opinion. The goal of the model is to uncover which downtown blocks are currently underserved with greenspace. The 8 variables were normalized by quartiles at the Census block level for consistency when running the GIS model. Each variable is detailed below and pictured in Figure 9 on the following page.

Environmental Constraints

1. Acres of existing greenspace
2. Percent of tree cover
3. Percent of impervious surface area
4. High runoff potential

Demographic Distribution

5. Total number of residents
6. Total number of downtown employees
7. Walkability

Public Opinion

8. Public priority (Usage and Interest Survey)

The resulting map (Figure 9) is an un-weighted model. In other words, none of the 8 variables are given higher priority over other variables. Each variable assigns a 1 – 4 score to each block based upon the pre-determined scale for what is desired in terms of greenspace needs (see Figure 10). For example, in terms of susceptibility for high runoff, blocks with low rates of drainage are ideal for development because greenspace can alleviate poor soil quality and infiltration. Similarly, blocks that contain a high percentage of impervious surfaces are the most effective for mitigating urban heat island effects and stormwater related issues. Blocks that have higher concentrations of residents and workers are also desired, based upon the reasoning that greenspaces in closer proximity to workers and residents will be utilized more often than greenspaces located outside of a reasonable walking distance. These findings were compared to the feasibility criteria presented on page 23 in order to delineate public and private land within high priority blocks.

The results of the GIS model are spatially illustrated in Figure 9. Blocks colored in orange or red are considered "High Priority" and "Very High Priority," respectively. Conversely, blocks colored in green and light green are considered "Low Priority" and "Medium

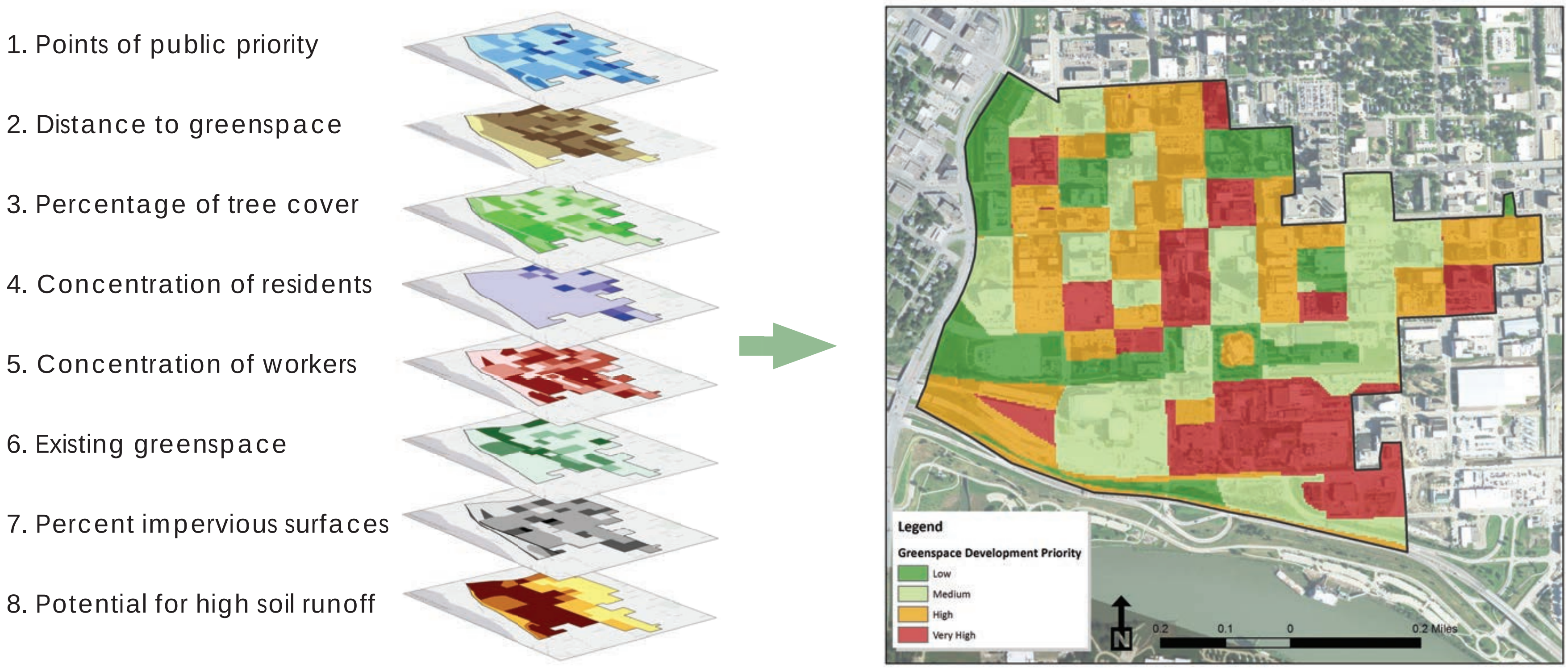

Figure 9. (Left) The Need-Based Evaluation model. (Right) Final greenspace development priority blocks. Source: authors.

Variable Name	Blocks given more weight, if:
Points of Public Priority	High public priority
Distance to Greenspace	Greater distance to greenspace
Percentage of Tree Cover	Low tree cover percentage
Concentration of Residents	High concentration of residents
Concentration of Workers	High concentration of workers
Existing Greenspace	Low existing greenspace
Percent impervious surface	High impervious surface
Potential for high soil runoff	High runoff potential

Figure 10. Weights given to blocks in Need-Based Evaluation model. Source: authors.

Priority." We discovered that 10 blocks are "Very High Priority." These blocks present a combination of high public interest for greenspace development, low tree cover and high impervious surface area, high susceptibility to runoff, low existing greenspace, and are located near high concentrations of workers and residents.

This model was created to serve as a rational and quantitative decision-making tool for selecting future greenspaces. Although some spaces throughout downtown have already been identified as potential for greenspace development, this model aims to provide an equitable process to prioritize greenspace. Furthermore, this model provides a method for determining how primary, larger downtown greenspaces can be connected to each other through blocks that present a “High” necessity for greenspace development. This process aids in the development of a comprehensive network of greenspaces downtown.

3.4 Feasibility Criteria

We performed a feasibility analysis to identify all potential greenspaces in downtown at the parcel level. Using the results of the block level analysis, the feasibility criteria locate parcels within high priority blocks. Feasibility was studied by looking at the following attributes:

- Ownership, either public or private land
- Parking or other space, either landscaped or not landscaped

Ownership information is useful when prioritizing the development of greenspace on public lands and guides decisions regarding potential private property owners that could be partners in creating greenspace. Knowing the location of parking lots helps determine if any could be potentially converted to parks. Figure

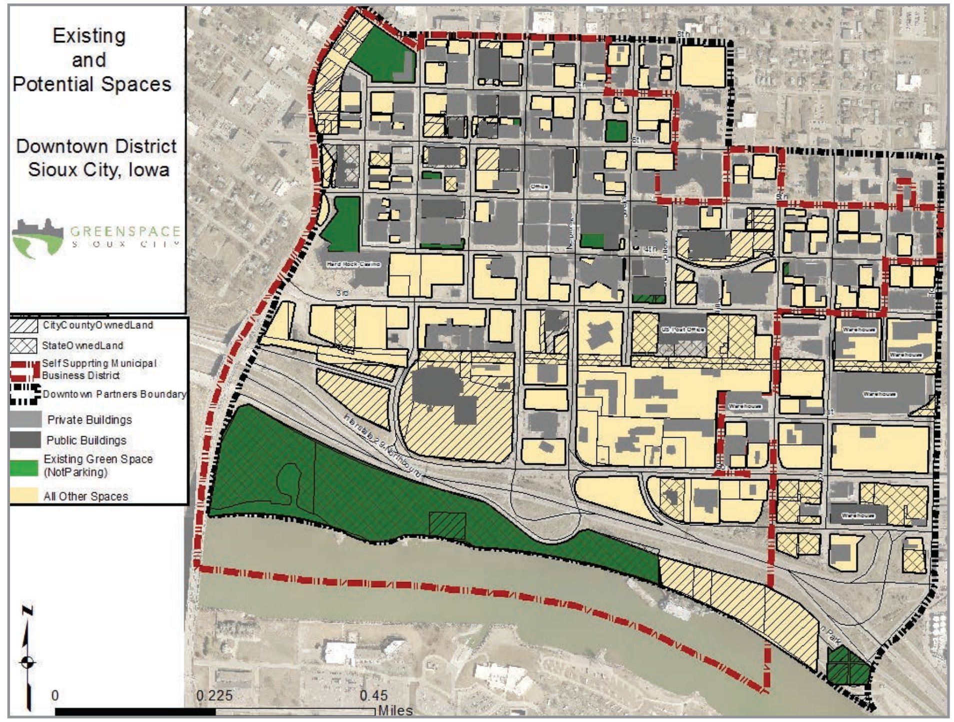

Figure 11. Parcel ownership and existing greenspace ownership. Source: authors.

11 helps with decisions regarding how spaces are connected or could potentially become connected to create a greenspace network. Figure 11 also helped us obtain public input related to different spaces, the results of which are presented later in this plan. Figure 12 identifies spaces based on ownership, parking and non-parking areas.

Downtown Sioux City contains both publicly and privately owned current greenspaces and many

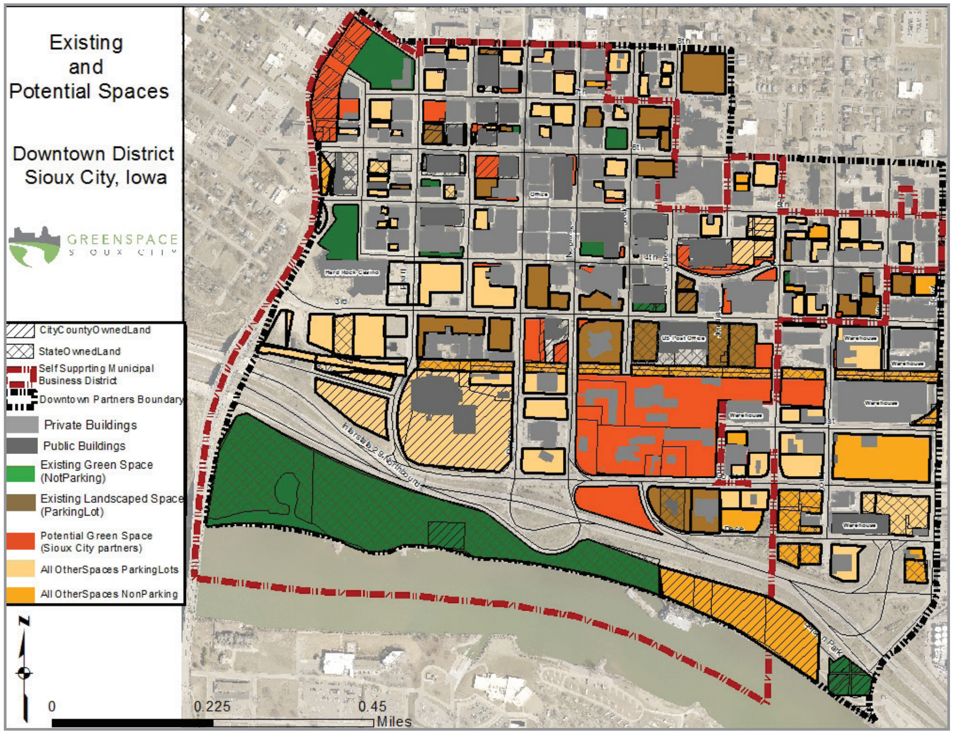

Figure 12. Existing and potential greenspace inventory. Source: authors.

potential greenspaces. Figure 12 shows the locations of existing and potential public and private greenspaces in many different forms such as pocket parks and trail buffers. The Riverfront Park and the trail adjacent to Wesley Parkway are linear parks to the south and west of downtown. Other larger existing spaces include open space near the Hard Rock Casino, a grass covered area near an assisted living development in the northwest of downtown, and the Shepherd's Sensory Garden near the First Presbyterian Church on Sixth Street. The block on Fourth Street adjacent to the MidAmerican Energy building is an example of a well-designed and maintained streetscape and a successful private investment in greenspace.

3.5 Ecological Analysis

3.5.1 Soil Qualities & Contamination

Soils are a dynamic and foundational component of survival for all species. Northwest Iowa's historic primary land cover, short-grass prairie, supports large quantities of nutrient-rich soil with high organic matter. In addition, the unique geologic characteristics of northwestern Iowa result in a distinguished Loess-soil that favors certain vegetation such as prairie dropseed and butterfly milkweed.

The physical, chemical, biological, and functional characteristics of soil are key indicators of the health and resiliency of the ecosystems they support. Attention to soil biology in cities may relieve urban stresses and promote the establishment of plants that were previously unsuccessful (Pavao-Zuckerman, 2008).

Over the years, land use changes due to urban development and farming have greatly reduced the quality and quantity of soil in northwest Iowa. In heavily built areas such as downtown Sioux City, the impact is significant. Soil in the urban environment is heavily compacted and sensitive to hydrologic and chemical variation. The removal of topsoil and native vegetation has stripped the soil of its nutrients and organic matter and can lead to poor tree and plant health. Past and current industrial waste and leaks also introduced a variety of chemicals and metal into the soil that pose ecological risk.

Soil characteristics were obtained from the U.S. Department of Agriculture Natural Resources Conservation Service digital soil survey. These data were accessed from the Iowa Natural Resources Geographic Information Systems Library. The digital soil survey data was manipulated to show six soil characteristics useful in analyzing the quality of the local soil: erodibility, depth to water table, slope, average pH, hydrology (drainage), and parent material.

Soil maps are shown in Figure 13. There are two primary locations with defining characteristics: the north to northeast portion of downtown, and the mid to south portion. Each of these areas of downtown Sioux City poses unique challenges. While the northern portion has good drainage, this region is most prone to erosion and is the farthest from the water table. The mid to south portion is less erodible and closer to the water table, but the slow drainage

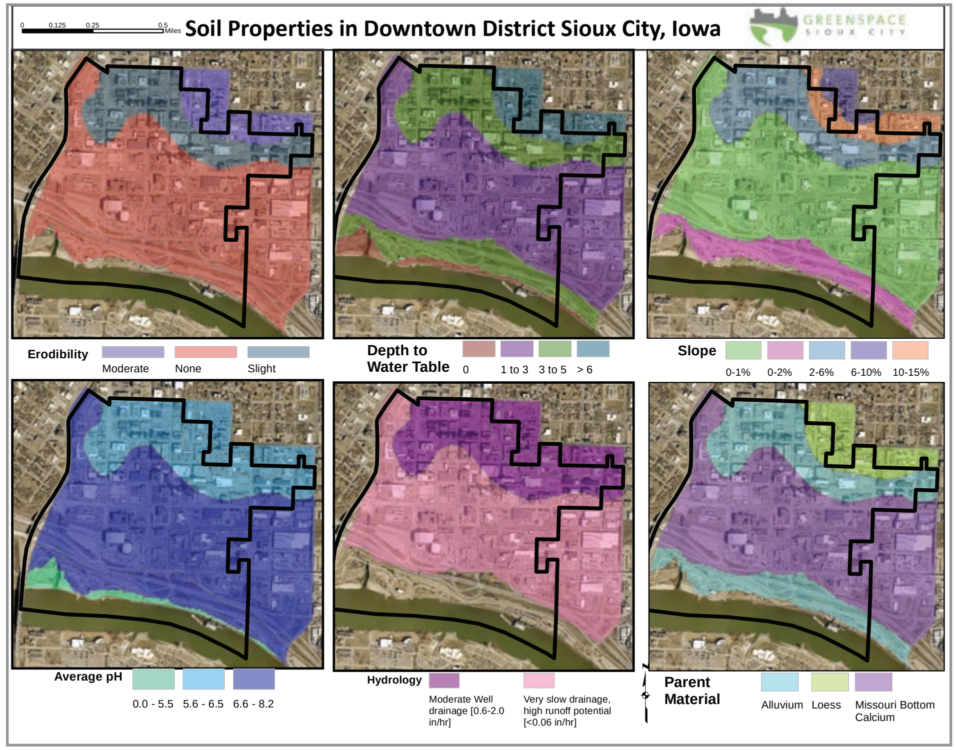

Figure 13. Soil properties in downtown. Source: authors.

rate may result in high quantities of runoff that never infiltrate into the soil.

The results of a potential ground contamination analysis are shown in Figure 14. The location of contamination events are not considered in the evaluation and prioritization of potential greenspaces in downtown Sioux City because none of the reported spills or contaminated sites are of serious concern. However, they serve as an important reference for future construction involving excavation.

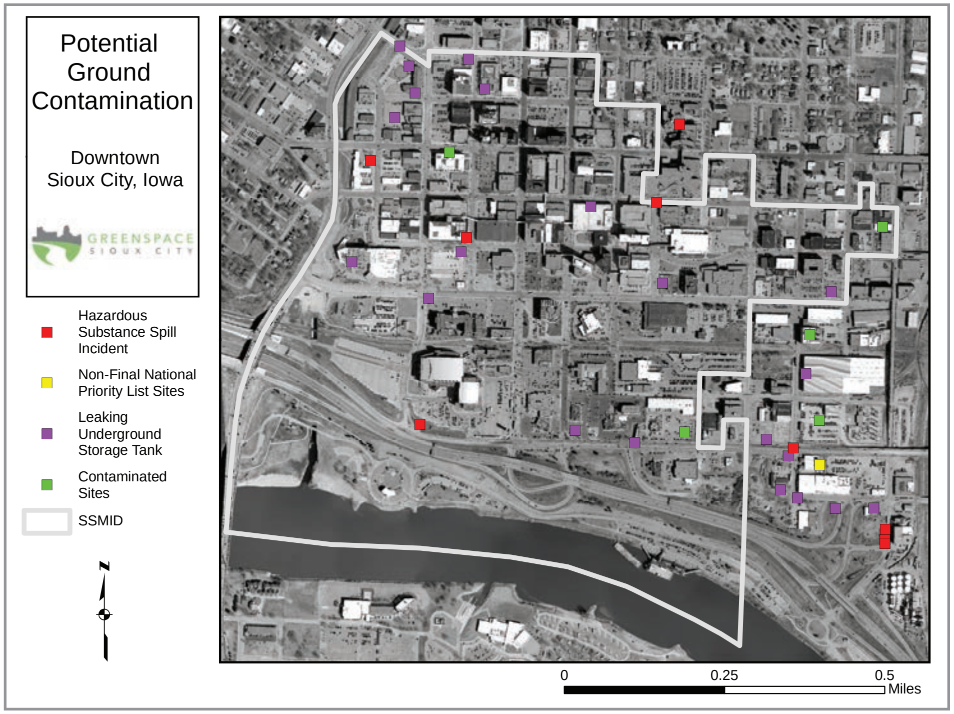

Figure 14. Sites of potential ground contamination. Source: authors.

3.5.2 Tree Species & Cover

Urban tree canopy is important because it provides shading and thermal comfort (cooling), reduced energy costs, improved local air quality, enhanced soil health, noise abatement, increased aesthetics, infiltration of stormwater runoff, carbon sequestration, and improved citizen well-being and public health. When planning for increasing and strengthening tree canopy in an urban area, it is essential to create an effective long-term urban forestry management plan that addresses goals for tree canopy coverage and distribution, tree species best suited to thrive in local climate conditions, optimal planting locations relative to infrastructure, maintenance and care, and sustaining long-term canopy cover and tree health at minimal cost. Increasing the quantity of tree cover is an important component of greening downtown Sioux City because of the social, economic, and environmental impacts of trees. The quantity and quality of tree cover is an indicator of the extent to which the local trees provide ecosystem services to the local community.

Urban forests across the country are affected by pests, diseases, and chemical agents. Many pests and diseases target specific tree species. In areas with little species biodiversity they can cause catastrophic tree mortality. As an example, many cities throughout the Midwest disproportionately planted Ash trees because they are relatively inexpensive, grow quickly, and produce a large canopy. However, with the spread of the Emerald Ash Borer (EAB), these cities are currently experiencing large die-outs and incurring significant costs in removal and replacement. This plan is not constrained by the impact of the EAB infestation since there are no Ash trees within downtown Sioux City. Sioux City as a whole, however, could potentially lose about 17 percent of the total tree canopy (Sioux City Journal, 2013). The important lesson is that cities need tree diversity for a resilient urban forest. Furthermore,

TREE COVER CASE STUDIES

Portland, Oregon

In 2013, Portland conducted a street tree inventory of their 535-acre downtown core. They found the total downtown tree population to be 3,617, which covered 17% of the downtown area. In addition, the downtown hosted a diverse array of tree types – 45 species total. Finally, they determined that their downtown tree population provides $560,000 annually in environmental services and aesthetic benefits. (Ramsey, 2013).

Atlanta, Georgia

Atlanta, Georgia's 2011 downtown tree inventory found that their 1,248-acre downtown business district contains 3,350 total trees and 62 species of trees. 93% of their downtown trees are along street right-of-ways, while the remainder of the trees are located in parks. The inventory also found that 62% of the Downtown inventoried street tree population was located in small growing space best suited only for species that remain small at maturity. In addition, of the 137 trees in raised planters, 79% were not suitable for that growing space size (City of Atlanta, 2012).

Seattle, Washington

Finally, Seattle's 2007 downtown tree cover was 4.7% and the city has a target goal of 12% tree cover in downtown. They estimated they would need to plant 8,224 trees to reach their target canopy cover over 28 years (City of Seattle, 2010).

cities require trees that are well adopted to harsh downtown climates and conditions such as droughts.

Finally, the types of species chosen for an urban area determines a tree's ability to survive and adapt to local climates. In the United States, climate change is expected to produce warmer air temperatures, altered precipitation patterns, and more extreme temperature and precipitation events (EPA, 2009; IPCC, 2007). Climate change will also impact urban forests (Johnston, 2004). Drought-tolerant trees evolved to survive in drier, less hospitable climates. As the average surface temperatures continue to rise, downtown Sioux City will need to adapt by evaluating

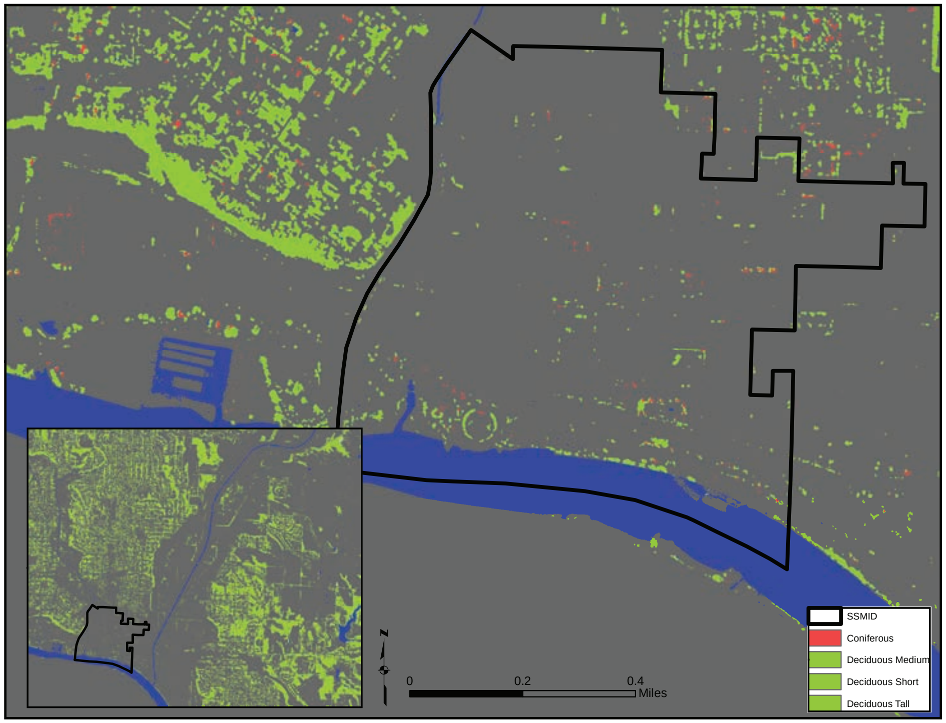

Figure 15. Coniferous and deciduous tree cover in downtown. Source: authors.

the current and future planting of species that can thrive in a variety of unpredictable conditions.

Another factor that contributes to tree attrition is how trees are planted. Currently, many trees in downtown are housed in above-ground planters, which constricts natural root growth and can compromise the health of a tree. In addition, above-ground planters must be irrigated, which adds to maintenance costs. In-ground planters provide better opportunity for the vitality of a tree because it allows for more space for root growth and better access to rainwater.

In order to determine tree quantity in downtown Sioux City, we calculated and mapped: (1) the percentage of tree cover and (2) the percentage of tree cover per census block. These calculations were performed using 2009 land cover data provided by the Iowa Department of Natural Resources. Although these data do not account for the trees planted in the past five years, most trees planted in that time are small or have died out and thus provide no notable tree cover. As a result, we don't believe the vintage of this dataset significantly impacts results.

We did not conduct a comprehensive inventory of downtown tree species and health due to time and resource constraints. The last tree inventory completed by the City of Sioux City Parks and Recreation Department was in 1994. It did not provide us with relevant information because many of the trees in downtown Sioux City are relatively young and newly planted. As a result, we relied on observation and project partner knowledge to assess downtown tree species diversity and health.

Figure 15 illustrates a significant difference in tree cover in downtown Sioux City compared to surrounding neighborhoods. Coniferous trees are shown in red and deciduous trees are shown in green. Total tree cover in downtown Sioux City is about

6.3 percent of the total area, which includes a large portion of trees located south of Interstate 29 within or near the Riverfront Park. Excluding the Riverfront Park, the downtown tree cover is 1.43 percent. There are only 4 species of trees within the downtown area: Locust, Pear, Ginkgo, and Armstrong Maple. Thus, downtown Sioux City has minimal tree cover and diversity. This plan seeks to address this shortcoming.

The data collected as part of this assessment provide us with a baseline for tree cover percentage and species composition, which inform policy recommendations made in this plan. This aids in the establishment of reasonable short and long-term goals for the future of tree cover and tree biodiversity in downtown Sioux City.

3.6 Built Environment Analyses

3.6.1 Hydrology & Slopes

Due to the topography of the region, downtown Sioux City faces a significant issue with regards to stormwater runoff. Downtown sits at the bottom of a steep hillslope and lies between three major surface water conveyors in Perry Creek and the Floyd and Missouri Rivers. The northeast region of downtown consists of particularly steep slopes, which contributes to increased peak stormwater runoff velocities and flow rates. An example of the magnitude of these slopes can be seen in Figure 16, which shows a Digital Elevation Model (DEM) for Woodbury County paired with two-foot contour lines to enhance the visibility of steep slopes. The red shades represent higher elevations, whereas the light green shades represent lower elevations. As can be seen in this figure, while the downtown sits at a low elevation, the areas to the north of the district sit at a much higher elevation. In addition, the watershed boundaries for Perry Creek and the Floyd and Missouri River basins are shown in blue on the map. These boundaries further depict where stormwater would flow.

The stormwater problem is exacerbated by the high amount of impervious surfaces in downtown (see page 34). Impervious surfaces prevent stormwater from infiltrating into the ground, which causes it instead to runoff over land. Runoff leads to the accumulation of debris, sediment, chemicals, and other pollutants that have an adverse effect on the quality of water that discharges from the city's stormwater management infrastructure into the Missouri River (Environmental Protection Agency, 2015). In addition, runoff can contribute to the deterioration of roads, sidewalks, and other infrastructure. This can be seen in Figure 17, which shows the differential settling of bricks along the Fourth Street promenade from stormwater runoff, which travels across the bricks from downspouts in order to reach storm sewer intakes in the middle of

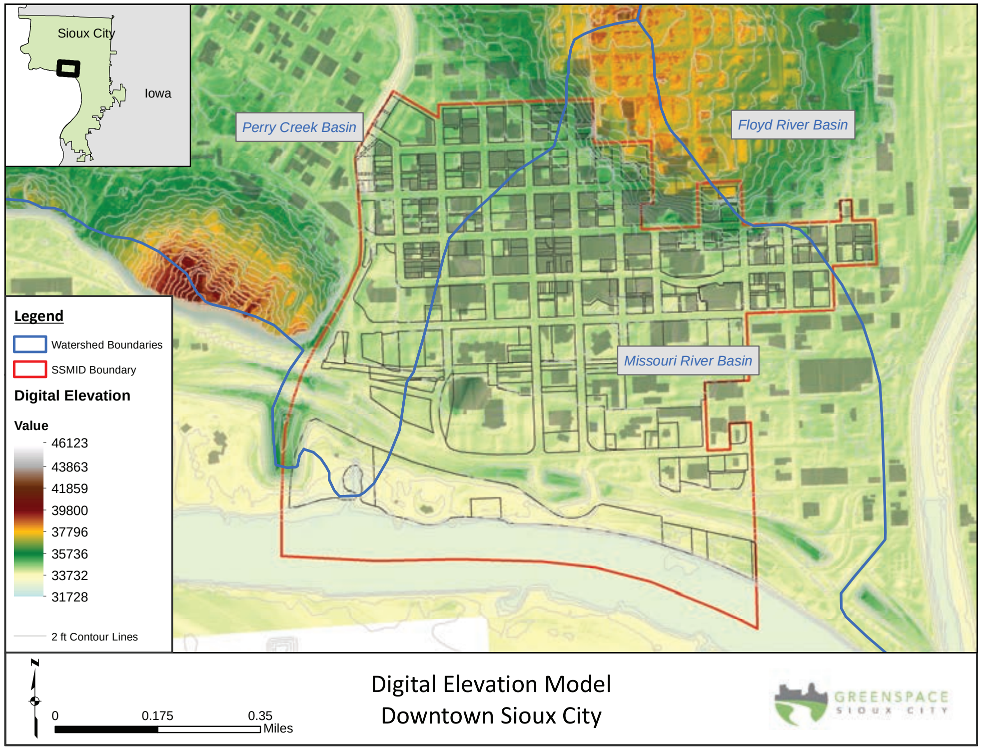

Figure 16. Digital elevation model of downtown Sioux City. Source: authors.

the pedestrian walking path. The promenade space is slated for reconstruction utilizing bioretention cells, bioswales, native turf, and tree trenches to showcase urban water quality practices. This project funded in part by $80,000 from a State of Iowa urban water conservation grant. Increasing the amount of permeable surface area in downtown can mitigate the negative consequences of the hydrologic cycle, especially when employed in strategic locations within the SSMID selected to optimize the conveyance of stormwater.

Urbanization increases the amount of impervious surfaces such as roads and buildings and reduces soil quality and infiltration capacity. As a result, a shift in the hydrologic cycle occurs. As impervious surfaces increase, the percentage of rainfall that is converted to runoff increases. This phenomenon is described in Figure 18, which describes the effects of urbanization on the three basic components of the hydrologic cycle: runoff, evapotranspiration, and infiltration. Highly impervious areas such as downtown Sioux City have a drastic impact on the hydrologic cycle that can lead to several unintended consequences.

Besides increased runoff and infrastructure deterioration, there are several environmental quality issues associated with stormwater. These include stormwater pollution, erosion, and sedimentation. Stormwater naturally acts as a transfer medium for pollutants into ground and surface water supplies. Untraceable sources (also called non-point sources) of pollution associated with urban areas include vehicle exhaust, heavy metals, salts and acids from vehicle use, construction activities, garbage, dirt, and other street debris (Environmental Protection Agency, 2015). Non-point source pollutants combined with point-source pollutants from factories or other businesses that outfall into rivers and streams seriously degrade the quality of surface and ground water supplies and also can significantly drive up costs of drinking water treatment for downstream communities.

Figure 17. Differential brick settling at the Promenade Theatre. Source: authors.

Erosion is a naturally occurring phenomenon that leads to the displacement of solids by the elements, gravity, or by living organisms and can be worsened by urbanization. By increasing impervious surfaces, stormwater flows and runoff velocities increase, which speeds up the rate of erosion. Construction activities are particularly significant contributors to erosion, especially when adequate sediment and erosion control measures are not employed on site. Water bodies downstream of areas with a lot of impervious areas and construction activity (such as the Missouri River) are susceptible to stream bank instability, ecosystem damage, soil loss, and higher degrees of sedimentation.

Sediment is the top pollutant source in the United States, and issues with sediment are exacerbated in urban areas (City of Aspen, 2008). Sediment is picked up by rain and snowmelt runoff as well as through stream bed and bank erosion. Common pollutants transported by sediment include phosphorous and nitrogen, which can hinder water quality both for drinking water and aquatic life. Excess nitrogen commonly leads to algae blooms and subsequent mass fish kills. Aside from the pollutants that it carries, excess sediment particles can bury aquatic insect life and suffocate fish. In addition, an excess of sediment decreases the amount of available sunlight in marine environments, increases water temperatures, and inhibits the growth of natural vegetation (United Nations Environment Programme, n.d.). Excess sediment also contributes to the clogging and deterioration of storm drains and sewers as well as the reduction of stream channel or reservoir capacity due to accumulation. This can necessitate expensive dredging as well as increase flood risk due to the reduction in stream depth. While these issues may not necessarily be visible on the surface to many users of downtown Sioux City, these issues are nonetheless critical to the overall environmental health of the district in terms of drinking water quality and recreational opportunities adjacent to Perry Creek and the Missouri River as well as to downstream waters.

Stormwater ponding is a visible problem that our

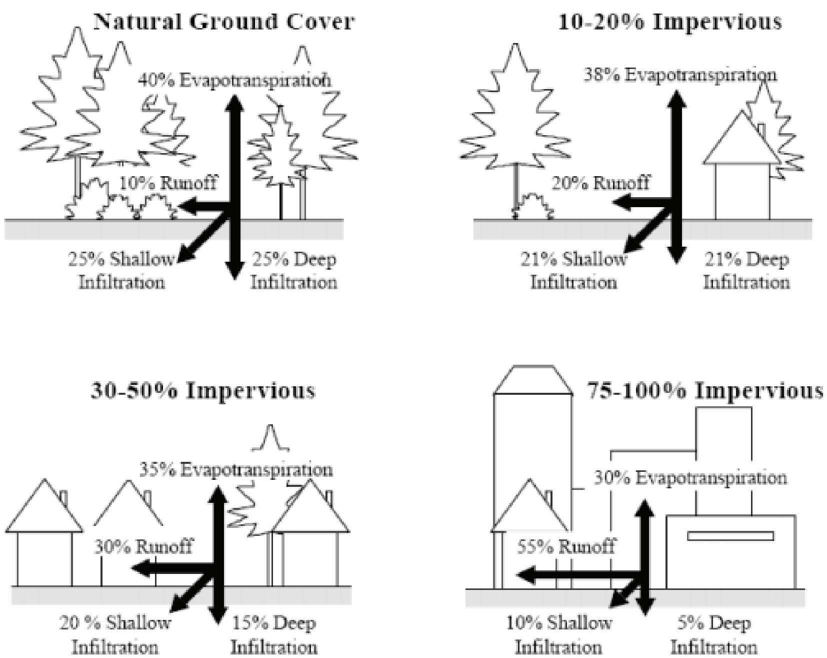

Figure 18. The effect of urbanization on the hydrologic cycle. Source: Iowa Stormwater Managament Manual.

project partners identified. While this issue is partly attributed to the differential settling of roads due to age and wear, ponding becomes more problematic during high intensity rainfall events. Furthermore, our project partners specifically singled out the following four locations as being particularly problematic with regards to ponding during our initial visit: the intersection of Sixth and Pierce Streets, the intersection of Sixth and Jackson Streets, along Fourth Street in front of Karlton's Clothiers and Tailors, and on Fourth Street near the theatre and promenade.

While this list is not exclusive, it points to specific areas that can be targeted in order to optimize the conveyance of stormwater by slowing runoff and promoting infiltration. For example, Figure 19 shows Sixth Street looking north at the intersection with Nebraska Street. Ponding along Sixth Street is a direct result of the amount of impervious surface along this corridor as well as the steep slopes that stormwater travels down. Increasing the permeability along this corridor through the use of technologies such as a vegetated swale system can slow the velocity of runoff and reduce the intensity of ponding downstream of this area (Iowa Stormwater Management Manual, 2010).

To reduce runoff volumes, velocities, and peak flows, optimize the conveyance of stormwater, and limit the strain of stormwater on existing gray infrastructure, we recommend utilizing technologies such as swales, rain gardens, and other natural retention structures that facilitate the infiltration of stormwater into the ground. They will also contribute to the greening of downtown. Section 5.2.3 presents a summary of feasible Best Management Practices that can be incorporated in downtown Sioux City to reduce runoff and ponding while increasing the quantity and quality of greenspaces.

An analysis of existing and potential hydrologic conditions to quantify the effectiveness of a single bioswale in reducing runoff, treating pollutants, and promoting infiltration is useful when promoting stormwater best management practices. The result of such an analysis using a bioswale as a Best Management Practice is presented in Section 5.2.3, and a more detailed study that serves as a template for future stormwater analysis is shown in Appendix B. This study is used to demonstrate the benefit of stormwater management technologies on the hydrologic conditions of downtown.

3.6.2 Impervious Surface Area

A key indicator for assessing natural space in downtown Sioux City is the total amount of surface area that is impervious, or unable to naturally infiltrate water into the ground. The total impervious surface area for downtown Sioux City was derived from land cover data from 2009, provided by the Iowa Department of Natural Resources.

We applied runoff coefficients to account for each land cover category's ability to infiltrate rainwater. Runoff coefficients were translated from the Virginia Stormwater Management Handbook were utilized and matched to hydrologic soil group B, which is the primary category of soils in downtown Sioux City. The resulting values are spatially represented in a greyscale, which range from impervious to permeable

Figure 19. Sixth Street looking north showing significant slope. Source: authors.

(Figure 20). More permeable areas (spaces that are coded with lower runoff coefficients) are primarily grassland and trees while highly impervious areas located downtown are roads, parking lots, and buildings. Land cover data was available at a 1 square meter resolution from the Iowa Department of Natural Resources.

Within the SSMID, impervious surface area is 77 percent. In comparison to adjacent neighborhoods, the more impervious areas of the downtown

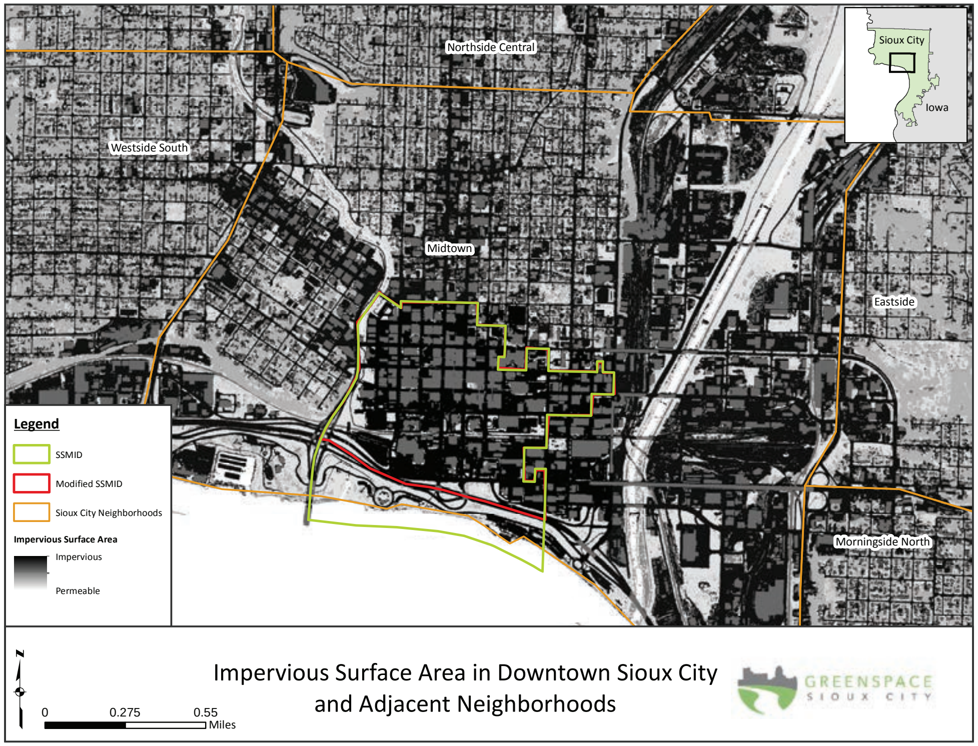

Figure 20. Impervious surface areas in downtown. Source: authors.

district stand in stark contrast with land uses such as residential districts. The whole City of Sioux City has 40 total percent impervious surfaces, which is much greater than the national average for total imperviousness for urban areas of 17 percent and higher than the state average 27 percent (Nowak and Greenfield, 2011). Focusing on the downtown area, 77 percent imperviousness has major implications on quality of life, environmental quality, stormwater runoff, and the urban heat island effect. This plan thus presents ways to decrease imperviousness and increase the permeability of downtown.

3.6.3 Urban Heat Island

As a result of the high imperviousness of downtown Sioux City, the urban heat island (UHI) effect is significant and a noticeable impact for downtown workers and residents. This phenomenon describes "temperatures [rising] during the day and [staying] warmer at night because of the huge amount of paved surface and the lack of tree cover" (Daniels and Daniels, 2003). Heat gains originate from solar radiation that is not reflected away from the surface but rather stored in buildings, streets, and pavement and then released at night, which does not allow the surface to cool. The lack of trees and shade also does not help to mitigate urban heat.

Our team built a dynamic systems model to quantify the UHI in summer at a 1.5 meter spatial resolution. The model compares historical temperatures of rural cities with observed and simulated temperatures in downtown Sioux City. The model calculates the heat absorbed and released by the largely impervious surfaces of downtown, and by anthropogenic heat added from downtown combustion activities and building heating and cooling. This tool measures the effectiveness of UHI mitigation strategies at the block level and for the entire downtown. Our model predicts that Sioux City is on average 8.1 degrees Fahrenheit hotter than the neighboring rural city of Denison on a typical clear summer day.

Our research investigated 4 mitigation strategies: (1) painting building roofs white, (2) adding evenly spaced trees on major downtown streets, (3) converting various parking lots into pocket parks, and (4) a combined scenario that includes all 3 mitigation techniques. The goal for each of the mitigation scenarios was to increase reflectivity of land surfaces, which consequently decreases the amount of solar radiation that is absorbed. The smaller amount of radiation that is absorbed effectively decreases the amount of sensible heat that is released and thereby reduces the increase in surface temperatures. Figure 21 shows the daily solar insolation, albedo and emissivity rates for the study area for June 8, 2015. The study area was chosen because it shows high variability in greenspace and imperviousness in a smaller geographic context. These maps help determine where mitigation efforts should be targeted. For example, the eastern border of the study area (Douglas Street) receives heavy solar insolation and presents low albedo rates. This translates to massive heat absorption that is slowly released as sensible heat over time, which directly increases the surface temperature of the area.

In both the context of the entire downtown and the three block study area, white roofs were found to lead to the most significant reduction to the UHI. In the

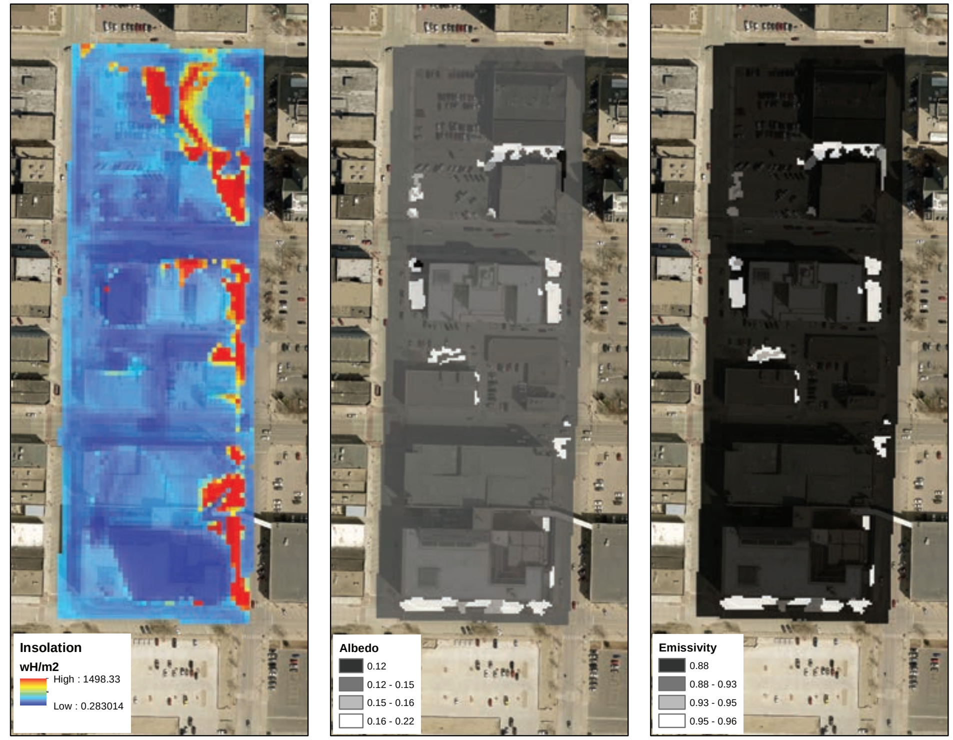

Figure 21. Solar insolation, albedo, and emissivity for the urban heat island asessment study area. Source: authors.

optimal combined scenario for the three block study area, which included implementing white roofs, street trees, and pocket parks, the total reduction of the UHI was about 2.05 degrees Fahrenheit. For more detail on the model or methodology, and for full results of this research, see Appendix C.

3.7 Demographics & Accessibility

3.7.1 Demographics

In order to serve the residents and workers of downtown, we examined demographic characteristics of the downtown area at the Census block level. The demographic variables we examined include employment and housing trends and spatial distribution of businesses and residents, the spatial distribution of employee age, and derived measurements of access to greenspaces from places of work and residence.

Figure 22 shows trends in the numbers of people living and who are employed within the SSMID. Between 2002 and 2013, the number of people living downtown has increased by 35.3 percent (Economic Census, 2013). This is reflected by an increase in the available downtown housing stock as a result of the rehabilitation and retrofitting of several historic buildings into condominiums. This trend is expected to continue as a result of the city's commitment to making downtown more attractive to residents. During the same time period, the number of people employed in the SSMID has steadily decreased by 36.2 percent (Economic Census, 2013). While these trends are not necessarily an indicator of who uses greenspaces in downtown, they are useful to understand the historical context of the downtown district with regards to population and employment

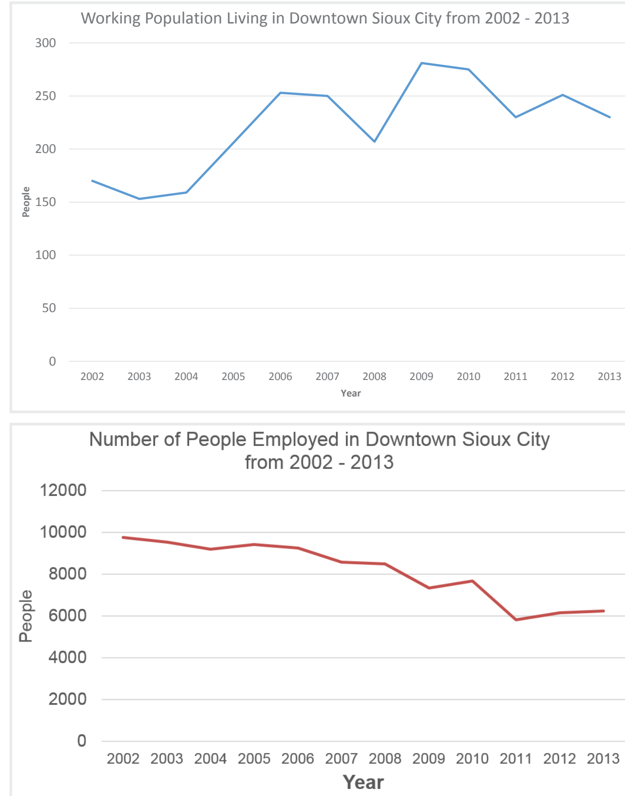

Figure 22. Living and working population trends. Source: authors.

growth and reinforce that this plan is intended for both current and future residents and employees within the SSMID.

Figure 23 shows the density of employees by size of company downtown. While employment is widely dispersed throughout the SSMID, the area between Fourth and Seventh Streets to the south and north and between Pearl and Nebraska Streets to the west and east is the densest area of employment within the district. Other employers located outside the SSMID (such as Mercy Medical Center) also add employees who are potential users of greenspace in downtown Sioux City. Information about where people within the downtown work was considered when evaluating access to greenspace as well as potential locations for new greenspace.

The spatial distribution of age in downtown Sioux City is another useful variable to guide potential programming and functionalities of greenspace. This analysis examines the characteristics of employee and resident age in the SSMID. Broad based age distribution characteristics are shown in Figure 24. Just over half of the workforce in the SSMID is between the ages of 30 to 54, which is expected of a typical American workforce. A similar breakdown is shown in the lower graph of Figure 24, which shows the age breakdown of downtown working resident population. Again, just over half of this population is between the ages of 30 and 54, with a slightly higher proportion of younger residents than older compared to workers. The presentation of this figure reinforces that our team is planning for all age levels when identifying potential uses for additional greenspace.

In order to explore age characteristics of workers in greater depth, the distribution of employee age by 2010 Census block was derived and is depicted in Figure 25. This figure features three maps that depict

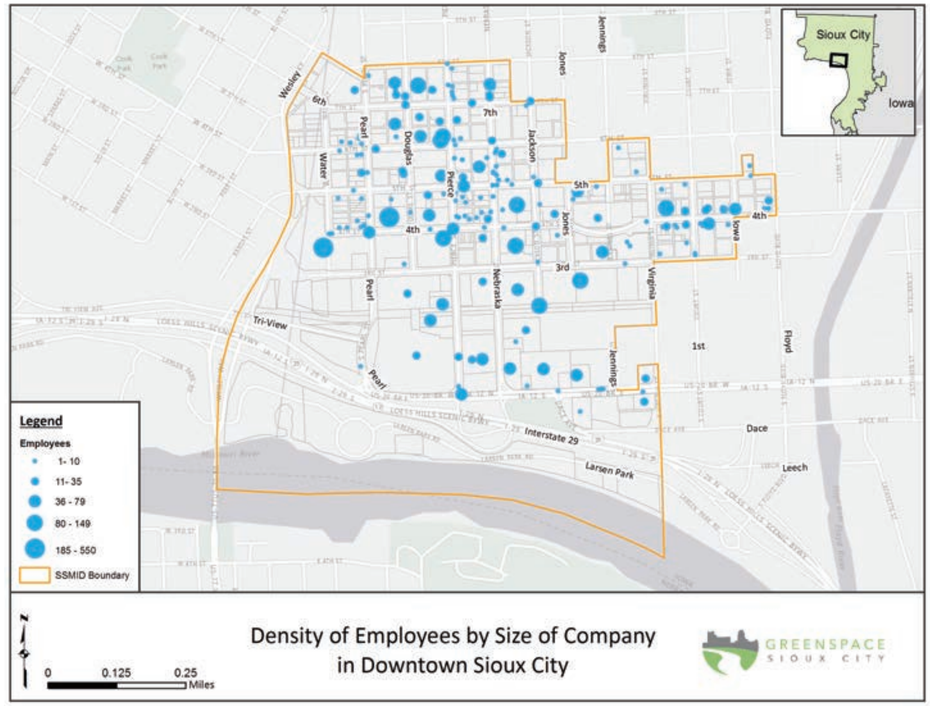

Figure 23. Density of employees by size of company in downtown. Source: authors.

the percentages of each of the three age breakdowns shown in Figure 24 by block. The spatial breakdown of employees in the SSMID by block guides recommendations for age appropriate features and programming current and future greenspaces in order to optimize use and accessibility to greenspaces for people of all ages.

Figure 26 depicts the spatial distribution of population in occupied housing units by 2010 Census blocks. Residential populations in the SSMID are located

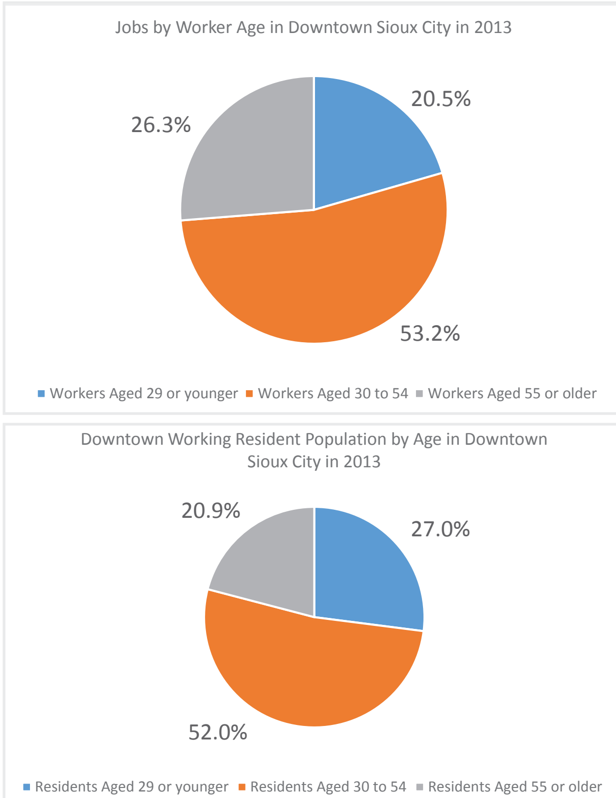

Figure 24. Age distribution among workers and workers living downtown. Source: authors.

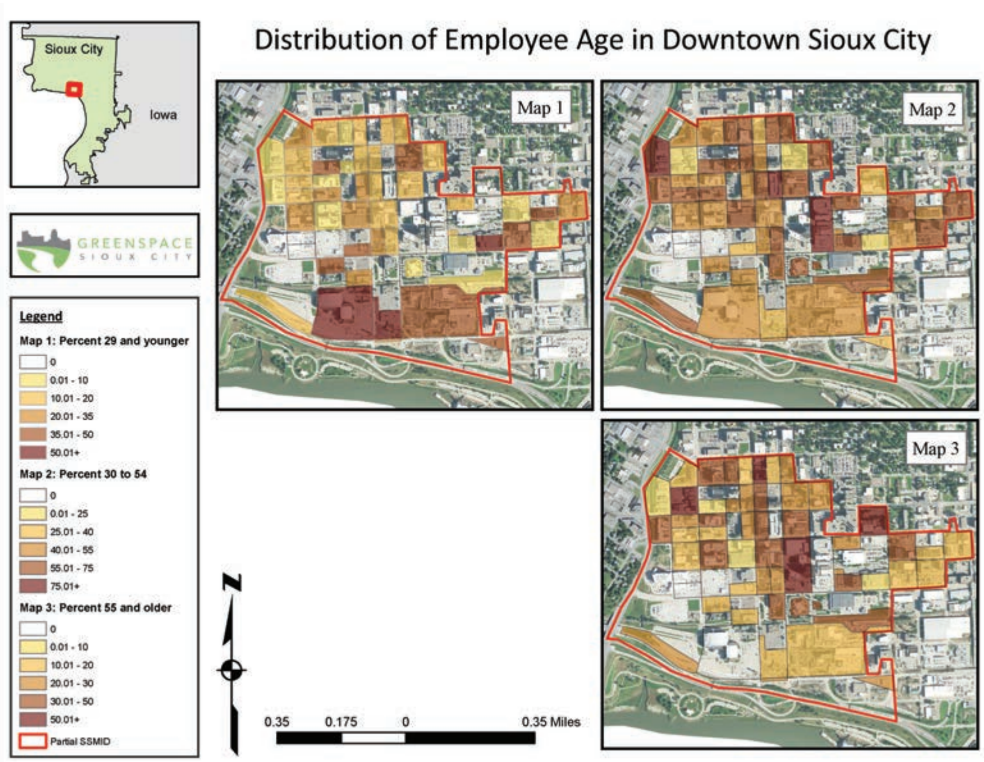

Figure 25. Distribution of age among downtown employees. Source: authors.

exclusively north of Third Street and are concentrated on the fringe of the densest employment hubs in the district. Identifying the population demographics and distribution is used for analyzing access to greenspaces. Figure 26 (housing map) and Figure 23 (employment density map) identify areas where residential and employee populations are underserved by the current supply of greenspace downtown.

3.7.2 Greenspace Proximity

In order to quantify resident and employee access to greenspace, the number of acres of greenspace per Census block in the downtown district was calculated. GIS was utilized for intersecting existing greenspace with Census blocks in order to determine total acreage of greenspace within each Census block area.

This analysis is depicted in Figure 27 on page 40.

The green circles represent the number of acres of greenspace per block. The smaller the green circle, the less greenspace there is per block. This map shows that the highest concentrations of greenspace are located on the western edge of the downtown district as well as just south of Third Street along the railroad tracks. There is a clear deficiency in access to greenspaces for people living and working in blocks with small or non-existent green circles; especially in the area bordered by Third and Seventh Streets to the south and north and Pearl and Nebraska Streets to the west and east, as well as between Interstate 29 and the railroad. Evaluating access to greenspace in this manner indicates where the current greenspace network is deficient and helps identify specific sites for future greenspaces.

A commonly held standard related to greenspace access is the amount of greenspace per person in a given area should be 10 acres of greenspace per 1,000 residents (0.01 acres per resident), which is used by communities across the nation. For example, the City of Atlanta recommends this benchmark as a factor in sustainable development (Davey Resource Group, 2011). However, given that less than 500 people live in downtown Sioux City and also that this plan will primarily serve the downtown workforce, the ratio of existing greenspace to residents is skewed in favor of an adequate supply of greenspace.

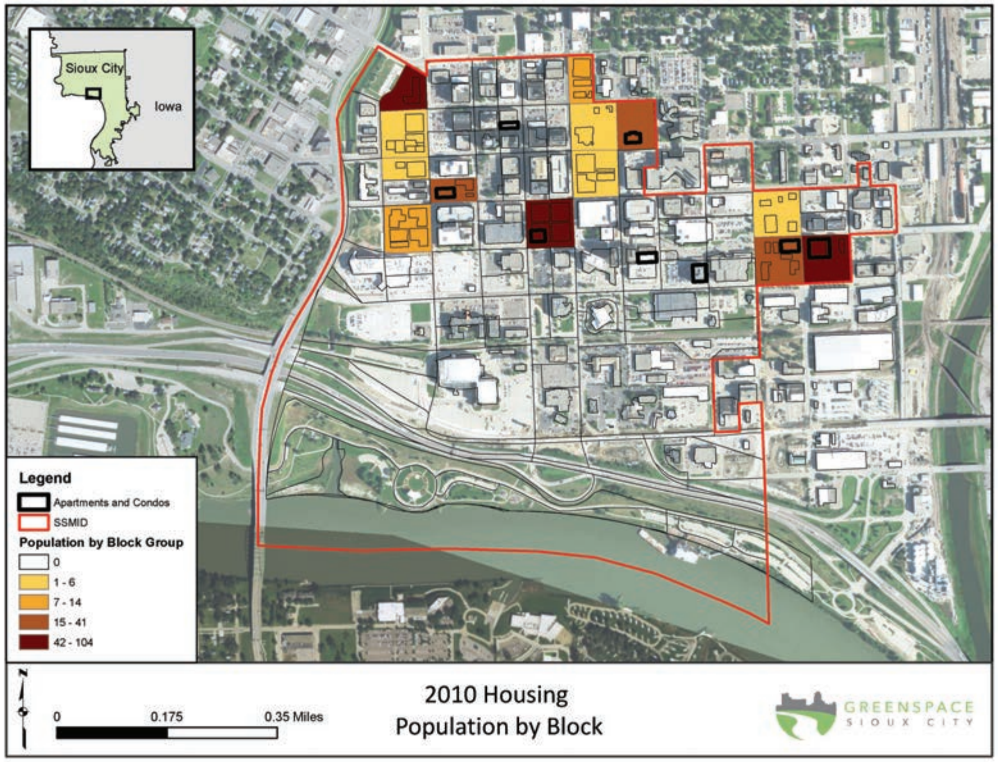

Figure 26. 2010 housing population by Census block. Source: authors.

Rather than providing a ratio of greenspace per person for downtown Sioux City, we evaluated access to greenspace in the given analysis based on proximity to existing greenspace for employee and resident populations. This helped us determine where populations are underserved by the current stock of greenspace in downtown. This metric was used as a variable in the Need-Based Evaluation model as an indicator of where greenspace should be added or improved in the future.

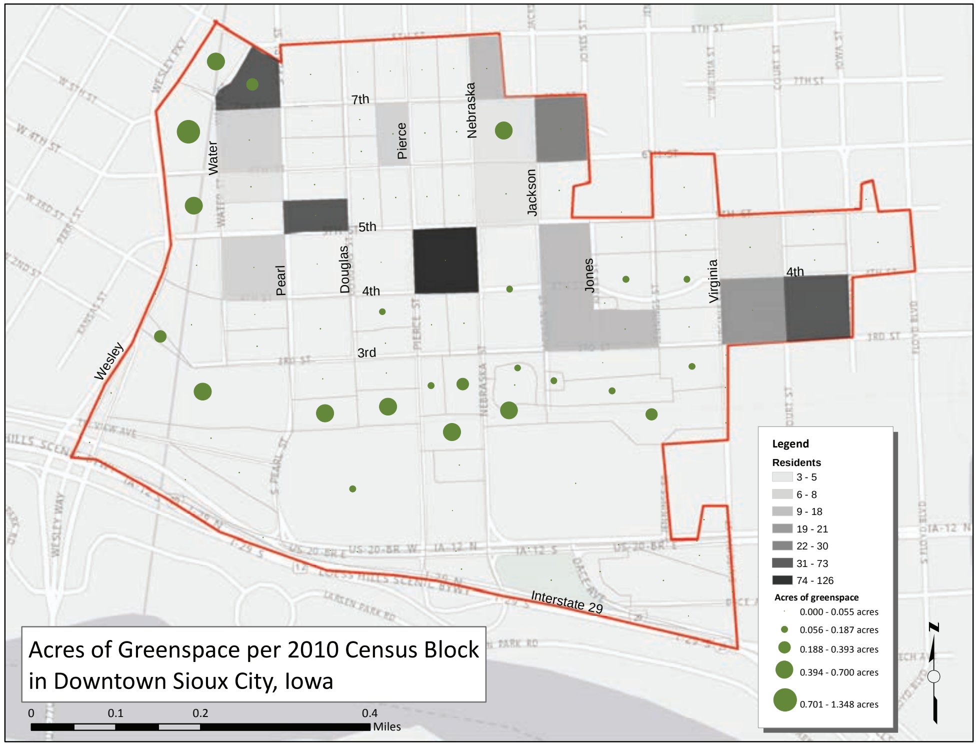

Figure 27. Acres of greenspace per Census block. Source: authors.

Our research indicates that the average distance from the center of each city block to the nearest greenspace is about 1.88 blocks, or 695 feet. Urban design literature regarding walkability to greenspace has determined that the recommended distance should be no more than a half block, or about 185 feet (Ståhle, 2009). This recommendation is directly addressed in the implementation section of this plan, which can be found starting on page 68.

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4.1 Potential Spaces

Potential locations for greenspaces were also identified by Sioux City residents and visitors at the Community Open House. During this event, open ended comments regarding publicly desired locations for greenspace were collected on a large aerial map of downtown. These comments are detailed in Figure 28. Incorporating green roofs, pocket parks, greening parking lots, and connectivity to the Riverfront Park within the overall greenspace network were commonly prioritized by participants and align with many of the priority projects detailed in later sections.

4.2 Usage and Interest Survey

Figure 29 shows the demographic comparison for the total population and survey sample. The survey sample is comparable to the actual population, with the exception of educational attainment and tenure living in Sioux City. Based on a 95% confidence level, the sample percentage of people with a Bachelor's degree or higher is significantly higher for the surveyed sample population than the actual population. This is likely due to the survey's oversampling of downtown employees and under-sampling of downtown residents. In addition, Figure 29 demonstrates an average years lived in Sioux City for workers that is significantly higher than the average years in Sioux City for residents based on our

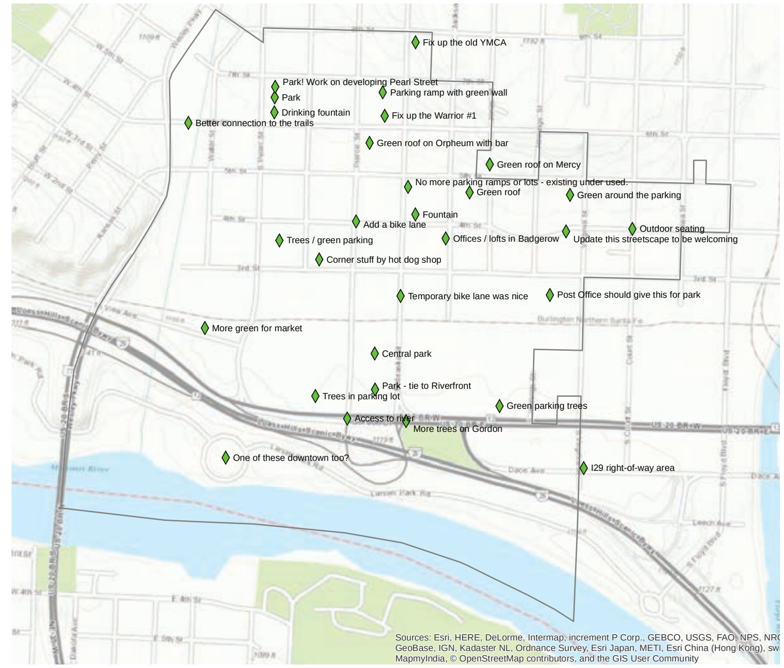


Figure 28. Locations of comments compiled at the Community Open House. Source: authors.

	Residents Sample	Residents Actual	Workers Sample	Workers Actual
Age: 18 - 54	54%	60%	69%	74%
Female : Male	36% : 64%	37% : 62%	56% : 44%	58.5% : 41.5%
Bachelor's Degree or Higher	96%	5%	81%	23.60%
White : Hispanic	100% : 0%	75% : 10%	95% : 4%	94.6% : 5.4%
Mean Years in Sioux City	17	Not available	26	Not available

Figure 29. Demographic comparison between the survey sample and actual downtown population of residents and workers. Source: authors.

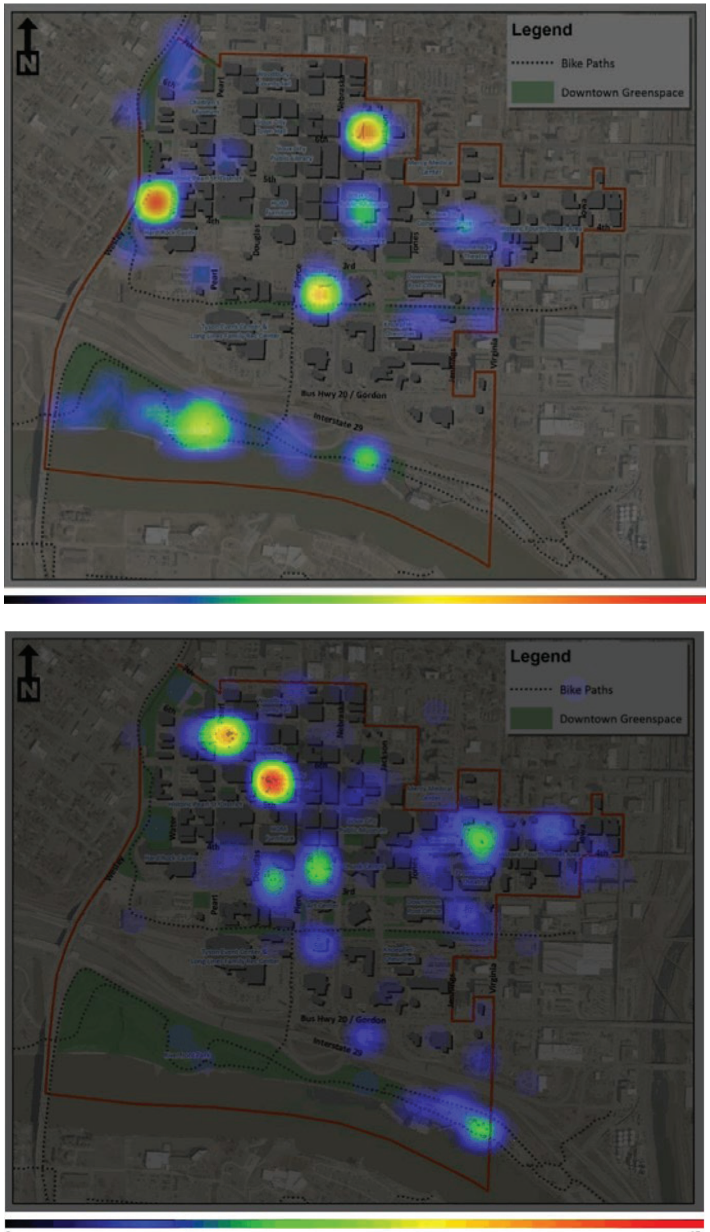


Figure 30. (Top) Exisiting locations of greenspace usage. (Bottom) Ideal locations for future greenspace as reported by respondents of the Usage and Interest Survey. Source: authors.

survey sample.

Results show that one-fifth of respondents never utilize downtown greenspace and that another fifth of respondents utilize downtown greenspaces less than once per month. Figure 30 displays where survey respondents most commonly utilize downtown greenspace. Currently, the most utilized greenspaces are the Shepherd's Sensory Garden, the Riverfront Park, greenspace located outside the Sioux City Public Museum, and grassy areas north of the Hard Rock Casino.

In general, survey respondents agreed on ideal locations for new greenspaces. Many parking lots were viewed as potential locations for future greenspace including the parking lot east of the Children's Museum, the parking lot adjacent to the Public Library, and lots north of Third Street between Douglas and Nebraska Streets. These areas are depicted as "hot spots" in Figure 30. Several of the identified areas are already slated for greenspace development. For example, funding for the development of the parking lot east of the new Children's Museum has been allocated in the City CIP budget for the upcoming year.

Survey respondents were asked to rate the importance of recognized environmental issues in downtown Sioux City. Figure 31 shows that the

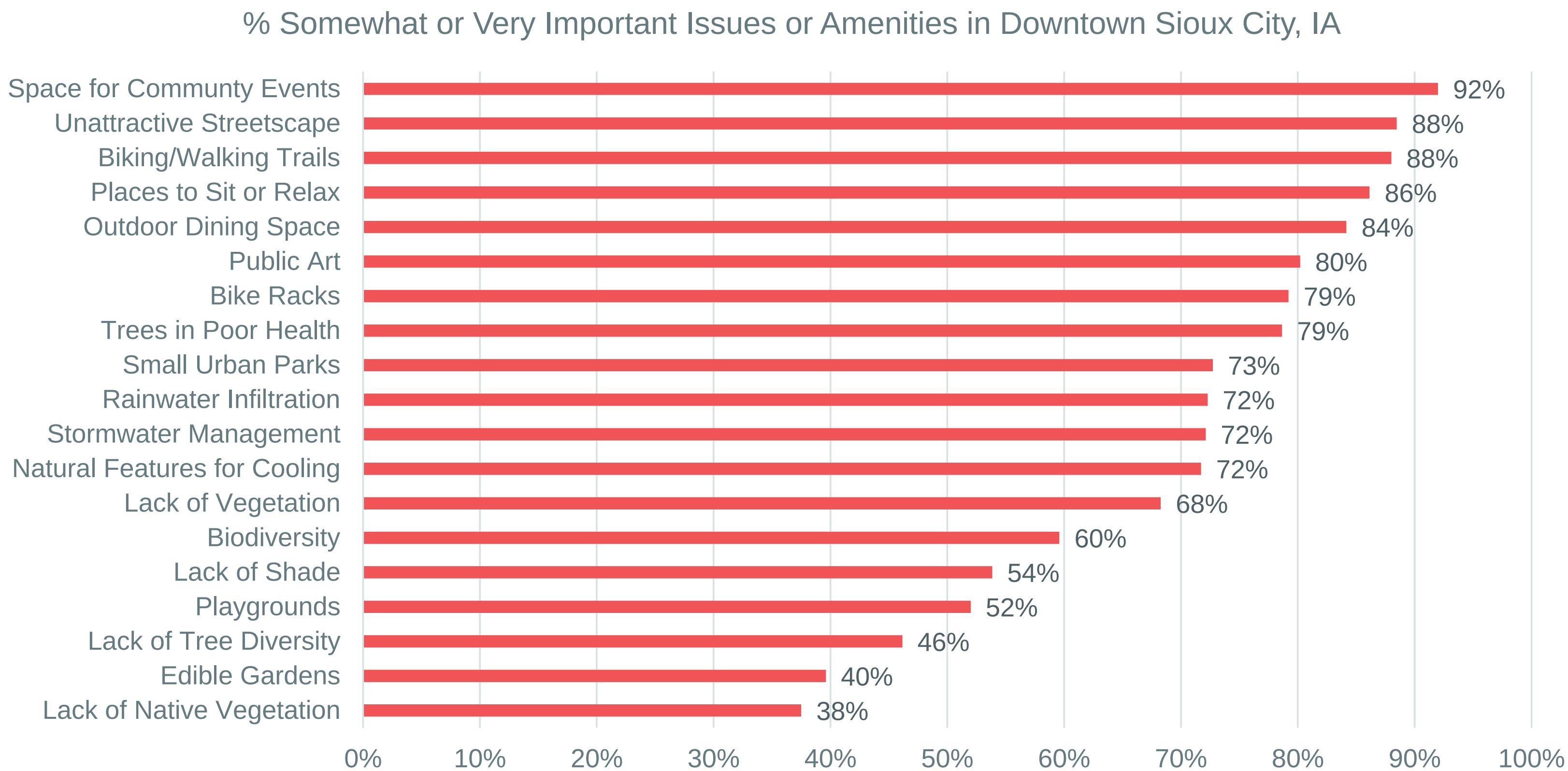


Figure 31. Important issues as identified by the Usage and Interest Survey. Source: authors.

majority of respondents see unattractive streetscapes, trees in poor health, and stormwater infiltration as important issues for downtown Sioux City. There is no overall significant difference between worker and resident opinion on downtown issues based on a chi-square test. Although issues such as native vegetation and lack of tree biodiversity were rated as less important, this plan also recommends solutions that address these issues because of the need to ensure resilience, durability, and low maintenance of new greenspace and plantings.

Respondents were also asked to rate the importance of twelve greenspace amenities for downtown Sioux City. They rated space for community events, biking or walking trails, and places to sit or relax as the three most important amenities for downtown greenspaces, as seen in Figure 31. There is a significant difference between downtown residents and workers opinions regarding these amenities. There is also a significant

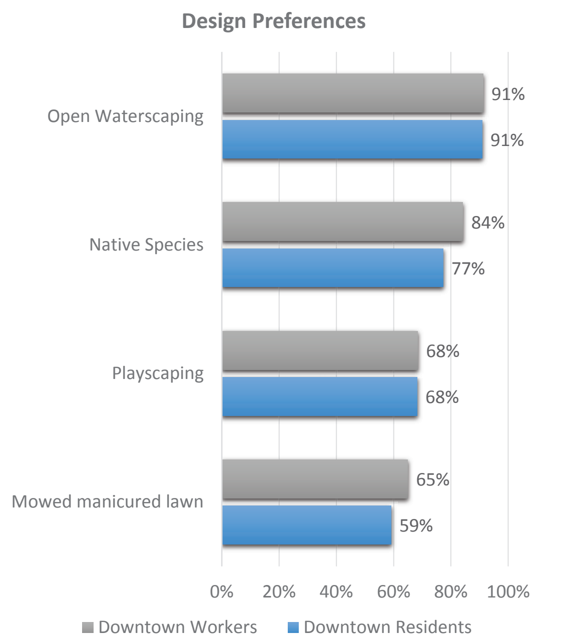


Figure 32. Design preferences identified through the Usage and Interest Survey. Source: authors.

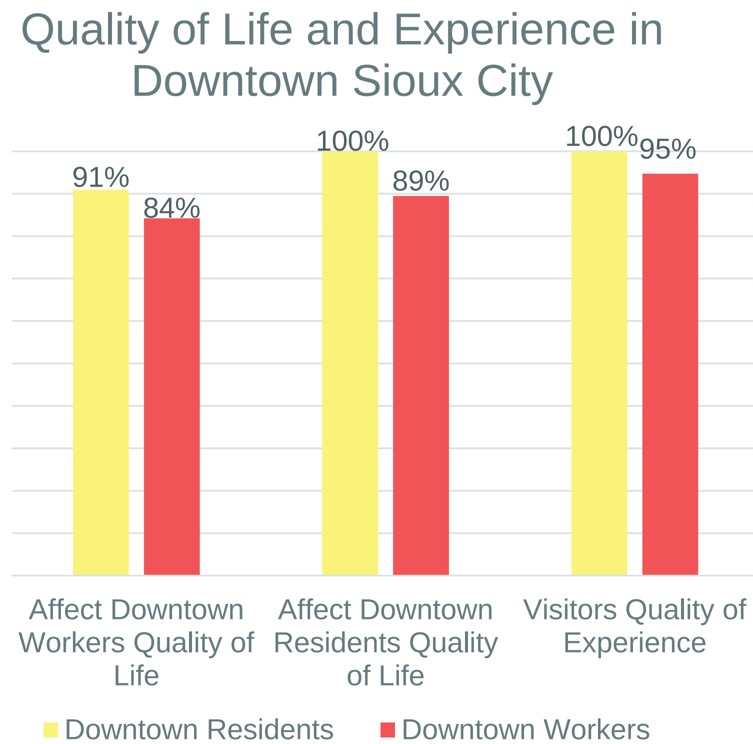


Figure 33. The impact of additional greenspace on the quality of life residents and workers. Source: authors.

difference (at the 90 percent confidence level) between the proportion of workers and residents who see natural features for cooling as important. Edible gardens, playgrounds, and biodiversity were not as important.

Survey respondents were also asked to rate their preference for different types of greenspace design. There is a significant difference between the percentage of respondents who prefer open waterscaping, native species, or a mowed or manicured lawn, which is shown in Figure 32. There is no significant difference between downtown residents and workers design preferences.

Survey participants were asked to consider the impact of downtown greenspaces on local quality of life. Figure 33 shows that high percentages of survey respondents believe that additional greenspaces would positively impact the quality of life and experience of residents, employees, and visitors of downtown Sioux City. More specifically, a majority of

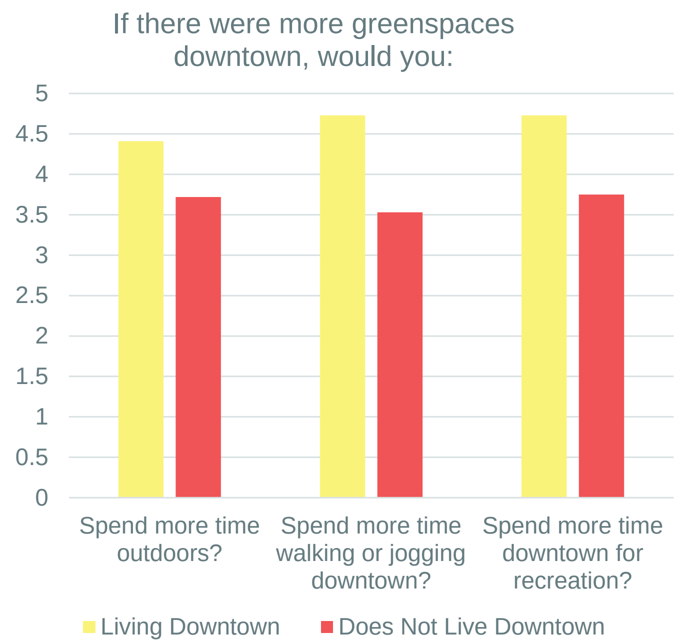


Figure 34. Change in time spent outdoors with additional greenspaces as indentified by the survey sample. Source: authors.

survey respondents reported that they would spend more time outdoors and spend more time walking, jogging, and recreating in downtown Sioux City, as shown in Figure 34. Furthermore, these results show a difference (at the 95% confidence level) between the proportion of residents versus the proportion of workers who would spend more time outdoors, walking or jogging, and recreating. Thus, workers and residents have differing needs for greenspace.

Finally, although only a few business owners responded, the responses received do indicate interest in both hosting and financially supporting greenspace projects on their property. This is shown below in Figure 35. The Sioux City Livability Taskforce and board members of Downtown Partners also agree that customer and employee satisfaction, the ability to attract new customers, and the general downtown business climate would improve with addition of more greenspaces in downtown Sioux City.

Amenity	Yes, and interested in hosting on property	Yes, and would support financially
Green Roof or Garden	4	1
Green Wall	3	2
In-Sidewalk Planters	2	5
Permeable Pavement	3	2
Outdoor Seating or Dining	2	4

Figure 35. Number of downtown business owners willing to host or fund greenspace on their property. Source: authors.

4.3 Community Open House Event

The Community Open House, held on March 5th, 2016, served as an opportunity to inform the public about the Downtown Greenspace Plan and how it aims to improve the social, environmental, and economic viability of downtown. Participants were handed 15 stickers each and asked to place them next to a total of 41 amenities featured alongside the conceptual renderings they preferred.

In total, 6 posters were presented to about 105 participants regarding the following concepts:

- Pearl Street Pocket Park Concepts, Alternative 1
- Pearl Street Pocket Park Concepts, Alternative 2
- Green Open Surface Parking Lot Designs
- United Center Green Alleyway Concept
- Pierce Street and General Greenscaping
- Other General Greenspace Ideas and Concepts

The General Greenspace Ideas and Concepts poster included incorporating a green wall and green roof on the Discovery Parking Ramp near the intersection of Jackson Street and Fifth Street, enhancing the existing greenspace in front of the Public Museum, utilizing native prairie grasses as an aesthetic benefit and stormwater filtration system along the Perry Creek Trail, constructing a bioswale along Sixth Street, and vegetated rainwater detention strips between a parking lot and the sidewalk along Fourth Street.

The posters and results of the voting process at the Community Open House can be located in Appendix D. Specifics for these designs are discussed in Chapter 5.

Of all the individual amenities and concepts that were presented, building a green roof on the top of the Discovery Parking Ramp received the highest support. The construction of a pond with a bridge in the Pearl Street Pocket Park and utilizing native landscaping in the United Center Green Alley concept followed in rank. Incorporating native prairie grasses and diverse tree and plant species throughout downtown received high public priority across all concepts.

The Community Open House also incorporated a variety of open ended exercises in order to generate additional ideas for downtown greenspace. In order to make the event interactive for families, we supplied participants with a blank template of the Pearl Street Pocket Park location and asked them to draw and describe their dream pocket park. One example is shown in Figure 36. We also provided a large aerial map of downtown Sioux City so that participants could place sticky notes next to spaces in downtown that they thought could be improved with additional greenspace and blank paper for which the public could write general comments. Comments placed on the aerial map can be found in Figure 28 (shown earlier in this chapter). These interactive activities

Figure 36. One child's drawing of what could be included in her ideal park. Source: authors.

provided the Greenspace Team with valuable insight regarding potential designs, amenities, or locations for additional greenspace that were not originally taken into account.

The results from the Community Open House have been shared with City of Sioux City staff and inform aesthetic and funtional design decisions for future greenspace in downtown Sioux City.

4.4 Public Input Analysis

The results from the Usage and Interest Survey, Community Open House, and conversations with local residents are consistent. Sioux City residents and workers believe that the presence of greenspaces will enhance the character and desirability of downtown Sioux City. Many of the concepts presented were attractive to public input participants, and many had difficulty picking their favorites. Residents are interested in incorporating greenspaces that will make a walk across downtown from one destination to another more enjoyable and aesthetically pleasing.

Overall, the public preferred greenspaces that incorporate the following concepts and amenities, in no particular order:

- Greening surface parking lots
- Greenspace with water features
- Native vegetation
- Innovative greenspaces such as green roofs
- Amphitheaters
- Bird feeders
- Stormwater management infrastructure
- Public art
- Diverse tree and plant species

Figure 37. 1 of 6 greenspace design posters presented at the Community Open House. Source: authors.

5.1 The Vision

To help guide the implementation of greenspace in downtown Sioux City, we developed a Greenspace Vision Map, pictured in Figure 39. The Vision Map shows a combination of existing and proposed greenspace in downtown Sioux City. It prioritizes the implementation of a network of green streetscapes and highlights parcels identified as high priority in the assessment.

5.2 Greenspace Design Categories

The design section of this plan is separated into five sections: (1) Streetscaping, (2) Pocket Parks, (3) Stormwater Infrastructure, (4) Parking Lots, and (5) Retrofits and Enhancements. Each section includes conceptual renderings for the types of green features that could be incorporated into the downtown landscape. Following each rendering, a short description states the importance of each feature for downtown and which project objectives are met with each design, which is communicated through the objective icons located below each image. An approximate cost estimate range based exclusively on material costs also accompanies each design.

The designs presented in this section are intended

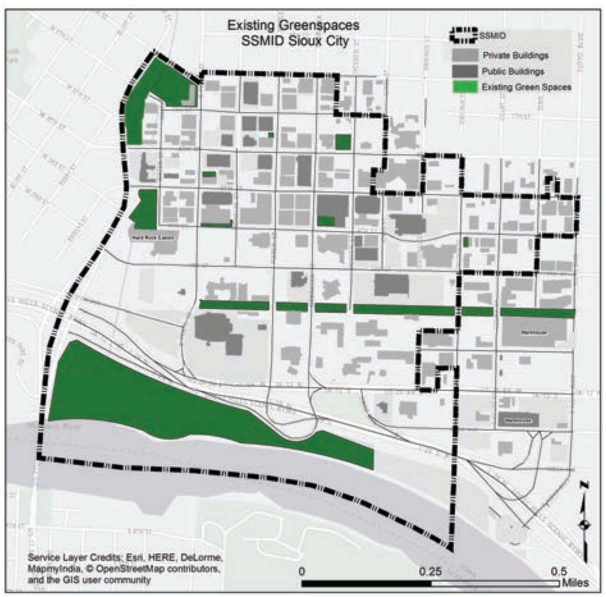


Figure 38. Existing greenspace. Source: authors.

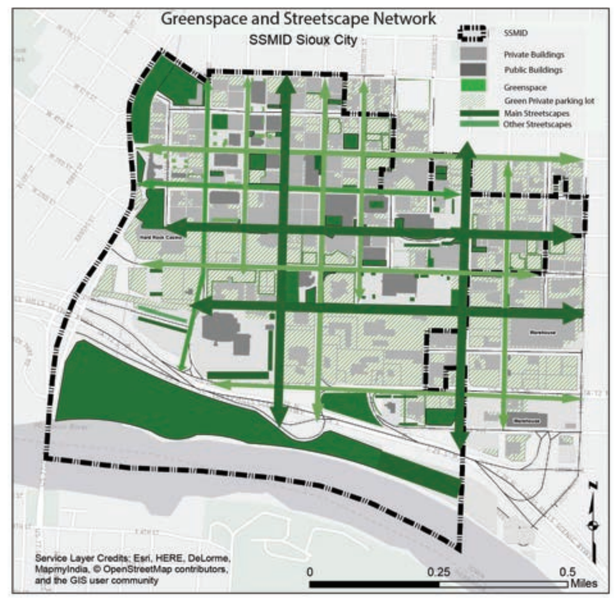


Figure 39. Greenspace vision. Source: authors.

to serve as representations of what could be implemented based upon the infrastructural constraints presented in downtown Sioux City. The renderings also serve as templates for future greenspace development. The designs are intentionally "busy" in terms of the amount of different features in order to graphically depict as many potential features as possible.

5.2.1 Streetscaping

Figures 40 and 41 show renderings of streetscapes for two locations along Pierce Street. The blocks along Pierce Street scored high on the Need-Based Evaluation with a score of 21 out of 29 points. Although the Usage and Interest Survey results identified varying interest for streetscaping, our partners indicated streetscaping as a priority. Streetscapes address 12 of the 15 objectives of this plan.

Streetscapes help bring coherency to downtown by creating a network of connected greenspaces throughout the district and serve as places of social interaction. The renderings bring scale to the area and provide shade, color, and interest through street furniture and trees. The streetscapes have been designed to buffer pedestrians from the street.

We prioritized streets based on their importance to

Figure 40. Conceptual rendering of enhanced streetscaping practices along Pierce Street such as public seating and prairie plantings. Source: authors.

Figure 41. Conceptual rendering of enhanced streetscaping practices along Pierce Street looking south. Source: authors.

Figure 42. Conceptual rendering of Best Management Practices in green streetscaping. Source: authors.

downtown in terms of pedestrian use, gateways to downtown, or linkages to the riverfront and trails. Based on these attributes, we identified Pierce Street, Fourth Street, and Virginia Street as priority streets and the remainder of downtown streets as secondary streets. The Vision Map (Figure 39) shows the locations of priority and secondary streetscapes within the overall network of greenspaces.

The majority of sidewalks along Pierce Street are 12 feet wide. Trees, native landscaping, and street furniture have been added to the sidewalks in the renderings. Sidewalks will maintain six or more feet of walking space. Trees ideally should be placed about 30 feet apart at the base. Sidewalks on secondary streets typically are up to 12 or more feet wide. Trees and in-ground planters should be added to these streets as well.

Pierce Street is a one-way street that runs north-south and connects downtown to the Riverfront Park. It is the main pedestrian access to the Riverfront Park and is also used by residents and visitors to walk to the Tyson Events Center and other nearby attractions. As pedestrians walk toward the Riverfront Park, buildings give way to open parking lots. Thus, the enclosure provided by buildings disappears. The streetscape becomes barren without any trees or landscaping. Proposed streetscaping renderings in this plan contain shade trees, native grasses, flowering plants, benches, lamp posts, wayfinding signage, and bicycle racks as shown in Figure 41. The rendering shows that toward the southern part of Pierce Street, a double row of trees has been installed on the sidewalk where there are currently parking lots on both sides. This shaded space has benches and can serve as an informal resting and socializing space.

The renderings and amenities shown are estimated to cost between $36,000 and $110,000 per block in material costs only. When considering streetscaping, the city should also take into account bioswales as discussed in Section 5.2.3.

Virginia Street will become an important gateway to downtown following the reconstruction of Interstate 29. Fourth Street is a historic street and serves as an east-west artery to many destinations in downtown. As such, these are other ideal streetscapes for greenspace development.

5.2.2 Pocket Parks

A "pocket" park – a term used for urban park space that is typically less than a few acres in size – is the best strategy for significantly adding to the total amount of greenspace downtown. Figures 43 and 44 are conceptual renderings our team has produced for a potential pocket park located at the corner of Seventh Street and Pearl Street. Currently, this space is a surface parking lot. This space holds great potential given pedestrian traffic generated by nearby residential housing and several local business, notably a new Children's Museum that has been opened across the street. As illustrated by the icons below Figure 44, both of these designs meet all of the 15 project objectives.

As the designs clearly illustrate, many features could be incorporated into a park of this size. Several

Figure 43. Conceptual rendering of a potential pocket park featuring an amphitheatre, playground, and gazebo. Source: authors.

Figure 44. 2nd alternative for a potential pocket park featuring a pond, edible garden, and pergola. Source: authors.

Figure 45. Panoramic view of the 2nd pocket park alternative design near the edible garden within the park. Source: authors.

features are worth mentioning in detail. First, a small amphitheater is incorporated into Figure 43, which could serve as space for music events, public or educational events, or simply as seating area for a lunchtime crowd. In the same design, a human sundial is designed at one of the park entrances. By standing at the center of circle, a person's shadow is cast onto a corresponding number on the ground in front of them telling the time of day. This component is a simple, fun, and relatively inexpensive park feature that is also an opportunity for placemaking through the use of historic terracotta bricks. It also provides users with a connection to solar orientation and changing seasons.

In Figure 44, an edible garden is designed into the southwest corner of the park. An edible garden could be an excellent public education feature with regards to topics like plant growth, local foods, or composting. The operation and maintenance of the garden, or portions of the garden, could be delegated to the city, schools, local organizations, or volunteers. Another feature presented in Figure 44 are bird feeders. By adding bird feeders, park guests have the opportunity to view a wider range of species downtown, which could be furthered through the planting of diverse native species and trees. Bird feeders are inexpensive to purchase and install but do require periodical maintenance to refill bird seed.

Of all the 14 features presented in these two designs, the public preferred the pond feature, the amphitheater, and diverse tree species as the top three park features. The lower ranked features based on input at the Community Open House event were

Figure 46. Panoramic view of the 1st pocket park alternative design near the entrance to the park. Source: authors.

bike racks, a gazebo, and the small playground. These results are detailed in more depth in Appendix D.

This space was previously identified by our project partners as a potential location for greenspace. Through our Need-Based Evaluation model, we discovered that this space is also ranked high for greenspace development. Currently, this area is highly impervious, has low proximity to other greenspace, and is located near a high concentration of residents and workers. This space was also the second highest rated hot spot for future greenspace as identified by downtown residents and workers surveyed in the Usage and Interest Survey. It is thus a priority for all stakeholders.

Our team estimates that the cost of raw materials required to develop this space into either of the previous designs would range between $185,000 and $445,000. This includes new topsoil once the existing concrete is removed, which is the largest individual cost for the project. The cost estimates do not include future design work, labor, or maintenance. Our team believes this type of project would be primarily funded through the city's CIP program. Currently, there is $50,000 budgeted from the CIP for this site. However, there are many opportunities for private donors to gain naming privileges for individual features of this park. This could includes features like benches, the amphitheater, or even the park as whole.

BMP Type	Typical Pollutant Removal (Percent)				
	Suspended Solids	Nitrogen	Phosphorous	Pathogens	Metals
Bioswales (enhanced dry swales)	80	50	50	<30	15-45
Pervious/porous pavement systems	65-100	65-100	30-65	65-100	65-100
Vegetated filter strips	50-80	50-80	50-80	<30	30-65
Bioretention areas (rain garden or cell)	80	60	50	N/A	80

* Derived from Section 2D-3 of the Iowa Stormwater Management Manual

Figure 47. Pollutant removal abilities of select stormwater best management practices. Source: authors.

5.2.3 Stormwater Infrastructure

Several Best Management Practices (BMPs) can be incorporated in downtown to reduce stormwater runoff while simultaneously greening the city. Infiltration strategies such as replacing concrete parking lots with park space as well as utilizing permeable pavement and filtration techniques such as bioretention cells, rain gardens, filter strips, and bioswales can all be employed in downtown Sioux City. Each of these BMPs should be designed to appropriate engineering standards in order to maximize their stormwater infiltration and environmental treatment benefits. Engineering design criteria for these BMPs can be found in the Iowa Stormwater Management Manual. Moreover, each BMP provides different but substantial pollutant removal benefits, as summarized above in Figure 47.

Permeable pavement can be employed in areas otherwise paved with concrete or asphalt in order to improve infiltration of stormwater. These systems are designed to allow water to infiltrate through the pavement surface and either into the soil underneath or into a drain pipe. Permeable pavement decreases the imperviousness of a site, thus reducing runoff and pollutant loads leaving the site. For smaller storms, permeable pavement can almost completely eliminate surface runoff. While these systems are more expensive to install and maintain than traditional pavements, costs are often offset through downsizing or extending the lifespan of on-site and downstream drainage systems and infrastructure (Iowa Stormwater Management Manual Section 2J, 2009).

Figure 48. Parking lot with permeable pavement. Source: Bract Retaining Walls.

Permeable pavement is most suitable for parking lots and roadways with light traffic as well as pedestrian oriented areas and thus can be incorporated in urban areas with ample surface parking lots such as downtown Sioux City. (Environmental Protection Agency, 1999). An example of a parking lot with permeable pavement can be seen in Figure 48. A rendering of how permeable pavement could look in an existing private surface parking lot in Sioux City can be seen in Section 5.2.4, and a detailed summary on maintenance requirements for permeable pavement can be found in Appendix E. Parking lots can also be greened by incorporating trees, buffer strips, and infiltration trenches on lot edges.

BMPs designed to pretreat stormwater and filter pollutants while facilitating infiltration of stormwater include bioretention structures, rain gardens, filter strips, and bioswales. These can be installed on parking lots, edges of parking lots, or wide sidewalks on priority streets. They can also be installed in pocket parks as well as on private property to capture stormwater runoff from roofs. Rain gardens and bioretention cells consist of shallow landscaped depressions that temporarily store and infiltrate stormwater. These systems are effective at removing pollutants associated with urban areas such as sediment, heavy metals, nutrients, bacteria, and organics. Rain gardens depend primarily on soils with high percolation rates alone, while bioretention cells usually include a rock chamber, subdrain, and modified soil mix. These systems incorporate the use of grasses, perennial plants, shrubs, and trees. These can incorporate native prairie plants, flowers, or no-mow grasses to reduce mowing costs.

Vegetation in bioretention systems and rain gardens provide value with regards to evapotranspiration. Native species are highly resistive to moisture changes, and insects that are attracted to these plants provide uptake of runoff and pollutants. Deeply rooted native plants are especially useful to maintain high organic matter in soil. In Sioux City, native prairie grasses, fescues, and sedges would provide significant benefit. Moreover, bioretention structures are ideal for highly impervious areas, which maximizes their effectiveness when retrofit into downtown stormwater management networks (Iowa Stormwater Management Manual Chapter 2E-4, 2011).

Ideal spaces for the construction of bioretention cells or rain gardens include new and existing greenspace in downtown Sioux City and natural depressions in areas acquired by the city following the completion of Interstate 29 reconstruction. They can also be incorporated in parking lot islands and edges, road medians, public right-of-way, courtyards, or underutilized grassy areas on a site. As long as adequate space is available, rain gardens can be landscaped to conform to many configurations or built into a landscape. An example of a landscaped

Figure 49. Urban rain garden. Source: South Side Green Infrastructure Charrette.

Figure 50. Filter strip in parking lot. Source: American Society of Landscape Architects.

urban rain garden can be seen in Figure 49.

A filter strip is a similar type of filtration mechanism to bioretention cells. Filter strips are narrow, vegetated sections of land that are designed to intercept overland sheet flow. As such, filter strips are ineffective at treating large volumes of concentrated flows, but are effective at increasing stormwater infiltration. Similar to bioretention cells and rain gardens, filter strips can employ a variety of plant types to fit stormwater and aesthetic needs. In addition, filter strips can be designed to filter pollutants associated with runoff.

Filter strips work best when incorporated into parking areas, especially in the center or along the edges of parking lots. They are also effective and easy to construct in narrow public right-of-way. Filter strips are an attractive alternative to curb and gutter systems along roads and highways since roads are already designed to route stormwater to curbs. They can also be used as a riparian buffer adjacent to streams, which would be ideal adjacent to Perry Creek. An example of a filter strip in a parking lot can be seen in Figure 50, and a rendering of how a filter strip could look when built into the middle of a surface parking lot in downtown Sioux City can be seen Figure 55 in Section 5.2.4.

Bioswales are another way to strategically intercept and treat stormwater. They can consist of gentle sloped trapezoidal or triangular cross-sections in areas with ample right-of-way or concrete rectangular channels in urban areas to be retrofit into existing sidewalk or parking lot space. In most cases, the concrete shell contains soil and plants that collect and drain stormwater into a subdrain, which subsequently connects to existing stormwater pipes. While their primary function is to reduce stormwater flow rates compared to traditional pipe systems, they can also improve water quality by infiltrating the first wave of storm flows that they are designed to convey through plant media and soil (Natural Resources Conservation Service, 2005).

Stormwater can enter the swale either as at-grade sheet flow (if no curbs are involved) or as concentrated flow from curb cut intakes. These are usually smaller than typical sewer intakes and often are covered with grates in areas adjacent to street parking in order to provide a landing for passengers to exit their vehicles and feed parking meters. It is

Figure 51. Urban bioswale located in the public right-of-way. Source: Walkable West Palm Beach.

also recommended that bioswales in urban areas be constructed in a way so that the concrete swale walls are raised slightly above existing sidewalks to prevent pedestrians from falling into the bioswale.

An example of an urban bioswale is shown in Figure 51. This swale is an excellent model for how bioswales can be retrofitted into a downtown streetscape while being sensitive to site constraints. This swale includes a rectangular cross section, curb cuts, grates above the intakes, a landing for automobile users,

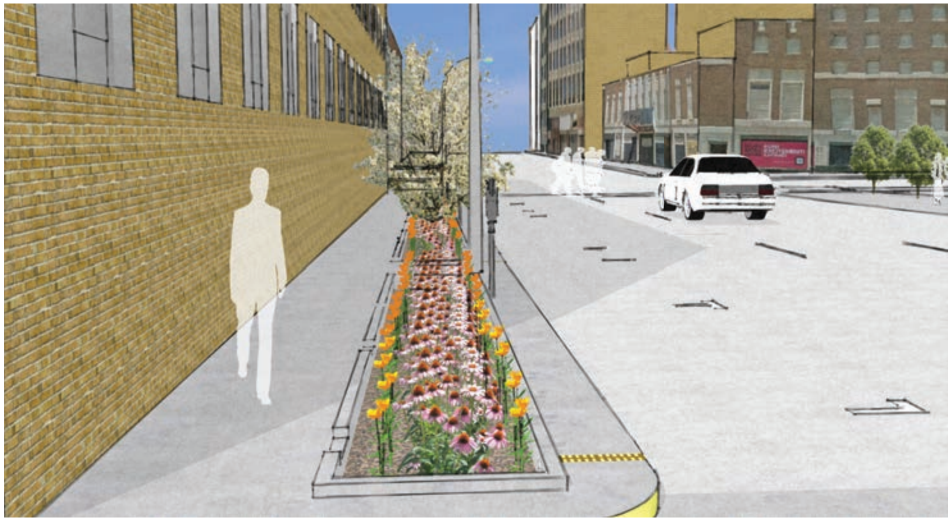


Figure 52. Conceptual rendering of a bioswale with a variety of forbs. Source: authors.

Figure 53. Conceptual rendering of a bioswale featuring bluestem grasses. Source: authors.

and a small lip adjacent to the sidewalk. Bioswales are typically constructed in areas with less than 4 percent slope but more than a 3 to 5 foot difference in elevation from inlet to outlet in order to provide enough slope for gravity to convey desired storm flows (Iowa Stormwater Management Manual Section 2I-3, 2013). Bioswales placed in areas with steeper slopes may require the construction of check dams, which can be cumbersome in urban areas both spatially and cost-wise. In downtown Sioux City, swales would work best at the base or at the very top of the steep-sloped areas near Mercy Medical Center within public right-of-way in order to maximize stormwater interception before and after it runs off down the hills. These locations also reduce the necessity to install check dams. Complete engineering specifications for bioswales can be found in the Iowa Stormwater Management Manual Section 2I-3. Maintenance requirements for bioswales are also summarized in Appendix E.

A specific site on the south side of Sixth Street at the intersection with Nebraska Street is an ideal location for a bioswale due to the gentle slope of the area. This site is immediately downstream of a steep sloped, highly impervious area that would stand to benefit significantly from its installation. One of the two alternatives for this site shown in Figures 52 and 53 was presented at our Community Open House in order to share the benefits of stormwater management techniques such as bioswales.

The bioswale was sized according to appropriate engineering standards as well as block level constraints. Predominant features include several street intakes with grates to cover them on the sidewalk, a short landing for automobile users, and a small overhang of the bioswale walls for pedestrian safety. The two alternatives present similar capabilities with regards to stormwater filtration and pollutant removal despite presenting one alternative with a variety of colorful native forbs such as butterfly milkweed and purple coneflower and another with a native grasses like prairie dropseed and little bluestem to showcase different plant styles.

In order to quantify the effect of constructing a bioswale at this location on stormwater runoff reduction, a hydrologic study was performed. For an estimated watershed area of 0.26 acres and an estimated swale size of 0.012 acres, this study determined that peak flows and runoff depth in this watershed can be expected to decrease by nine percent assuming no other green treatments. Given that most of this watershed is impervious streets and sidewalks and the swale covers a small fraction of its area, this represents a substantial improvement. Complete design details of the bioswale as well as a full description of the study that was performed to derive the reduction in runoff and peak flows can be found in Appendix B.

This site scored very high on our Need-Based Evaluation rank, receiving a score of 23 out of 29. This is due to the highly impervious ground cover as well as low tree cover. This area received a low score on our Usage and Interest Survey, which could be due to low understanding of what could be possible with regards to greening public right-of-way since this area is predominantly roads and buildings. In addition, these renderings meet ten of our fifteen objectives. Raw material costs for the renderings shown above are estimated to range from $17,300 to $28,500, with the largest cost occurring from the removal and replacement of old soil.

5.2.4 Parking Lots

The renderings shown in Figures 54 and 55 depict general concepts for greenscaping open surface parking lots in downtown. These alternatives were designed to minimum existing city standards (Subsection 25.05.090.1 Parking Lot Landscaping) for new parking lot construction and expanded upon in order to incorporate new green features such as permeable pavement in parking areas, public art, tree islands, and stormwater filtration facilities. General features in both concepts include vegetated or landscaped buffer strips between parking areas and the sidewalks and increased shaded public seating

Figure 54. Conceptual rendering of a parking lot “green” conversion. Source: authors.

Figure 55. 2nd alternative for a “green” parking lot conversion. Source: authors.

areas. These designs meet eleven of the fifteen plan objectives, as shown in the set of icons on the bottom of the next page.

Parking lot enhancements scored very highly on our Need-Based Evaluation, receiving a score of 25 out of 29. This is due to existing surface parking lots generally consisting of high impervious area and low tree cover as well as receiving high public priority for improvements. Public priority is shown in our Usage and Interest Survey results, where current parking lots received the third, fourth, and fifth highest level of interest for new development of greenspace on our interactive hot-spot map depicted in Figure 30 on page 43. Furthermore, the need to greenscape surface parking lots in downtown has been a significant issue identified by our project partners from the beginning of the planning process.

Raw material costs for the renderings shown can be expected to range between $43,300 and $205,000 for Figure 54 and $61,500 and $237,000 for Figure 55, with the largest expected cost for the installation of permeable pavement systems in the parking area. Cost savings may be realized by paving lots with a more traditional concrete or asphalt, although doing so would not reduce stormwater runoff.

While existing city standards provide a good baseline for parking lot design, we encourage the City of Sioux

City and private property owners to explore ways to go above and beyond the standard. With these renderings, this plan hopes to inspire better aesthetic and environmental practices in surface parking lot design. We also recommend that future parking lot designs utilize the results from our Community Open House, in which the top three amenities that participants preferred were public art, stormwater filtration infrastructure, and tree islands. Given the substantial amount of open surface parking lots in downtown, we believe that improvements in parking lot design are crucial to improve the overall attractiveness of downtown Sioux City.

5.2.5 Retrofits & Enhancements

Figure 56 shows a conceptual rendering for the potential enhancement of greenspace outside the Sioux City Public Museum. The greenspace next to the museum currently contains a lawn with a sculpture and a few trees. While it is currently a greenspace, it could be improved. This design makes the space more attractive by introducing a splash pad with a fountain that children can enjoy. Since the museum is a regional destination frequently visited by families with children, a fountain could be an attractive feature for children to use for cooling down on hot summer days. The grass is intercepted by narrow pathways that foster a sense of private space in the park and allows people to socialize or relax. Many flowering

Figure 56. Conceptual rendering of an enhanced public greenspace located outside of the Sioux City Public Museum. Source: authors.

and shade trees are incorporated. A stepped seating area overlooking the splash pad is also shown in order to serve as an informal gathering space. Benches can be added to the smaller space on the east side of the park for lunch or coffee breaks. This design meets 13 of the 15 plan objectives. The Need-Based Evaluation recognizes this space as medium priority

Figure 57. Digital rendering of a green roof on a public parking garage. Source: authors.

Figure 58. Digital rendering of a green wall. Source: authors.

for greenspace enhancement. We recommend that similar enhancements be undertaken at other existing greenspaces in downtown as well.

A green roof and wall concept on top of the Discovery Parking Ramp was the most favored design at the Community Open House event despite its low score on the Usage and Interest Survey. We believe this low score points to the fact that this block is currently a densely built up city block that does not appear to have much retrofitting capacity for greenspace. This block scored 22 points out of a total of 29 points in our Need-Based Evaluation model, marking it as high priority for greenspace development. Additionally, the green roof meets 11 of the 15 plan objectives. Renderings for the green roof and green wall are

Figure 59. Native prairie landscaping enhancement along the Perry Creek trail. Source: authors.

shown in Figure 57 and Figure 58. Native grasses and flowering plants provide relief from buildings visible from the roof and for residents, employees, patients, and visitors to the nearby hospital. The green roof has an excellent vantage point of downtown and can be seen from Mercy Hospital and the adjacent hotel. The renderings shown have material costs range from $343,500 to $1,030,000. Renderings and design are subject to additional structural analysis for a green roof. A preliminary structural analysis of this structure performed by University of Iowa College of Engineering students is located in Appendix F. Although the analysis determined that a green roof on this parking garage was not structurally feasible, we beleive the designs are useful for future retrofitting opportunities on other buildings or new construction.

Figure 60. Conceptual rendering of a green alley conversion featuring a pergola and native grasses. Source: authors.

Figure 61. 2nd alternative for a green alley conversion featuring a bike fixing station and permeable pavement. Source: authors.

A rendering for an enhancement to the Perry Creek Trail is shown in Figure 59. The Usage and Interest Survey identified that there is significant interest in trail usage and enhancement. There is also interest in incorporating native prairie grasses along trails. To aid in the development of prairies, construction and maintenance requirements for urban prairies are noted in Appendix E. In addition to the aesthetic benefits that native grasses provide, these plants also help reduce erosion on areas of the trail adjacent to Perry Creek. Longer prairie roots provide water uptake and storage and thus reduce runoff and streamflow velocities. Native grasses help improve the biodiversity of the area and make it attractive for walking and running as well as conducive to pollinators and birds. Similar treatment can be used along other trails, especially along the railroad greenway that cuts through downtown.

Retrofitting alleyways is another greenspace concept featured in this plan. Figures 60 and 61 show conceptual renderings of an alley located between the United Center and Promenade Theatre. The goal of these renderings is to increase public space and seating, as well as decrease the amount of impervious space. These designs meet 8 of the 15 plan objectives.

A feature highlighted in Figure 60 is the pergola, which provides some shade and acts to define the public space. Native landscaping is seen in both renderings, which is intended to absorb stormwater runoff sloping away from the northern portion of the alley. Decreasing the amount of impervious space is achieved through the use of permeable pavement as well. A bike fixing station, where bicyclists can tighten handlebars or pump tires, is also seen in Figure 61. This project was previously identified by our project partners as a potential public-private partnership. The site also recieved high priority for greenspace development based on the Need-Based Evaluation model. The cost range for this project was estimated between $11,500 and $50,000.

Increasing public space and green features in space that is often considered unusable is a key component of this plan. In addition to incorporating more green features into the public right-of-way, utilizing alleys for public space increases the utility of the space and can provide links between existing greenspace.

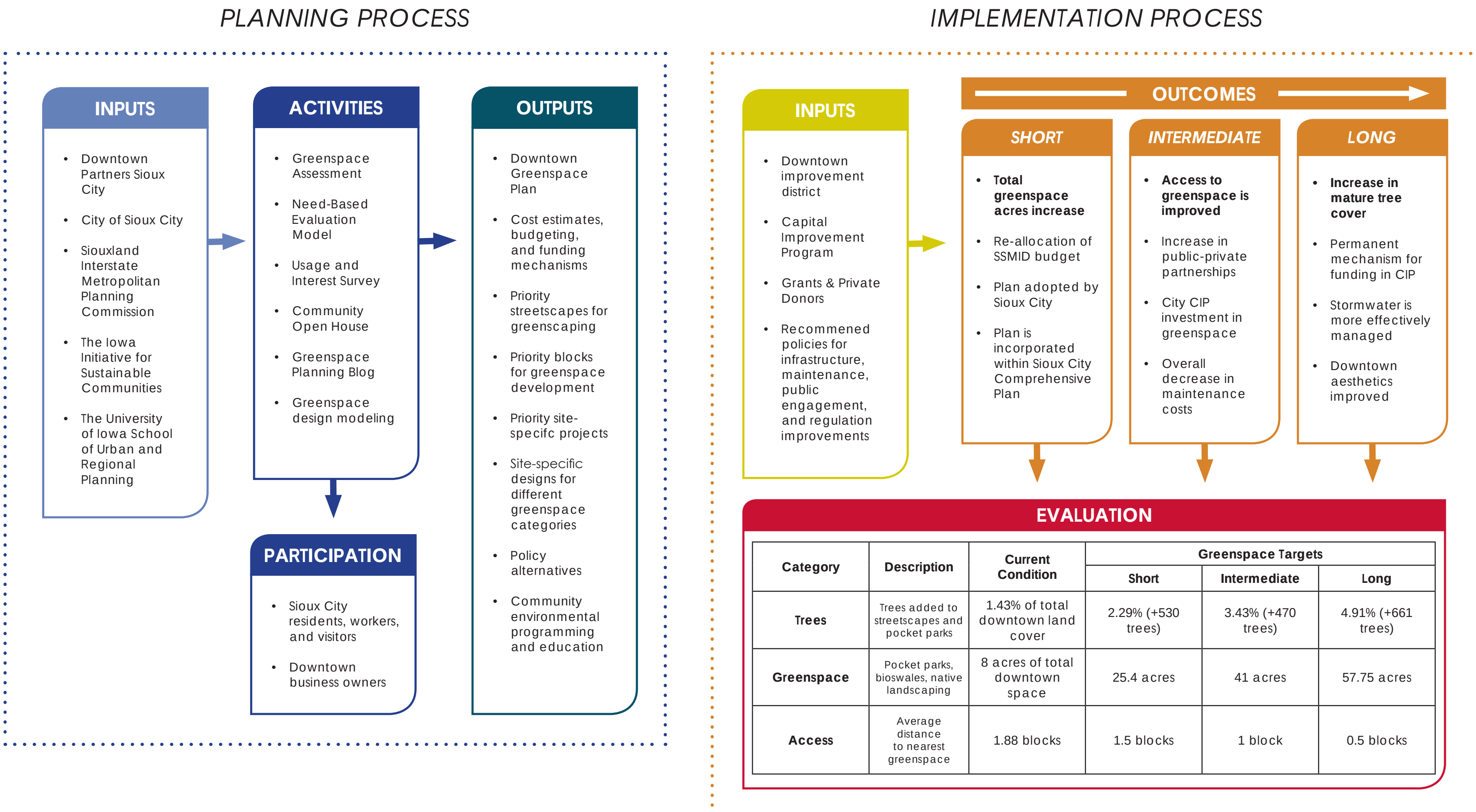
6.1 Greenspace Targets

Three key greenspace targets were identified as goals for the future of downtown: the amount of trees, the amount of greenspace, and the extent to which resident and employee access to greenspace is improved. The following targets are the result of the planning process, which is shown in the Logic Model for this project. Figure 62 details the recommended greenspace targets.

A Logic Model describing how this implementation strategy fits into the planning process is depicted in Figure 63 and provides a template for evaluation of greenspace outcomes. On the left side of the graphic, the planning process is illustrated with relevant stakeholders engaging the public through various activities such as the Usage and Interest Survey and the Community Open House. Through activities including the Greenspace Assessment, the Need-Based Evaluation, and Greenspace Design Modeling, the Greenspace Plan was created. The implementation process of the Greenspace Plan is depicted on the right side of the graphic. Based upon the recommendations put forth in this plan, inputs such as the SSMID, the City's CIP, grants, and private donor funding of greenspace development over the course of the next 20 years are grouped together. The expected outcomes provide specific, actionable metrics for evaluating progress over time.

Category	Description	Current Condition	Greenspace Targets		
			Short	Intermediate	Long
Trees	Trees added to streetscapes and pocket parks	1.43% of total downtown land cover	2.29% (+530 trees)	3.43% (+470 trees)	4.91% (+661 trees)
Greenspace	Pocket parks, bioswales, native landscaping	8 acres of total downtown space	25.4 acres	41 acres	57.75 acres
Access	Average distance to nearest greenspace	1.88 blocks	1.5 blocks	1 block	0.5 blocks

Figure 62. Existing greenspace conditions and targets for trees, greenspace, and access. Source: authors.



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			Short	Intermediate	Long
Trees	Trees added to streetscapes and pocket parks	1.43% of total downtown land cover	2.29% (+530 trees)	3.43% (+470 trees)	4.91% (+661 trees)
Greenspace	Pocket parks, bioswales, native landscaping	8 acres of total downtown space	25.4 acres	41 acres	57.75 acres
Access	Average distance to nearest greenspace	1.88 blocks	1.5 blocks	1 block	0.5 blocks

Figure 63. The Logic Model for greenspace planning and implementation. Source: authors.

This plan recommends gradually increasing tree stock in downtown Sioux City to 4.91 percent tree cover by 2035. This plan recommends that a net total of 1,661 trees are planted and adequately maintained in order to minimize attrition. These trees, if properly maintained (see Iles, 2001; Coder, 1999, 2000), would improve the existing tree cover by nearly 250 percent.

This plan also recommends a total of 57.75 acres of greenspace be added by 2035. This represents the maximum feasible area of greenspace given existing downtown land cover conditions. This is a significant upgrade from the current 8 acres of existing greenspace located downtown. Our team determined that of the 57.75 total acres of greenspace, 47.75 acres are undevelopable, public right-of-way, city owned land, land assumed to be acquired by the city following Interstate 29 construction, or existing and earmarked land for greenspace. This includes all land adjacent to Perry Creek and the Perry Creek Trail. The remaining 10 acres are existing developable space, which includes redefining grassy areas on private land as greenspace and assumes that ten percent of open surface parking lots in downtown are converted in some manner to greenspace through right-of-way improvements or on-site treatments as outlined in Section 5.2.4. This also assumes that all of the priority projects introduced in Section 6.1.1 are implemented.

As tree cover and greenspace increase, accessibility to natural space should also increase. This plan recommends that the long-term objective for accessibility should be that from the center of every downtown block, a natural space (i.e. tree cluster, public space, pocket park, native vegetation, bioswale, etc.) should be only about 185 feet away, which translates to half of a block. Currently, the average distance to the nearest natural space or feature in downtown is about 1.88 blocks, or approximately 660 feet. Strategic network connections should be made when determining future locations for greenspace to further the accessibility target. Figure 9 in Section 3.3 shows priority blocks that should be considered when expanding the greenspace network. Red and orange blocks represent space that is lacking in greenspace and thus would serve as connections to existing spaces. This analysis should be used when planning for future greenspaces.

The three greenspace targets recommended in this plan represent a significant shift in how greenspace, trees, and other natural features are prioritized by downtown residents, workers, businesses, and the city. All fifteen of the project objectives shown in Section 1.6.2 are achieved through the execution of the recommended greenspace targets.

6.1.1 Priority Projects

Significant progress toward achieving the greenspace targets can be accomplished through 12 priority projects that can feasibly be achieved within the next ten years. It is recommended that the city and Downtown Partners focus their immediate efforts on publicly-owned land. While this includes a few parcels in downtown Sioux City, effort should primarily focus on right-of-way greenspace improvements such as bioswales or streetscaping. Efforts to acquire land for the specific purpose of greenspace creation should focus on land that comes available following the reconstruction of Interstate 29. Additional land for greenspace could be acquired through land for sale on the free market, as is the case with the Pearl Street Pocket Park currently slated for development.

Several strategies can be implemented within the next five years to begin to address greenspace deficiencies in downtown. Principally, the city should continue to guide the development of the Pearl Street Pocket Park based on the renderings that were shown in the preceding chapter as well as results from the Community Open House. Following through on this project provides an excellent opportunity to address a high priority area for greenspace development on the western edge of downtown.

The city should subsequently invest in streetscape treatments as shown in Section 5.2.1 to beautify and increase seating and shading in downtown streets. The first priority street for greenscaping should be Pierce Street due to its high volume of pedestrian traffic and status as a backbone in downtown. Other corridors to prioritize after Pierce Street include Virginia Street due to its emergence as a gateway into downtown following the completion of Interstate 29 and Fourth Street due to its importance as an east-west link to many of downtown's primary attractions.

Additionally, bioswales should be incorporated in public right-of-way on gently sloping areas immediately upstream and downstream of steeply sloped areas of downtown in order to optimize interception and treatment of stormwater. These should be placed on sidewalks at least twelve feet wide in order to account for minimum ADA sidewalk requirements and incorporate landings for automobile users to exit their vehicles as per the design in Section 5.2.3. The south side of Sixth Street just east of Nebraska Street is an excellent site to start. Other stormwater management technologies such as filter strips, rain gardens, or permeable pavement systems should also be incorporated.

A simple and cost-effective means by which to substantially increase the stock of greenspace in downtown Sioux City is for the city to acquire land for sale following the construction of Interstate 29. Public parkland may not be feasible in this location or attractive due to the proximity of the highway and a lack of parking. However, this area could be a strong candidate for the installation of a gateway art piece or serve as a stormwater detention area complete with native prairie grasses and flowers. Using acquired land in this area for greenspace will beautify the gateways into downtown and improve downtown's overall attractiveness from the highway.

Finally, the city can look to foster public-private partnerships in order to increase greenspace as well as to provide opportunities to split costs with property owners. Examples include working with owners of private open surface parking lots in downtown in order to incorporate green features as outlined in Section 5.2.4. Costs can be split between the city for right-of-way improvements and private property owners for improvements within their parcel. Fostering

Priority Project	Timeframe	Low Estimate	High Estimate
Pearl Street Pocket Park	2016 - 2020 (Phase 1)	$185,000	$445,000
Pierce Street Greenscaping*	2016 - 2020 (Phase 1)	$218,400	$660,000
6th Street Bioswale	2016 - 2020 (Phase 1)	$17,300	$28,500
Acquisition of Parcels adjacent to I-29	2016 - 2020 (Phase 1)	Unknown	Unknown
Right-of-Way Improvements Adjacent to Open Surface Parking Lots**	2016 - 2020 (Phase 1)	$20,600	$32,500
United Center Alley	2016 - 2020 (Phase 1)	$11,500	$32,500
Discovery Parking Ramp Green Roof and Wall	2021 - 2025 (Phase 2)	$759,135	$2,276,300
Virginia Street/Fourth Street Greenscaping	2021 - 2025 (Phase 2)	$965,328	$2,917,200
Additional Bioswales***	2021 - 2025 (Phase 2)	$14	$22
Development of Greenspace between I-29 and Gordon	2021 - 2025 (Phase 2)	Unknown	Unknown
Right-of-Way Improvements Adjacent to Open Surface Parking Lots**	2021 - 2025 (Phase 2)	$45,526	$71,825
Perry Creek Trail Improvements and Creek Buffering****	2021 - 2025 (Phase 2)	$105,947	$464,385

* Cost from Third Street to Eighth Street

** Based on Green Parking Lot Design Alternative 2 price estimates less costs on private land, per parking Lot

*** Cost of Acquisition of Native Prairie Plants. Not indicative of labor costs

**** Inflation Rate is assumed to be 1.14%, which is the average for 2011-2016

Figure 64. List of priority projects and estimated cost range. Source: authors.

small-scale improvements in publicly-owned alleys adjacent to private property such as the United Center Alley project as shown in Section 5.2.5 is another example. Funding opportunities for these projects are discussed in Section 6.2.

Enhancing the downtown trail experience through additional greening should also be incorporated within the next ten years. This could include incorporating native prairie grasses and flowers along the Perry Creek Trail immediately adjacent to the creek in order to improve aesthetics as well as serve as a filtration buffer for runoff flowing off of adjacent buildings and streets prior to entering the creek.

Within ten years, the city should invest in construction of the green roof and wall on top of the Discovery Parking Ramp. Doing so will not only add to an area that is currently lacking in greenspace, but provide an opportunity for Sioux City to stand out regionally for its investment in greenspace. The rendering presented in Section 5.2.5 serves as a template for how this could be designed. A green roof would provide new economic opportunities such as attracting food trucks or rooftop events. Building off of the art collective located on the ground floor, this space could be a premier venue for social and cultural events. Figure 64 details the full list of priority projects our team has identified.

Cost Estimates for Recommended Greenspace Targets	FY16 - FY20		FY21 - FY25		FY26 - FY30		FY31 - FY35	
	Low	High	Low	High	Low	High	Low	High
Priority Site Projects	$452,800	$1,216,000	$2,143,700	$6,276,400	$0	$0	$0	$0
Trees: Primary Streetscapes	$11,900	$45,220	$26,299	$99,936	$0	$0	$0	$0
Trees: Secondary Streetscapes	$0	$0	$0	$0	$40,449	$153,706	$46,816	$177,901
Trees: Other Locations	$2,013	$7,648	$4,448	$16,901	$3,904	$14,836	$3,099	$11,777
Greenspace: Pocket Parks	$0	$0	$0	$0	$549,505	$1,343,450	$436,205	$1,066,450
Greenspace: Green Infrastructure	$0	$0	$0	$0	$604,172	$2,533,402	$479,601	$2,011,051
Total Low/High Cost Estimate	$466,713	$1,268,868	$2,174,447	$6,393,237	$1,198,031	$4,045,394	$965,721	$3,267,179
Average Cost Estimate over 5 Years	*$867,790*		*$4,283,842*		*$2,621,712*		*$2,116,450*	
Annual Average Cost Estimate	***$173,558***		***$856,768.38***		***$524,342.49***		***$423,290***	

Figure 65. Estimated costs for greenspace targets. Source: authors.

6.1.2 Cost Estimates

Our team has determined average cost estimates for the next 20 years that are required to fund the recommended greenspace targets. These costs, which are broken down by 5 year periods, are shown in Figure 65 and do not include the cost of land acquisition (if necessary) or labor. Specific low, medium, and high cost estimates for alternative greenspace amenities can be found in Appendix G. Primary streetscapes are projected to be accomplished in the next ten years, while the costs for secondary streetscapes will be incurred in the second decade of implementation.

Figure 65 has 3 primary cost categories: (1) priority site projects, (2) trees, and (3) greenspace. Cost estimates for priority site projects, which are detailed in the previous section, are incurred over the course of the next 10 years.

In terms of trees, cost estimates are provided for primary and secondary streetscapes. Trees located within pocket parks or in other locations are not classified under streetscapes. Greenspace costs are also broken into 2 categories: pocket parks and green infrastructure. Due to the development of the already-funded Pearl Street Pocket Park and the priority site projects planned for in the near future, costs estimated for pocket parks do not begin until fiscal year 2026. This is because priority projects consume a significant portion of the budget in the early stages of the implementation process. Similarly, costs estimated for the development of green infrastructure do not

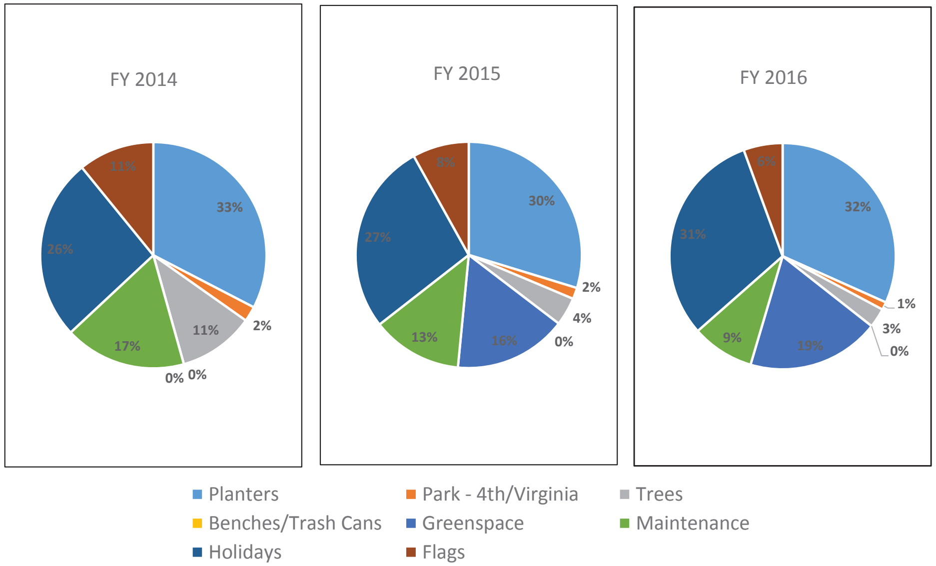


Figure 66. SSMID budget allocation percentages. Source: Downtown Partners Sioux City.

begin until the second 5-year block, or starting in fiscal year 2021.

These costs provide a rough estimation for the total annual cost of greenspace development over the next 20 years. More importantly, these figures reflect the funding required to achieve the recommended greenspace targets that are stated in this chapter. These cost estimates can be useful when applying for grants as well. The next section of this plan outlines the financial resources and opportunities that could be utilized for funding the recommended greenspace targets. Section 6.3 also provides recommended policies for maintaining greenspace and for pursuing greenspace funding.

6.2 Financial Resources

6.2.1 Self-Supporting Municipal Improvement District (SSMID)

The downtown improvement district is one of the principal sources for greenspace funding and maintenance. Currently, the SSMID applies $17,000 to general greenspace funding. In 2016, the district budgeted to spend $8,000 on maintenance, about $28,000 on planters, $2,500 on trees, and an additional $1,000 on a small park located at the corner of Fourth Street and Virginia Street. In total, the SSMID will apply nearly $57,000 to greenspace-related projects in 2016. These expenditures are shown in Figure 66.

In addition to common SSMID operations such as snow removal or street cleaning, the SSMID has the unique potential to significantly improve the overall aesthetics of the downtown through greenspace and trees and through connections with local business owners. Our research has illustrated that improved aesthetics can increase property values, which is intended to attract further investment in downtown. Section 6.3.4 provides a specific recommendation for the improvement district to continue funding greenspace development.

6.2.2 Capital Improvement Plan

The City of Sioux City's Capital Improvement Plan (CIP) is the other major source for greenspace funding. Greenspace-related funding that appears in Sioux City's approved CIP for fiscal year 2016 to fiscal year 2020 is shown in Figure 67. The figures shown include both regularly scheduled maintenance as well as special projects.

Greenspace can be funded in Sioux City's CIP through two avenues: (1) special, stand-alone projects and (2) incorporating green infrastructure into streetscape or stormwater projects. A good example of a stand-alone project is Pearl Street Pocket Park, which has been proposed in the 2017 – 2021 CIP for Sioux City. The project calls for a proposed budget of $50,000 for 2017, and $1.6 million in unprogrammed money through fiscal year 2021. According to CIP documentation for the project, the park will "be developed to include open greenspace for recreational usage; however, due to the location and proximity to downtown businesses and tourism, the park location is certain to be a destination for thousands of visitors throughout the years," and "the proposed downtown park will be a vibrant community space that will encourage special events, arts, music,

Project Description	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	Beyond 2020
Downtown Aesthetic Improvement		$50,000	$50,000	$50,000	$50,000	$50,000
Historic Pearl District	$150,000	$100,000				
West 7th Corridor Improvement	$200,000	$200,000	$200,000	$200,000	$200,000	
Pierce St. Corridor Improvement	$75,000					
Prairie Corridor						$100,000
Riverfront Recreation Upgrades	$37,500	$212,500	$195,000			$300,000
City Trails	$300,000	$300,000	$300,000	$300,000	$300,000	
Project Description	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**
Long Lines Family Recreation Center			$414,635	$429,129	$418,650	$469,304
Parks Maintenance			$2,492,507	2,601,315	2,825,737	$2,827,926
Large Area Mowing (acres)	5,001 acres	2,716 acres	1,723 acres	3,580 acres		
Riverfront Maintenance			$162,825	$141,340	$211,137	$209,280
Trees Removed	470	690	793	534		
Tree Maintenance			$109,518	$110,560	$120,300	$120,524
Recycling Rate Increase/Decrease		+1.8%	-5.8%	+13.7%		

Figure 67. Approved CIP allocations for Sioux City in 2016. Source: Sioux City Capital Improvement Program Approved 2016.

and fun." This language and type of project is precisely how greenspace should be pursued by the CIP in the future.

The second method for funding greenspace development through the CIP is systematically incorporating green infrastructure such as bioswales, rain gardens, infiltration trenches, native grass strips, and other vegetation into downtown streetscapes or stormwater projects as they occur or are scheduled. In the proposed 2017 – 2021 Sioux City CIP, several projects incorporate green infrastructure. For example, the Chautauqua Park project plans for a prairie corridor to be developed as a detention and filtration basin for stormwater draining from the Singing Hills watershed. This is not the primary objective of the project. However, incorporation of the prairie corridor is an excellent example of how green infrastructure should be planned for in CIP projects. In general, green infrastructure is seen as a secondary objective behind traditional methods of stormwater management in Sioux City. In the future, Sioux City should prioritize green infrastructure as not only a method for improving greenspace but also as a cost-saving measure.

6.2.3 Grants

Grants are an important mechanism for funding greenspace development. In order to achieve the recommended planning goals, grants will be necessary to supplement SSMID and CIP budgets. There are many opportunities for greenspace in downtown Sioux City to be funded through federal, state, and local grants. Figure 68 highlights the primary grant opportunities available for downtown Sioux City and provides details about the funding organization and the general intention for the how the grant can be utilized. Figure 68 is not an exhaustive list. For a full list of grant opportunities, refer to Appendix H, which includes more details regarding the application process, relevant dates, and potential grant amounts.

6.2.4 Public & Private Partnerships

Public-private partnerships are increasingly being used by cities to as a cost-sharing mechanism to finance urban projects. Well-maintained parks increase the appeal of downtown and can prove economically

GRANT OPPORTUNITIES FOR GREENSPACE DEVELOPMENT			
Program Description	**Eligibility**	**Cycle**	**Grant Amount**
REAP - Iowa Department of Natural Resources (IDNR)			
5 different grant programs including projects for city parks, education, trails, gateway projects	Cities, non-profits, and individuals	Annually (April)	$26,000 to $300,000, mini-grants also available
Fund for Siouxland - Siouxland Community Foundation			
Intended for community betterment, citizen participation, parks & recreation	Cities or non-profit organizations	Annually (January)	$5,000 ceiling
Brownfields Cleanup - Environmental Protection Agency (EPA)			
Program for creation of greenspace, recreational use, or natural habitat restoration	Cities or non-profit organizations	Annually (June)	$200,000 ceiling
State Revolving Fund - IDNR & Iowa Finance Authority			
Low-interest loans for financing for stormwater infrastructure improvements	Cities or non-profit organizations	Quarterly Rolling	Varies based on project scope

Figure 68. Shortened list of grant opportunities. Source: authors.

beneficial to nearby businesses.

We recommend that the SSMID and City of Sioux City pursue public-private partnerships for its downtown parks and streetscapes. This can be done at two levels; businesses can fund the construction of the park or streetscape close to their business, maintain the parks and streetscapes once built, or both. The Usage and Interest Survey identified some businesses interested in funding greenspace near their businesses. We recommend the SSMID encourage businesses by allowing them to install signage and provide opportunities for naming rights in greenspaces as an incentive. Greening awards are another way to incentivize businesses to maintain parks and streetscapes. For example, Baltimore implemented an awards program to successfully incentivize increasing greenspace in their downtown. Some cities have also created non-profit park foundations that manage capital.

Downtown greenspace can also be funded through donor contributions. Private donations from individuals, corporations, foundations, and non-profit organizations are other ways that funds can be generated. In addition, volunteer labor could be utilized to reduce construction and maintenance costs. MidAmerican Energy's investment in public greenspace, as evidence through the greenspace located south of their building, is an excellent example of private leadership in developing greenspace. This greenspace is pictured in Figure 69.

Figure 69. Greenspace located south of the MidAmerican Energy building. Source: authors.

6.3 Policy Recommendations

This plan is the first of its kind for downtown Sioux City. It provides both general and site-specific recommendations for the implementation of greenspace projects to improve the quality of life in downtown Sioux City. The implementation of greenspaces into downtown Sioux City's urban environment will improve aesthetics, serve an important role in the downtown's ability to address its stormwater, soil, and other ecologic challenges, and will help make Sioux City more sustainable and resilient in the midst of climate change.

Adopting greenspace policies will facilitate the implementation of greenspace into downtown Sioux City and ensure its protection in the future. The most appropriate policies for Sioux City are those that address local needs and concerns and capitalize fully on the multiple benefits of greenspace. In order to improve downtown Sioux City, it is important that city and building codes remain flexible and open to policy changes, additions, pilot projects, and innovations as needed. Refer to Appendix I for relevant downtown codes. We recommend the implementation of the following policies in order to allow Sioux City to reach its greenspace targets.

6.3.1 Greenspace Policies

Policy recommendations for greenspace aim to ensure that new greenspaces are adequately planned for and designed to ensure maximum benefit.

Recommendation #1: Utilize the opportunity of streetscape renovations or construction to incorporate green features. In order to ensure a dense network of green streets is incorporated as outlined in this plan, all streets and sidewalks undergoing updates or reconstruction should be concurrently retrofitted with green features. See Chapter 5 for ideas on how to increase tree cover, introduce stormwater management techniques, and incorporate native plantings into the public-right-of-way.

Recommendation #2: Prior to developing a new greenspace, ensure the soil is uncontaminated and encourage the use of local materials in the construction of greenspace. This plan recommends soil testing before a new greenspace is developed. If soil is contaminated, topsoil should be added or raised planting beds should be incorporated utilizing robust native species. Moreover, as a new greenspace is being conceptualized, aim to utilize local, recycled materials such as wood, granite, and terracotta. This decreases the distance for which raw materials travel and unifies the character of greenspaces throughout downtown.

Recommendation #3: Develop healthy, low-maintenance greenspaces with native species. There are many methods for developing a space that will require minimal maintenance. The primary method recommended in this plan is to plant native, non-invasive species. Native plants are more suitable to thriving in Sioux City's climate. Non-invasive plants do not require removal if they spread. Designing, selecting, and cultivating appropriate native ground cover placed alongside street trees is an attractive technique that helps naturally insulate trees from street heat and reduces maintenance and costs for mulching. Additional information about tree maintenance can be found in the References section of this plan (see Iles, 2001; Coder, 1999, 2000).

In addition, surrounding a tree with as much permeable land as possible will enable the tree to capture sufficient water, which will reduce maintenance costs and increase tree health. Finally, the city should consider hiring a horticulturist, if funding permits, in order to ensure that appropriate native tree and plant species are selected in downtown to increase their chances for survival and success.

Recommendation #4: Avoid or mitigate shadows that buildings may cast onto greenspaces. Some municipalities manage their greenspaces by restricting new construction that would block sunlight on a public park. Although shadow mitigation is not discussed in detail in this plan, it is important to prioritize parcels on the north side of a street, with no tall buildings directly south of the site when seeking land to acquire for greenspace. For new buildings constructed south of existing greenspace, height should be reduced or the building should be terraced to mitigate shadow impacts.

Figure 70. Digital rendering of a biodiverse roadside near Interstate 29. Source: authors.

6.3.2 Biodiversity Policies

Biodiversity refers to the number of species in an ecosystem. High urban biodiversity safeguards downtown Sioux City against plant diseases, supports pest control, facilitates local pollination and seed heritage, and improves the health of soil and vegetation. Successful greenspace policy in downtown Sioux City should promote increased quantity and access to greenspaces and support high quality greenspaces with a healthy mix of trees, native

Figure 71. Digital rendering of native prairie landscaping along the Perry Creek trail. Source: authors.

grasses, flowers, edible vegetation, and shrubs.

Recommendation #5: Ensure a diverse, sustainable, attractive, and low-maintenance tree population throughout the downtown. No one tree species should make up more than 10% of all trees (Nuffield Foundation, 2008). Similarly, vegetation, especially trees, should be planted annually in order to replenish stocks and encourage a diversity of vegetation age. This will help ensure a balanced mix of young, medium, and old trees. Additionally, native grasses and flowers should be prioritized to further increase biodiversity. This plan recommends continual enforcement of Sioux City Code 25.05.080.1 Approved and Prohibited Plant and Tree lists and Water Wise Landscaping Principles.

Recommendation #6: In the selection of sites for greenspace, prioritize land that fills gaps in the greenspace network. The city should pursue creative options for acquiring land in target gap areas and consider filling gaps by implementing greenspace in unconventional areas such as walls, roofs, and vacant lots. See Figure 38 in Section 5.2 to see the current gaps in the greenspace network. Mobile species such as birds and insects respond well to a strong network of greenspaces.

6.3.3 Access & Networks Policies

This plan seeks to increase access to greenspace for current and future residents, employees, and visitors of downtown Sioux City. To accomplish this, we recommend increasing the acreage and diversity of greenspace near areas of high population density. In addition, we recommend developing interconnected networks, which are more beneficial than isolated patches for species, health, and mobility.

Prior to this plan, Sioux City had already begun creating a network of greenspaces by connecting recreational trails and major corridors that connect downtown to the rest of Sioux City. This plan presents an opportunity to view and plan for individual greenspaces as a part of a comprehensive network that links downtown greenspaces to adjacent neighborhoods, public and private business, attractions, walking and biking trails, other greenspaces, and to connecting streets. Viewing greenspaces in this way will increase the use, acceptance, and success of downtown greenspaces.

Recommendation #7: Prioritize the establishment of greenspaces in locations of high resident, employee, and visitor densities. See Figures 23 and 26 in Section 3.7.1 to see the current distribution of employess and residents in downtown. As a complement to the Sioux City Active Transportation Plan, this recommendation includes incorporating bike racks and public seating into greenspace design. It is also recommended that greenspace be prioritized on bike and pedestrian corridors in order to provide a safer, cleaner, and more enjoyable walking experience. It also may inspire locals and visitors to spend more time in downtown Sioux City. Additionally, we recommend implementing greenspace into streetscapes to increase outdoor dining opportunities, which could be in the form of food trucks or sidewalk cafes.

Recommendation #8: Create greenspaces that are ADA-accessible. A variety of amenities can help improve ADA-accessibility (Americans with Disabilities Act) to greenspace. For example, ramps can help provide access for people with disabilities, parents with strollers, pedestrians, joggers, and cyclists. They can also be used to link major sections of an urban area together, creating an opportunity for people to bicycle or walk to work.

Recommendation #9: Utilize the Perry Creek riparian buffer as a natural greenspace corridor. Riparian areas are natural candidates for greenspace network expansion. Preserving vacant land in riparian areas for greenspace provides an attractive recreation area for residents and helps restore the ecological health of the city's rivers and streams. These areas help capture and filter urban stormwater runoff and buffer adjacent areas from potential flooding.

6.3.4 Funding Policies

The policies presented in this section take advantage of existing and future collaboration between the City of Sioux City and the SSMID to implement greenspaces. The following policies also make suggestions for the utilization of incentives for greenspace implementation and the revision of the existing municipal stormwater fee.

Figure 72. Rain garden in urban area. Source: Google Maps.

Recommendation #10: Establish a Downtown Sioux City Greenspace Fund through the Siouxland Community Foundation and pursue grant opportunities. The Sioux City Greenspace Fund would consolidate greenspace allocations from both the City of Sioux City and the SSMID into one fund. This fund would be used to fund the implementation of new greenspace in downtown Sioux City such as tree plantings, bioswales, parks, and streetscaping. This fund would also collect funding from other sources such as grants and public or private donors. The fund will target private donations with naming rights for greenspace or amenities within greenspace. It also has the advantage of offering federal and state tax breaks for donations to greenspace.

Recommendation #11: Re-evaluate existing stormwater fee to be based on percentage of impervious land instead of land-use. The structure of the current stormwater fee system is meant to charge based on land use categories as a way to approximate stormwater discharge. However, basing the fee primarily on the amount of impervious surface area on a given parcel would incentivize property owners to increase the amount of permeable surface on their parcel in order to reduce their fee. While an analysis of the efficiency of this fee structure is not presented in this plan, it may be useful in the future for the city to examine the feasibility of a fee based primarily on impervious surface area rather than land use.

Recommendation #12: Support and provide incentives to property owners interested in implementing greenspace on their property. Similar to offering a reduction in the stormwater utility fee, this plan recommends offering incentives for property owners to implement greenspace features on their property. This could be in the form of cost-share dollars, density bonuses, or tax credits for allocating a certain percentage of land to greenspace for new and existing downtown development.

6.3.5 Education & Evaluation Policies

Conservation education is an important component of gaining public acceptance and support for greenspaces. Urban conservation education aims to increase public knowledge regarding the environment and teaches residents, visitors, and employees about sustainable land use practices. It also helps local municipal and regional planning agencies teach the community about social, economic, and ecological benefits associated with an urban greenspace. In many ways, Sioux City business partners and city staff are leading and should continue to lead by example. Through the implementation of greenspace they can educate the local community and inspire private landowners to utilize their greenspace to its greatest potential.

Recommendation #13: Conduct tours and host local events for downtown greenspaces for residents, workers, city staff, and visitors. Walking and biking tours provide an in-person experience of greenspace that is available for the public to utilize. These tours and events can be held by local organizations in order to provide opportunities for social interaction. Public "unveiling" events or celebrations can include planting a tree or inviting the public to ribbon-cutting ceremonies for new greenspaces. Additionally, the adopted Active Transportation Plan for Sioux City identifies other events related to biking and walking, most of which could be connected to greenspace-related activities.

Figure 73. Signage about rain gardens and bioswales. Source: The Watershed Company.

Recommendation #14: Install educational greenspace signage. Signage, which can be located at parks, along trails, or along streetscapes, is a vital component of public education with regards to greenspace. Signage can be used to highlight environmental topics like native plant species, tree types, or historic landmarks. Effective signage also has the potential to draw more park and trail users. By increasing the wayfinding capacity throughout downtown, the accessibility of downtown greenspace is increased.

Recommendation #15: Promote downtown greenspace through a variety of media. The city can increase the visibility of downtown greenspaces through a website or a mobile app that advertises downtown greenspaces. These online resources can include the amenities available in each park, showcase environmental features, and advertise potential programming available at that location. Maps and brochures can also be produced and distributed that highlight the network of greenspaces in downtown.

Recommendation #16: Collect and store relevant data to evaluate greenspace progress annually. It is recommended that downtown Sioux City conduct a tree inventory and continuously update the inventory utilizing GIS to track all plantings and removals. A tree inventory can help downtown Sioux City track maintenance, complaints, site visits, tree inspections and health, and budget planning. It can also help plan for the future by indicating the need to plant different species, help locate trees needing replacement, finding locations for large and small trees, and discovering vacant planting spots. Similarly, it is recommended that the Approved/Not Approved vegetation and tree lists be regularly updated. This plan recommends that an inventory of soil testing data be sustained over time. In addition, local birding groups should be encouraged to maintain a list of birds that inhabit downtown.

Furthermore, the following data should be collected and maintained over time in order to ensure accurate evaluation.

- Dollars spent on greenspace maintenance (staff time and supplies) per year
- Number of educational programs sponsored by the city, public schools, or other related entities and the number of children and adults in attendance
- Sources of funding and funding amount for greenspace implementation
- Access to greenspace: Track the amount of residents and employees who live or work within a half-block of greenspace.
- Acres of greenspace (total and annual additions)
- Quantity, distribution, age, and species composition of trees
- Soil test results

FY 16 - 20

- Implement priority site projects (Phase 1)
- Install trees on primary streetscapes
- Install trees in Very High Priority locations
- Apply for grants
- Establish a Greenspace Fund
- Re-evaluate the existing Stormwater Fee structure
- Evaluate the feasibility of other greenspace incentives
- Incorporate green features as street construction is completed, especially along Virginia St.
- Install signage at priority project sites
- Conduct a tree inventory
- Conduct at least 1 workshop, tour, or public ceremony
- Begin collecting and storing relevant greenspace data

FY 21 - 25

- Implement priority site projects (Phase 2)
- Install trees on primary streetscapes
- Install trees in Very High Priority locations
- Apply for grants
- Incorporate green features as street construction is completed, especially along Virginia St.
- Install signage at priority project sites
- Conduct at least 5 workshops, tours, or public ceremonies

FY 26 - 30

- Install trees on secondary streetscapes
- Install trees in High Priority locations
- Install green infrastructure as streets are renovated
- Install pocket parks
- Apply for grants
- Install signage at existing pocket parks and green infrastructure
- Conduct at least 5 workshops, tours, or public ceremonies

FY 31 - 35

- Install trees on secondary streetscapes
- Install trees in High Priority locations
- Install green infrastructure as streets are renovated
- Install pocket parks
- Apply for grants
- Incorporate green features as street construction is completed
- Install signage at existing pocket parks and green infrastructure
- Conduct at least 10 workshops, tours, or public ceremonies

REFERENCES

Bioswales. (n.d.): n. pag. Natural Resources Conservation Service. 2005. Web. 2 Dec. 2015. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_029251.pdf.

Bioswales for Better Stormwater Management. *Iowa Stormwater*. Rainscaping Iowa, Mar. 2014. Web. 6 Apr. 2016. http://www.iowastormwater.org/documents/resources/Bioswales2014_01E96EC73C3D6.pdf.

City of Seattle. Urban Forest Management Plan - Five Year Implementation Strategy (2010-2014). 2010. http://www.seattle.gov/trees/docs/5%20Year%20Implementation%20Strategy%202010-2014.pdf

City of Sioux City, IA Operating Budget. FY 2016. Approved. https://www.sioux-city.org/attachments/article/3656/FY%202016%20Approved%20Operating%20Budget.pdf

Coder, K. (1999, September). Heat Stroke in Trees. Retrieved from http://www.extension.iastate.edu/forestry/publications/PDF_files/for99-024.pdf

Coder, K. (2000, July). Soil Compaction Impacts on Tree Roots. Retrieved from http://www.extension.iastate.edu/forestry/publications/PDF_files/for00-008.pdf

Daniels, Thomas L., and Katherine Daniels. *The Environmental Planning Handbook for Sustainable Communities and Regions*. Chicago, Ill.: Planners Press, American Planning Association, 2003.

Davey Resource Group. Downtown Tree Management Plan. City of Atlanta. 2012. http://www.atlantaga.gov/modules/showdocument.aspx?documentid=10872

Diaz, C., Soft, A., Van den Broeck, M., Uyen, T., Market, V., & Reghellin, L. (n.d.). Noun Project. Retrieved May 08, 2016, from https://thenounproject.com/

Downtown Minneapolis Park Space Initiative Final Report. June 30, 2008. Accessed December 6, 2015. http://www.ci.minneapolis.mn.us/www/groups/public/@cped/documents/webcontent/convert_269347.pdf.

Downtown Open Space Plan Baltimore, Maryland. Http://www.godowntownbaltimore.com/. December 15, 2010. Accessed December 6, 2015. http://www.godowntownbaltimore.com/docs/openspaceplan.pdf.

Emerald Ash Borer Beetle Could Wipe out Sioux City Ash Trees. Sioux City Journal. February 22, 2014. Accessed November 19, 2015. http://siouxcityjournal.com/news/local/govt-and-politics/emerald-ash-borer-beetle-could-wipe-out-sioux-city-ash/article_8cda897a-8bf5-5668-93c6-e3e4a7948978.html

Floyd Monument. Sioux City History. Accessed November 20, 2015. http://www.siouxcityhistory.org/historic-sites/102-sergeant-floyd-monument

Hydrologic Methods. In *Virginia Stormwater Management Handbook*. Vol. II. 1999. Division of Soil and Water Conservation, Virginia Department of Conservation and Recreation.
Iowa Stormwater Management Manual. Iowa Department of Natural Resources, 7 Nov. 2013. Web. 1 Dec. 2015

Iles, J. (2001, April). Community Trees: Requirements for Plant Growth. Retrieved from http://www.extension.iastate.edu/forestry/publications/PDF_files/CTSPreqs.pdf

Intergovernmental Panel on Climate Change [IPCC]. 2007. Climate change 2007: the physical science basis—summary for policymakers. Geneva: IPCC Secretariat. 18 p. http://www.ipcc.ch/pdf/assessmentreport/ar4/wg1/ar4-wg1-spm.pdf.

Iowa Stormwater Management Manual Part 2I - Vegetated Swale Systems. April 1, 2010. Accessed November 11, 2015. http://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Storm-Water-Manual.

Johnston, M. 2004. Impacts and adaptation for climate change in urban forests. [Presentation]. 6th Canadian urban forest conference, 19-23 October, Kelowna, B.C. 15 p. http://www.treecanada.ca/cufc6/proceedings/papers/Johnston.pdf (01 April 2009).

Kaplan, S. The Restorative Benefits Of Nature: Toward An Integrative Framework. Journal of Environmental Psychology: 169-82.

Kline, Aaron, Catherine Dunn, Katie Gieszler, Peter Jordet, and Sidney Noyce. Self-Supported Municipal Improvement Districts. Iowa Initiative for Sustainable Communities. 2014. Accessed November 19, 2015. http://iisc.uiowa.edu/sites/iisc/files/project-files/CRSSMID_optimized.pdf.

Lee, A., Jordan, H., & Horsley, J. (2015). Value of urban green spaces in promoting healthy living and wellbeing: Prospects for planning. RMHP Risk Management and Healthcare Policy, 131. doi:10.2147/rmhp.s61654

Loughner, C. P., Allen, D. J., Zhang, D., Pickering, K. E., Dickerson, R. R., & Landry, L. (2012). Roles of Urban Tree Canopy and Buildings in Urban Heat Island Effects: Parameterization and Preliminary Results. J. Appl. Meteor. Climatol. Journal of Applied Meteorology and Climatology, 51(10), 1775-1793. doi:10.1175/jamc-d-11-0228.1

Marks, Constant R. *Past and Present of Sioux City and Woodbury County, Iowa*. Chicago: S.J. Clarke Publishing Company, 1904.

Nonpoint Source: Urban Areas. *United States Environmental Protection Agency*. N.p., 31 Oct. 2015. Web. 30 Nov. 2015. http://www2.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-urban-areas

Nowak, David J., and Eric J. Greenfield. Tree and Impervious Cover in the United States. *Landscape and Urban Planning*: 21-30. Accessed November 8, 2015. http://www.sciencedirect.com/science/article/pii/S0169204612001193

Nowak, David; Stein, Susan; Randler, Paula. Sustaining America's Urban Trees and Forests. USDA. 2010. http://www.fs.fed.us/openspace/fote/reports/nrs-62_sustaining_americas_urban.pdf

Nuffield Foundation. (2008). Ecology and Simpson's Diversity Index. Retrieved from http://www.nuffieldfoundation.org/sites/default/files/19_Ecology.pdf

Pavao-Zuckerman, Mitchell. The Nature of Urban Soils and Their Role in Ecological Restoration in Cities. Restoration Ecology. 2008. http://www.u.arizona.edu/~mzucker/Pavao-Zuckerman%202008%20Restoration%20Ecology.pdf

Pine Hall Brick. Permeable Pavement Maintenance. May 2011. Web. 6 Apr. 2016. http://www.pinehallbrick.com/userfiles/TechBullet16PermeableMaintenance.pdf
Ramsey, Jeff et al. Street Tree Inventory Report: Downtown Neighborhood. Portland Parks and Recreation. November 2013. https://www.portlandoregon.gov/parks/article/469287

Roman, Lara A. How Many Trees are Enough? Tree Death and the Urban Canopy. 2014. http://scenariojournal.com/article/how-many-trees-are-enough/

Rouse, D., Henaghan, J., Read, A., & Willemuth, A. (2016). Great Urban Parks: Green Infrastructure in Underserved Communities. https://planning-org-uploaded-media.s3.amazonaws.com/document/Great-Urban-Parks-Convening-Report.pdf

Sediment. *City of Aspen*. N.p., 2008. Web. 30 Nov. 2015. http://www.aspenpitkin.com/Departments/Engineering/Stormwater/Stormwater-Pollution/Sediment

Sedimentation and Erosion. *The Carribean Environment Programme*. United Nations Environment Programme, n.d. Web. 30 Nov. 2015.

Sedimentation, runoff. 2016. In Merriam-Webster.com. Retrieved May 8, 2016, from http://www.merriam-webster.com/dictionary

Sioux City (city) QuickFacts from the US Census Bureau. Sioux City (city) QuickFacts from the US Census Bureau. Accessed November 16, 2015. http://quickfacts.census.gov/qfd/states/19/1973335.html

Steve, Grabow. The Benefits of Parks and Riverwalks in Downtown: Watertown's Riverfront Plan. August 1, 2005. Accessed November 16, 2015. http://jefferson.uwex.edu/files/2010/09/The_Benefits_of_Parks_and_Riverwalks_in_Downtown.pdf

Storm Water Technology Fact Sheet: Porous Pavement. United States Environmental Protection Agency, Sept. 1999. Web. 2 Dec. 2015.

The Chicago Green Alley Handbook. Chicago Department of Transportation. http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf

The Space Between Buildings, Activating Downtown's Open Spaces. Accessed November 16, 2015. http://www.downtowndenver.com/wp-content/uploads/2013/05/DDLP-Report-Total-LO-RES.pdf

United States Environmental Protection Agency. Stormwater Homepage. June 4, 2015. Accessed November 11, 2015. http://water.epa.gov/polwaste/npdes/stormwater/index.cfm.

Urban Design Tools. Permeable Pavers. *Low Impact Development*. 6 Apr. 2016. Web. 6 Apr. 2016. http://www.lid-stormwater.net/permpavers_maintain.htm

U.S. Census Bureau, Center for Economic Studies. Work Area Profile Analysis: Downtown Sioux City, 2013. Accessed November 16, 2015. http://onthemap.ces.census.gov/

U.S. Environmental Protection Agency [EPA]. 2009. Climate change. http://www.epa.gov/climatechange/basic info.com

Walking Tours. Downtown Partners Sioux City. Accessed November 19, 2015. http://downtownsiouxcity.com/whats-happening/walking-tours/

White, M. P., I. Alcock, B. W. Wheeler, and M. H. Depledge. Would You Be Happier Living in a Greener Urban Area? A Fixed-Effects Analysis of Panel Data. Psychological Science: 920-28.

GLOSSARY

Accessibility: Measurement of the ease of reaching greenspaces for all people, including those with disabilities, including those with disabilities.

Attrition (trees): A reduction in trees due to death, disease, or other reasons for removal in a defined time period.

Connectivity: The density of trails or sidewalks that links to greenspaces.

Digital elevation model (DEM): A 3D computerized representation of a terrain's surface.

Ecosystem services: Benefits that people receive from ecosystems and wildlife.

Geographic information system (GIS): A digital mapping software that allows for visualization, analysis, and manipulation of geographical or spatial data.

Greenspace (potential public): Existing areas that can potentially be converted to greenspace through a partnership with governmental bodies.

Greenspace (potential private): Existing greenspaces or areas for other uses that can be converted to greenspace through a partnership with property owners.

Greenspace (urban): Public or privately owned space within the municipal boundary that is partly or completely covered in vegetation and is available for recreational, entertainment, aesthetic, and biological uses. This includes the following features and spaces: stormwater infrastructure (bio-swales, rain gardens, and bio-retention cells), streetscaping, landscaping, permeable paving, trailside vegetation, community gardens, and native grasses.

Impervious surface: A material that prohibits the passing of water. Examples include asphalt, brick, stone, or concrete in streets, buildings, parking lots, and sidewalks.

Non-point sources: A source of water pollution that is not fixed in location, but instead dispersed. Examples include stormwater runoff from a farm field or city street

Pocket park: Urban park space that is typically less than a few acres in size and can be programmed for educational, recreational, or biodiversity purposes.

Point sources: A source of water pollution that is fixed in location, such as a pipe from a factory that directly discharges into a waterway

Right-of-way: Publicly owned (i.e. by a municipality) land which is typically reserved for streets, sidewalks, and utilities and usually abuts private lands.

Runoff: water from rain or snow that flows over the surface of the ground into streams.

Sedimentation: the natural process in which material (such as stones and sand) is carried to the bottom of a body of water and forms a solid layer.

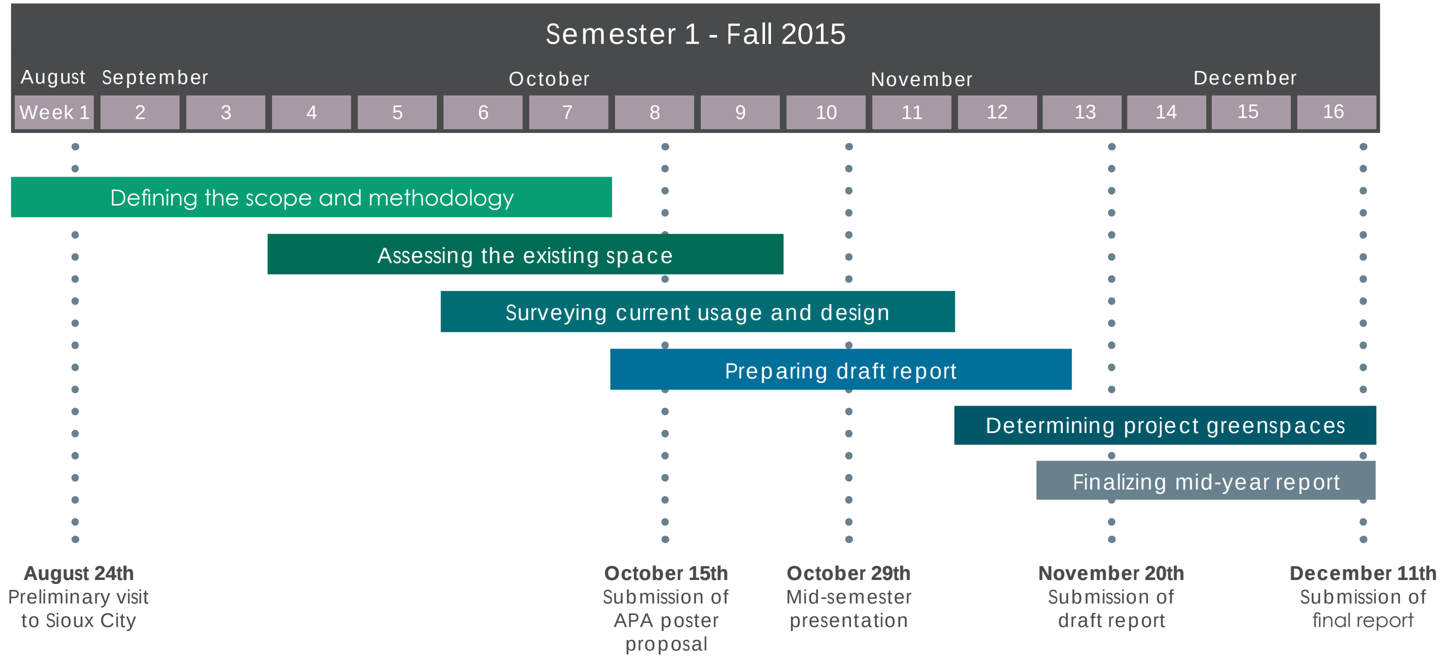
Stormwater management: The conveyance of precipitation and runoff into the ground or into alternative uses. Alternative uses may include recycling stormwater for use in fountains and gardens.

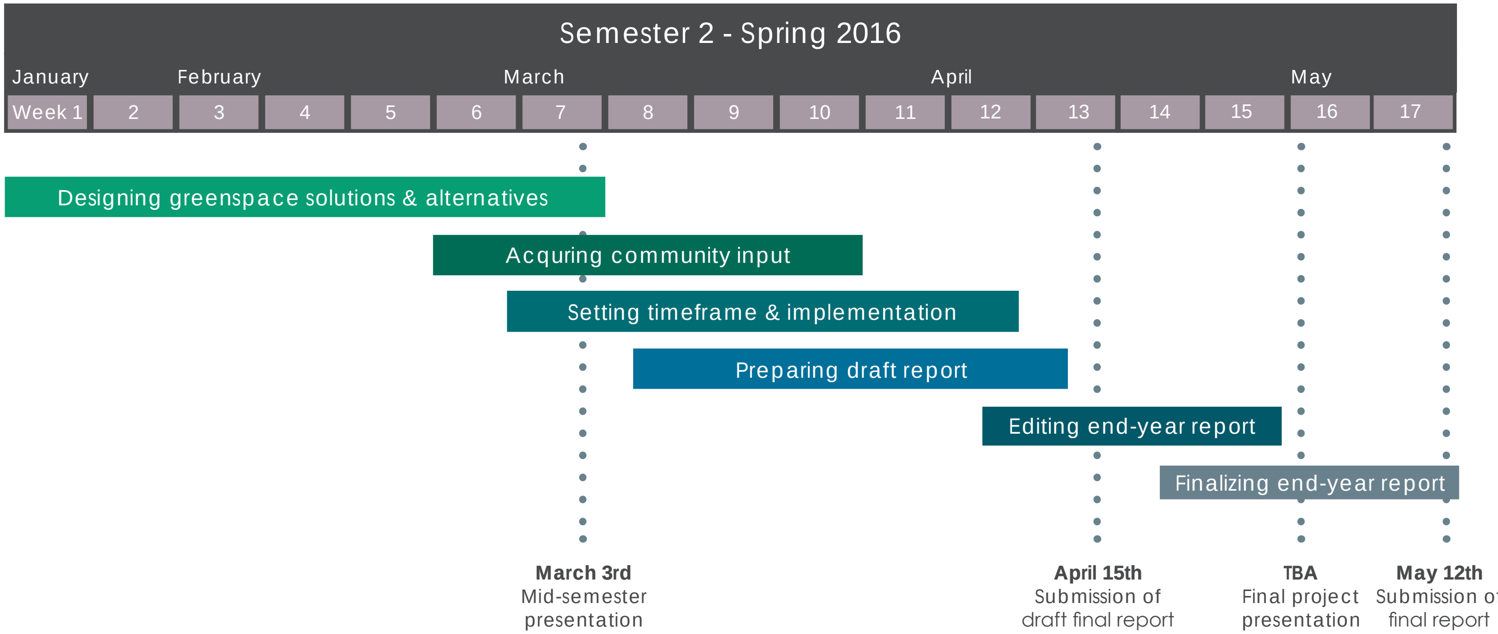
Streetscaping: Built and natural features meant to enhance the character of the public right-of-way along streets and trails

Urban heat island: The phenomenon in which urban areas are significantly warmer than surrounding rural areas due to human development and activities.

Tree cover: Measurement of the area underneath the reach of tree cover.

APPENDIX A: PROJECT TIMELINE




Semester 2 - Spring 2016
January
February
March
April
May
Week 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Designing greenspace solutions & alternatives
Acquring community input
Setting timeframe & implementation
Preparing draft report
Editing end-year report
Finalizing end-year report
March 3rd
Mid-semester presentation
April 15th
Submission of draft final report
TBA
Final project presentation
May 12th
Submission of final report

Case Study: Stormwater BMPs as applied to Downtown Sioux City

In order to analyze the effectiveness of stormwater Best Management Practices (BMPs), it is useful to perform a comparative analysis of existing peak flows and runoff volumes in a study region of downtown Sioux City with potential values following the construction of one of the aforementioned BMPs. For this analysis, a bioswale will be the BMP of choice. This section will examine the Sixth Street area between Nebraska Street to the west and Jennings Street to the east. This area is characterized by steep slopes from the north and along Sixth Street and is highly impervious. An image depicted the degree of imperviousness and steep slopes is shown in Figure 1. This photograph clearly shows why this area would be an ideal target for the incorporation of a bioswale system. The steep slopes and lack of permeable space in this area create significant issues with regards to stormwater ponding and runoff. In addition, Sixth Street is very wide and incorporates more on-street parking that what is necessary. Incorporating stormwater BMPs along this section of road is an excellent way to maximize their effectiveness while simultaneously improving the aesthetics of the area.

Figure 1: Sixth Street looking east at Nebraska Street. Photo Credit: Benjamin Curtis

Using ArcMap's hydrology tools combined with the Digital Elevation Model shown in Figure 1, a series of watersheds were delineated to outlet at storm sewer intakes in this region of downtown Sioux City. Manual edits to watershed boundaries were made. The result of this derivation is shown in Figure addition, the watersheds are overlain onto an aerial map of the city, which clearly depicts the amount of impervious surfaces in this area in the form of roads, parking lots, and buildings. The numbers shown inside the watershed boundaries are arbitrarily assigned labels for each watershed.

In order to derive quantitative measures of peak flow and runoff volume for these watersheds,

Figure 2: Watershed Boundaries in 6th Street Area in Downtown Sioux City

the SCS Curve Number Method was used. The result of this analysis is shown in Table 1. This process involved calculating the area of each of the watersheds shown in Figure 2, estimating a runoff Curve Number, and using appropriate calculations to determine the peak flow in each watershed. Weighted Curve Numbers were obtained by estimating the approximate areas of paved surfaces (Curve Number of 98) and open space under good condition for class B hydrologic soils (Curve Number of 61), which is meant to emulate grassed lawns, and calculating a composite number based on each area[1]. A 2-day, 24-hour design storm was employed in these calculations, which is a common design period for many engineering applications. This return period and intensity corresponds to a rainfall depth of 3.01 inches, which was used in order to derive peak flows for each watershed. Runoff depth was calculated using the following equation from TR-55 and Section 2C-5 of the Iowa Stormwater Management Manual:

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

Raw data and a complete breakdown of the methodologies used to derive these values can be found later in this appendix.

Table 1: Peak Flows and Runoff Depths in Study Area Watersheds

Catchment	Catchment Area, A (acres)	Curve Number	Peak Flow (cfs)	Depth of runoff (in)
1	2.82	92	15.89	2.19
2	0.31	93	1.84	2.31
3	1.36	91	7.28	2.07
4	0.51	96	3.44	2.59
5	1.14	95	7.32	2.48
6	0.27	89	1.35	1.92
7	1.17	94	7.17	2.38
8	0.23	95	1.43	2.46
9	1.41	92	7.78	2.13
10	1.55	92	8.71	2.18
11	1.32	90	6.68	1.97
12	0.26	98	1.84	2.78
13	0.11	98	0.80	2.78
14	0.05	98	0.35	2.78
15	0.41	98	2.92	2.78
16	1.25	92	6.97	2.17
17	0.18	95	1.17	2.46
18	1.54	89	7.49	1.89
19	0.13	98	0.91	2.78

Table 1 shows the relationship between catchment area, Curve Number, peak flow, and runoff depth. As expected, an increase in catchment area and curve number (which is a direct inference to the

[1] Curve Numbers were obtained from Table 2 from Section 2C-5 of the Iowa Stormwater Management Manual

amount of impervious area in the watershed) results in an increase in peak flow. Larger catchments will have a higher peak flow because they accumulate more water from the design rainfall as runoff travels to the outlet of the watershed. In addition, watersheds with higher Curve Numbers will have larger peak flows because there is less permeable surface area for water to infiltrate, which is thus converted to runoff. Runoff depth corresponds more directly to the Curve Number since it is derived directly from this parameter, as shown in later in this appendix. Finally, a Curve Number of 98 means that the watershed was composed entirely of pavement, which explains why runoff depths for these watersheds are higher than the depth for other watersheds.

A preliminary bioswale design for the south side of Sixth Street (which corresponds to watershed 12 from Figure 2) is shown in Figure 3. A rectangular cross section with a bottom width of six feet is proposed in order to maintain a two foot buffer between the street curb and the swale so that people getting out of their cars have room to feed the parking meter and transition from their car to the sidewalk. The small buffer between the two sections is designed to accommodate pedestrian transport.

Figure 3: Preliminary Swale Plan View

In addition, the bioswale was placed far enough from the building to the south in order to accommodate an Iowa Statewide Urban Design and Specifications required minimum sidewalk width of four feet and an encouraged minimum sidewalk width of five feet (Iowa SUDAS Chapter 12A, 2014). A similar bioswale designed to accommodate parking and pedestrian traffic is shown in Figure 4.

For this analysis, tall fescue was chosen to be the planting of choice in order to emulate the effect of planting native prairie grasses in this region. Likewise, a swale depth of five feet was chosen in order to accommodate downward root growth. Based on these parameters, this bioswale can be expected to treat a flow rate of 0.54 ft^3/s. In addition, the bioswale should be 100 feet long based on this flow rate, a residence time of five minutes, and site specific obstructions such as parking meters, curbs, and light fixtures. Detailed calculations for these values can be located later in this appendix. Additional engineering required such as placement of curb cuts to facilitate stormwater flow into the bioswale and the incorporation of subdrain pipes into existing sewer infrastructure will need to be determined at a later date, and swale sizing may need to be adjusted accordingly.

Figure 4: Bioswale designed to accommodate pedestrian traffic from street parking

Based on the addition of permeable space within the watershed, post-swale construction values for Curve Number, peak flow, and runoff depth were calculated. This was performed in the same manner as before, assuming that the total area occupied by the new bioswale is 0.0121 acres and the Curve Number for a swale composed primarily fescue in class B soils is 48, which corresponds to brush, weed, or grass mixtures in good condition (Iowa Stormwater Management Manual Section 2C-5 Table 4, 2009). The improvements to the hydrologic parameters of the watershed are shown in Table 2. Raw calculations for these values can be found in the last section of this appendix.

Table 2: Effect of bioswale construction on Curve Number, peak flow, and depth of runoff

	Existing Conditions	With Bioswale	Percent Improvement
Catchment Area (acres)	0.26	0.26	
Curve Number	98	95	3.06%
Peak Flow (cfs)	1.84	1.68	8.97%
Depth of runoff (in)	2.78	2.53	8.97%

From Table 2, it can be seen that the Curve Number in the watershed is expected to decrease by 3.06% and the peak flow and runoff depth are expected to improve by 8.97%. Compared to existing conditions and given that the swale only covers a small fraction of the watershed, these are noticeable improvements. Based on the expected treatable capacity of this swale of 0.54 ft^3/s and an expected peak flow of the post-bioswale watershed of 1.68 ft^3/s, it can be seen that while this swale won't be able to intercept all of the expected flow from the watershed based on a 2-year 24-hour storm, it can be expected to intercept a noticeable portion of peak flow. In addition, the environmental benefits of infiltration as an alternative to runoff will be obtained. Through this new system, stormwater will be able to be treated on-site prior to entering the sewer and discharging into the Missouri River, which provides significant environmental benefit.

This analysis serves as a template that will be used to design other types of BMPs throughout downtown. It also serves as a model by which a vast range of scenarios can be played out at the individual watershed level or at the district level. A potential scenario could model the result of a strategic BMP placement approach such as the effect of the construction of a swale or a parking lot with permeable pavement at a specific site on an individual watershed. This model could also be expanded in order to examine the results of a paradigm policy shift towards dramatic increases in permeable surfaces in the downtown area. For example, if policy makers in Sioux City wish to alter a watershed so as to create an area with a pre-defined percentage of pervious area, they could obtain quantifiable parameters of importance to watershed health or infrastructure capacity using this model.

Works Cited

- "4.2.5. Grass Swales (GS)." (n.d.): n. pag. *West Virginia Stormwater Management and Design Guidance Manual*. Web. 10 Dec. 2015. <West Virginia Stormwater Management and Design Guidance Manual>.
- Chin, David A. "12.3.3.2 Bioinfiltration Swales." *Water-Resources Engineering*. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2012. 607-09. Print.
- "Iowa Stormwater Management Manual." Iowa Department of Natural Resources, 7 Nov. 2013. Web. 1 Dec. 2015.

Calculations of Peak Flows and Runoff Volumes and Raw Data

Calculation of composite Curve Number. Composite Curve Numbers were estimated using the following equation:

$$CN = \left(\frac{1}{Total\ Area}\right) * [(CN1 * Composite\ Area\ 1) + (CN2 * Composite\ Area\ 2) + (CN3 * Composite\ Area\ 3)]$$

Catchment	Total Area (ac)	Total area (mi^2)	Composite Area 1	CN1	Composite Area 2	CN2	Composite Area 3	CN3	Composite CN
1	2.815	0.004398438	0.444	61	2.371	98			92.164
2	0.308	0.00048125	0.0375	61	0.2705	98			93.495
3	1.362	0.002128125	0.262	61	0.345	98	0.755	98	90.883
4	0.514	0.000803125	0.024	61	0.49	98			96.272
5	1.141	0.001782813	0.085	61	1.056	98			95.244
6	0.272	0.000425	0.0655	61	0.2065	98			89.090
7	1.168	0.001825	0.121	61	1.047	98			94.167
8	0.225	0.000351563	0.018	61	0.207	98			95.040
9	1.414	0.002209375	0.246	61	1.168	98			91.563
10	1.549	0.002420313	0.25	61	1.3	98			92.092
11	1.315	0.002054688	0.27	61	0.995	98	0.05	79	89.681
12	0.257	0.000401563		61	0.257	98			98.000
13	0.111	0.000173438		61	0.111	98			98.000
14	0.049	7.65625E-05		61	0.049	98			98.000
15	0.407	0.000635938		61	0.407	98			98.000
16	1.246	0.001946875	0.204	61	1.042	98			91.942
17	0.184	0.0002875	0.015	61	0.169	98			94.984
18	1.538	0.002403125	0.386	61	1.152	98			88.714
19	0.127	0.000198438		61	0.127	98			98.000

Values for runoff volume and peak flows were derived from Section 2B-4 of Iowa SUDAS. Screenshots of this method are shown as follows:

2. **SCS Depth of Runoff:** Depth of runoff may be calculated through the SCS Curve Number Method. This method separates total rainfall into direct runoff, retention, and initial abstraction to yield the following equation for rainfall runoff.

$$Q = \frac{(P-I_a)^2}{(P-I_a)+S}$$ **Equation 2B-4.04**

where:

Q = Depth of direct runoff, in
P = Depth of 24 hour precipitation, in. for design year storm (e.g. 10 year, 24 hour)
S = Potential maximum retention after runoff begins, in
I_a = Initial abstraction, in

The initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration during the early part of the storm. Interception and surface depression storage may be estimated from cover and surface conditions, but infiltration during the early part of the storm is highly variable and dependent on such factors as rainfall intensity, soil crusting, and soil moisture. Establishing a relationship for I_a

is not easy. Therefore, I_a is assumed to be a function of the maximum potential retention, S. An empirical relationship between I_a and S is expressed as:

$$I_a = 0.2S$$ **Equation 2B-4.05**

Removing I_a and substituting Equation 2B-4.05 into Equation 2B-4.04 gives:

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)}$$ **Equation 2B-4.06**

The potential maximum (S) is related to the soil cover and conditions of the watershed through the CN as follows:

$$S = \frac{1000}{CN} - 10$$ **Equation 2B-4.07**

After determining the CN and calculating the value for S, the total amount of rainfall, P, for the 24 hour storm with the selected return interval must be determined. Values for total rainfall depth by storm duration and return interval are listed in Section 2B-2. These values are inserted into Equation 2B-4.06 to calculate the total depth of runoff from the watershed.

3. **SCS Peak Runoff:** After the total runoff is determined, the SCS Peak Discharge Method may be utilized to determine the peak rate of discharge from the watershed. The equation for the peak discharge is given as:

$$q_p = q_u A_m Q F_p$$ **Equation 2B-4.08**

where:

q_p = peak discharge, cfs
q_u = unit peak discharge, $ft^3/s/mi^2/in$ (csm)
A_m = drainage area, mi^2
Q = runoff, in (from Equation 2B-4.04 above)
F_p = pond and swamp adjustment factor (Table 2B-4.05)

The unit peak flow is calculated with the following equation (graphical depictions are presented in TR-55):

$$q_u = 10^{[C_0+(C_1)(\log t_c)+(C_2)(\log t_c)^2]}$$ **Equation 2B-4.09**

where:

C_0, C_1, C_2 = Coefficients, listed in Table 2B-4.06. These are a function of the 24 hour rainfall distribution type and Ia/P.
t_c = time of concentration (refer to Section 2B-3)
I_a = Initial abstraction (refer to Equation 2B-4.05), in

Table 2B-4.06: Coefficients for SCS Peak Discharge Method

I_a/P	C_0	C_1	C_2
0.10	2.55323	-0.61512	-0.16403
0.30	2.46532	-0.62257	-0.11657
0.35	2.41896	-0.61594	-0.08820
0.40	2.36409	-0.59857	-0.05621
0.45	2.29238	-0.57005	-0.02281
0.50	2.20282	-0.51599	-0.01259

Note: Values are for Type II rain distribution, which applies to all of Iowa.

Source: TR-55, USDA

Table 2B-4.07: Adjustment Factor (F_p) for Pond and Swamp Areas that are Spread Throughout the Watershed

Percentage of pond and swamp area	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

These values were incorporated into the table shown below to calculate peak flow (qp). Since the Ia/P ratio was so small, a value of 0.10 was used in order to determine coefficients Co, C1, and C2. In addition, since the percentage of pond and swamp is zero in this region, an F_p value of 1.00 was used.

Catchment	S	2-day 24hr depth	Depth of runoff (in)	Ia (abstraction)	Ia/P	Co	C1	C2	tc	qu	qp (cfs)
1	0.850209	3.01	2.186	0.170	0.056492	2.55323	-0.61512	-0.16403	0.083	1652.475	15.88588
2	0.695744	3.01	2.311	0.139	0.046229	2.55323	-0.61512	-0.16403	0.083	1652.475	1.837694
3	1.003215	3.01	2.070	0.201	0.066659	2.55323	-0.61512	-0.16403	0.083	1652.475	7.279941
4	0.387196	3.01	2.591	0.077	0.025727	2.55323	-0.61512	-0.16403	0.083	1652.475	3.438
5	0.499388	3.01	2.484	0.100	0.033182	2.55323	-0.61512	-0.16403	0.083	1652.475	7.317641
6	1.224595	3.01	1.916	0.245	0.081368	2.55323	-0.61512	-0.16403	0.083	1652.475	1.345866
7	0.619437	3.01	2.376	0.124	0.041159	2.55323	-0.61512	-0.16403	0.083	1652.475	7.165859
8	0.521886	3.01	2.463	0.104	0.034677	2.55323	-0.61512	-0.16403	0.083	1652.475	1.430993
9	0.921449	3.01	2.131	0.184	0.061226	2.55323	-0.61512	-0.16403	0.083	1652.475	7.779604
10	0.858745	3.01	2.179	0.172	0.057059	2.55323	-0.61512	-0.16403	0.083	1652.475	8.714831
11	1.150683	3.01	1.966	0.230	0.076457	2.55323	-0.61512	-0.16403	0.083	1652.475	6.675361
12	0.204082	3.01	2.778	0.041	0.01356	2.55323	-0.61512	-0.16403	0.083	1652.475	1.843554
13	0.204082	3.01	2.778	0.041	0.01356	2.55323	-0.61512	-0.16403	0.083	1652.475	0.796243
14	0.204082	3.01	2.778	0.041	0.01356	2.55323	-0.61512	-0.16403	0.083	1652.475	0.351495
15	0.204082	3.01	2.778	0.041	0.01356	2.55323	-0.61512	-0.16403	0.083	1652.475	2.919558
16	0.876397	3.01	2.165	0.175	0.058232	2.55323	-0.61512	-0.16403	0.083	1652.475	6.966087
17	0.528123	3.01	2.458	0.106	0.035091	2.55323	-0.61512	-0.16403	0.083	1652.475	1.16753
18	1.272189	3.01	1.885	0.254	0.084531	2.55323	-0.61512	-0.16403	0.083	1652.475	7.486333
19	0.204082	3.01	2.778	0.041	0.01356	2.55323	-0.61512	-0.16403	0.083	1652.475	0.911017

Bioswale Sizing Calculations

Bioswale sizing was performed according to the steps outlined Section 12.3.3.2 – Bioinfiltration Swales in Chin, 2012.

Given: Minimum hydraulic retention time of 5 min, a minimum flow velocity of 1 ft/s, a minimum swale length of 100 ft, and a watershed slope of 0.015.

Step 1: Estimate peak runoff rate for design storm:

1.84 ft^3/s for watershed 12 (given in previous section)

Step 2: Establish the slope of the swale:

Slope was estimated to be 0.015 or 1.5% based on the topography of the site.

Step 3: Select a vegetation cover suitable for this site:

Tall fescue with soil retardance of B (according to Table 5.8 in Chin, 2012), with an estimated height of 18 in was chosen in order to emulate prairie grass.

Step 4: Estimate the height of vegetation that is expected to occur during the storm runoff season

Due to the height of tall fescue, a maximum height of 75 mm, or 3 inches was utilized.

Step 5: Select cross section:

A rectangular cross section will be used due to the urban nature of the site. Reinforced vertical walls will be needed in order to protect the structural integrity of the swale. In order to maintain ADA required widths for the sidewalk as well as to provide an area for drivers to transition from their cars to the sidewalk and feed parking meters, a design width of 6 feet was selected.

A 5 foot swale depth was determined as optimal in order to accommodate the growth of fescue plants. If further analysis of underground utilities determines that this depth is not feasible, the type of plantings in the bioswale will need to be re-evaluated.

Step 6: Determine a target peak flow based on swale design parameters

Based on the Manning equation for channel flow and a Manning's coefficient of 0.2 (West Virginia Stormwater Management and Design Guidance Manual, n.d.), the expected target flow treatment capacity is:

$$Q = \frac{1.49}{n} AR^{2/3} S^{.5}$$

Where A = Cross Sectional Area = (6 ft)*(3 in/12) = 1.5 ft^2; R = Hydraulic Radius = A/Wetted Perimeter = 1.5/[2(0.25)+6] = 0.23; and S=0.015.

$$Q = \frac{1.49}{0.2} 1.5 * .25^{\frac{2}{3}} * 0.015^{.5} = 0.54 \text{ ft}^3/\text{s}$$

Step 7: Using a minimum detention time of 5 min, the allowable length of the swale is determined by the following equation:

$$L = V * t$$

Where V = flow velocity and t = detention time in seconds.

V is determined by dividing Q/A. This gives a value of 0.36 m/s.

$$L = 0.36 * (5 * 60) = 108 \text{ ft.}$$

However, based on existing physical constraints of the site such as parking meters, curbs, a street light, and to maximize access to a handicapped accessible parking spot at the SE corner of 6th and Jackson, the swale length was reduced to 100 feet.

Calculation of Post-Bioswale Hydrologic Conditions for Watershed 12

Composite Curve Number, Runoff depth, and peak flow were calculated using the same method as presented above. Raw values for the parameters that result in the calculation of these values are as follows:

Catchment	Total Area (ac)	Total area (mi^2)	Composite Area 1	CN1	Composite Area 2	CN2	Composite Area 3	CN3	Composite CN
12	0.257	0.000401563	0.0121	48	0.245	98			95.684

Catchment	S	2-day 24hr depth	Depth of runoff (in)	Ia (abstraction)	Ia/P	Co	C1	C2	tc	qu	qp (cfs)
12	0.451063	3.01	2.529	0.090	0.029971	2.55323	-0.61512	-0.16403	0.083	1652.475	1.678228

APPENDIX C: URBAN HEAT ISLAND ANALYSIS

Urban Heat Island Mitigation Strategies for Downtown Sioux City, Iowa

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Spring 2016

URP 6257: Environmental Management

School of Urban and Regional Planning

The University of Iowa

INTRODUCTION

The urban heat island (UHI) effect describes built up areas that are hotter than nearby rural areas. Large amounts of paved surfaces in urban areas absorb and retain solar radiation at a much greater rate than natural areas with exposed vegetation or soil. The result is the release of warmer air at the ground level. Another factor that contributes to warmer ground temperatures is the inability of urban areas to absorb and naturally infiltrate rainwater, which equates to less local moisture in the soil making the evapotranspiration process less intense.[1] These processes are depicted in Figure 1 shown below.

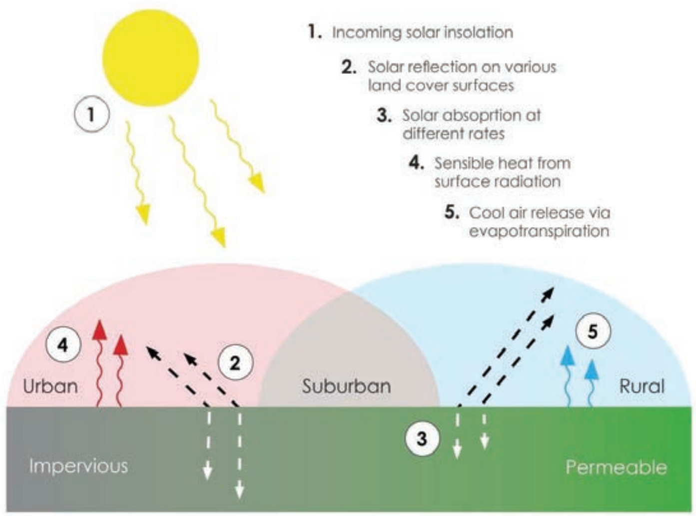


Figure 1. Main components of the urban heat island. Source: authors.

[1] "A Heat Island in the Amazon." Revista Pesquisa Fapesp. 2013. Accessed February 24, 2016. http://revistapesquisa.fapesp.br/en/2013/01/24/a-heat-island-in-the-amazon/.

It is estimated that in cities with 1 million people or more, the annual mean air temperature can be 1.8–5.4°F warmer than the surrounding areas. The effect is amplified in evening hours when the difference can be as high as 22°F.[2] Even in smaller and less dense cities the impact of the UHI is noticeable but is scaled by factors like tree canopy and the intensity of urban development. UHIs place a significant burden on vulnerable populations such as the elderly and children in terms of coping with heat. It is estimated that one thousand people, mostly those living in cities, die of heat in the US each year.[3] In terms of non-human impacts, research suggests that urban trees are more at risk of attracting pests that cause tree death since scale insects thrive in warmer temperatures.[4] It is also true that some trees suffer from heat stroke even when pests are not present.

Warmer temperatures also influence the cost of regulating temperature indoors through air conditioning. UHIs waste money by increasing the need for energy use and for building and infrastructure maintenance such as roads.[5] In fact, one study estimates the United States spends approximately one billion dollars per year on indoor air conditioning to mitigate UHIs.[6] The economic, environmental, and social costs associated with UHIs are likely to increase in magnitude as global climate temperatures continue to rise over time.

KEY TRENDS & FUTURE ISSUES

Heat islands have significant impacts on urban areas and the people who inhabit them. Some of these effects include hotter air temperatures in urban areas compared to

[2] "Heat Island Effect." EPA. Accessed February 24, 2016. http://www.epa.gov/heat-islands.
[3] "Urban Heat Island." *New Scientist* 192, no. 2575 (2006): 58.
[4] Meineke EK, Dunn RR, Sexton JO, Frank SD (2013) Urban Warming Drives Insect Pest Abundance on Street Trees. PLoS ONE 8(3): e59687.
[5] Gartland, Lisa. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. London: Earthscan, 2008.
[6] "Urban Heat Island." *New Scientist* 192, no. 2575 (2006): 58.

adjacent rural areas, hotter surface temperatures, higher energy use, and heat-related health problems such as heat stroke, dehydration, or exacerbation of asthma. In addition, they have an adverse effect on wildlife habitat and plant growth in urban areas.[7]

There are several main causes of the UHI effect. As mentioned previously, increased net radiation due the absorption of and subsequent storage of heat in man-made construction materials like steel, concrete, or insulation. Reduction in evaporative capacity due to lack of plant growth in urban areas results in urban areas storing more energy during the day and releasing it at night, explaining why observed UHIs are worse at night. Reduction in the conversion of energy from solid surfaces to fluid states, known as convection, is a result from urban areas having slower winds than rural areas. Lower convection rates are compounded by buildings, which act as windbreaks. Finally, the increase in anthropogenic heat from cars, buildings, and industry contribute significantly to the overall heat island equation. The final result is a vicious, unsustainable energy balance that positively reinforces the UHI effect.

Studies have shown a direct relationship between urbanization and an increase in air temperatures over time. Based on temperature gauges across the United States in both urban and rural areas, urbanization was shown to account for 14 to 21 percent of the rise in minimum temperatures since 1895 and an additional 6 to 9 percent since 1960.[8] Likewise, the difference between urban and rural temperature increases has been increasing since 1960. This period coincides with the most significant period of urbanization in the history of the United States. Internationally, UHIs have been increasing

[7] Gartland, Lisa. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. London: Earthscan, 2008.
[8] What Do We Think About Climate Change [Archive] - Page 19 - Boat Design Forums. Accessed March 02, 2016. http://www.boatdesign.net/forums/archive/f-3/t-21390-p-19.html.

in China since 2003 as a result of rapid urbanization and industrialization. Since 2003, 27 observed cities throughout China have exhibited temperature increases ranging from 1.1°C (~2°F) to 4.3°C (~7.7°F), with a mean increase of 2.9±0.8°C during the day and 3.1±0.5°C at night.[9] These studies show serious implications for both established and developing areas throughout the world with regards to increases in UHIs.

UHIs have been shown to increase as cities expand or become denser. For example, as Phoenix, Mesa, and Tempe, Arizona have developed intensely since the early 20th century, minimum night-time air temperatures have increased by 7°F compared to rural Sacaton, Arizona.[10] This implies that these cities are releasing more heat at night as a higher amount of heat is absorbed during the day. This is a direct result of urbanization, and points directly to the effect that urban development has on increasing UHI effects and the need for mitigation in urban areas. Based on these studies, it is a reasonable assumption that UHIs can be expected to increase in any city that sprawls outward or densifies without much thought to mitigation strategies such as increasing tree cover or increasing the amount of permeable surfaces in developing communities.

METHODOLOGY

This report analyzes the effect of the UHI in downtown Sioux City, Iowa, compared to an adjacent rural area. This report identifies and describes best management practices (BMPS) and strategies used to mitigate the UHI effect and provides a discussion of how UHI effects can be subdued within the study area. Various mitigation strategies were

[9] Zhou, Decheng, et al. "Spatiotemporal Trends of Urban Heat Island Effect along the Urban Development Intensity Gradient in China." *Science of The Total Environment* 544 (2016): 617-26.
[10] Ibid., 2016.

quantified and analyzed in spatial context to illustrate the impact through a reduction in the UHI.

The study area for this research is a four square block area bordered by Third Street to the south, Seventh Street to the north, Pearl Street to the west, and Douglas street to the east. This area was selected in order to quantitatively and visually analyze the UHI at a finer scale. This area of downtown Sioux City is composed primarily of mid-rise buildings, concrete streets, open surface parking lots, and very little greenspace. However, there are some areas in this area that provide higher amounts of grass and shade than others, which provides an excellent opportunity to explore block-by-block differences in the UHI effect. This research also investigated the UHI effect for the entire Sioux City downtown area in order to

The purpose of this research was to derive multiple quantitative measures of the UHI within the study area. The relationship between impervious surfaces, tree cover, albedo and the UHI was examined using STELLA software. A dynamic systems model in STELLA was created to compare historical temperatures of the nearby rural City of Denison with simulated and actual temperatures of Sioux City. Denison was chosen as it is the closest rural city to Sioux City with records of historical weather temperatures. The model is depicted in Figure 2. The model quantitatively expressed the additional heat absorbed and released by the largely impervious surfaces of downtown. Future development of the tool can be used for measuring the effectiveness of UHI mitigation strategies on the block level or for the entire downtown area.

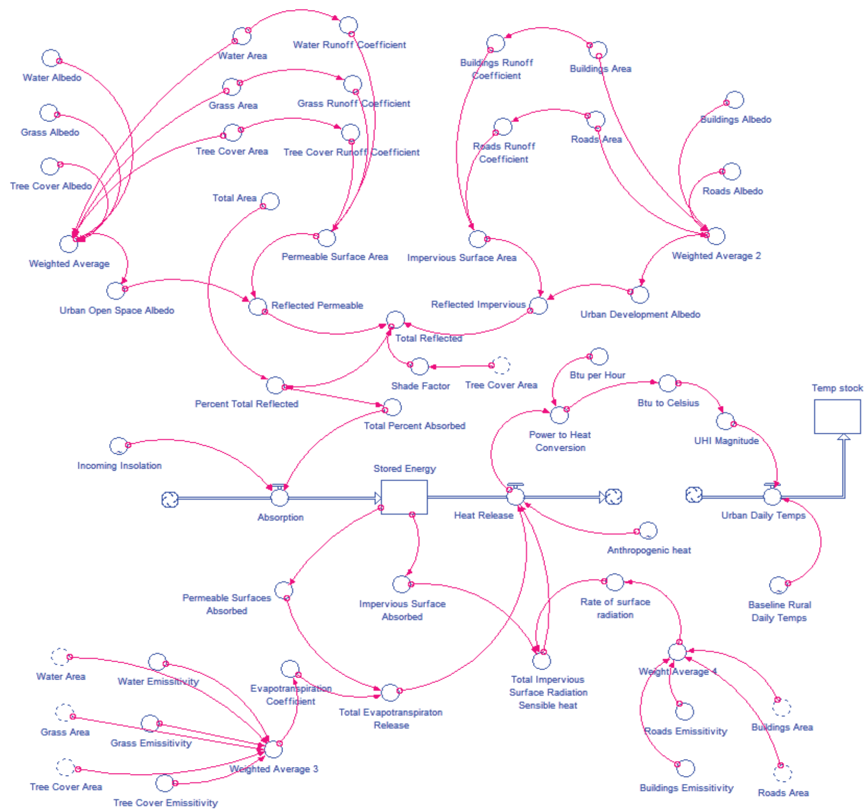


Figure 2. Urban heat island STELLA model. Source: authors.

The UHI effect was also examined spatially using ArcGIS in order to show how the UHI effect varies within the study area. Albedo and emissivity were calculated in ArcGIS based upon local conditions in Sioux City. Although mapping the change in albedo and emissivity after adding or removing greenspaces from downtown would illustrate the change in the UHI magnitude, our analysis sought to translate these changes into actual temperatures for comparison to rural areas. After albedo and emissivity were calculated, solar insolation was calculated for the study area using a digital elevation model (DEM) and the ArcGIS Solar Radiation Spatial Analyst tool in order to record the total amount of radiation reaching the surface. Solar insolation, albedo, and emissivity are shown in Figure 3 for the study area. Building heights were not considered in this research and may be a potential cooling factor given shadows. Thus, solar radiation is only dependent upon elevation. Values derived for albedo, emissivity, and hourly solar insolation were used as local inputs for the STELLA model, which then calculated how the UHI magnitude changed with each mitigation scenario.

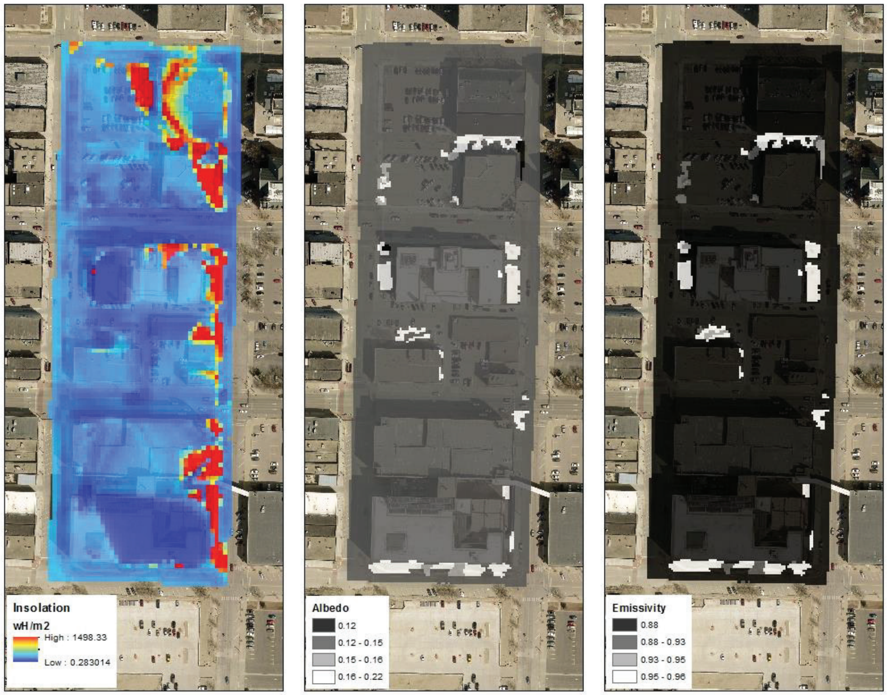


Figure 3. Insolation, albedo, and emissivity values for the three-block study area. Source: authors.

Local conditions of the downtown study area were derived using a 1 square meter land cover dataset provided by the Iowa Department of Natural Resources. Five main land cover classifications were used for the spatial and systems models: tree cover (deciduous and coniferous), water and wetlands, buildings, grass and open space, and roads. Through the application of coefficients for water runoff to each class, this layer represented total imperviousness of downtown. The Iowa Department of Natural Resources' 2-meter DEM for the Sioux City region was also downloaded in order to estimate solar insolation. Finally, baseline temperatures for a clear day (both at night and day) in summer in both Sioux City and the City of Denison were downloaded from Weather Underground.

UHI MITIGATION STRATEGY SCENARIOS

The incorporation of white roofs throughout downtown was the first mitigation strategy modeled in this study. White roofs directly address the overall albedo of the area. In the baseline scenario, the albedo for buildings in urban areas was determined to be 0.15, which means 15 percent of the incoming solar radiation is reflected and 85 percent is absorbed into the surface. In the mitigation scenario, an albedo of 0.75 was utilized to simulate the incorporation of white roofs. Although this scenario does not directly increase greenspace or trees within downtown, white roofs are a relatively inexpensive solution for mitigating the UHI effect and provide economic benefits in terms of heating and cooling cost reductions for the building. An example of a white roof is pictured in Figure 4.

Figure 4. Painting white on the roof of a commercial building. Source: nationswell.com

The second mitigation strategy is to completely overhaul several downtown streets with evenly spaced, full-growth trees. In this scenario, street trees provide needed shade to downtown, an example of which is shown in Figure 5. Trees act as a barrier between solar radiation and the concrete or asphalt of the road and sidewalk, especially in summer months when trees are in full growth. In the study area for this analysis, over 3,000 square meters of tree cover was added to simulate full tree growth along the east and west streets. For the entire downtown area, tree cover estimates were derived through the target greenspace metrics that are featured in the Downtown Greenspace Plan. Unlike the white roofs scenario, the addition of street trees provides more social and environmental benefits. Evenly-spaced street trees can calm traffic speeds and decrease traffic fatalities, increase adjacent property values, and generally improve the aesthetics of the streetscape.

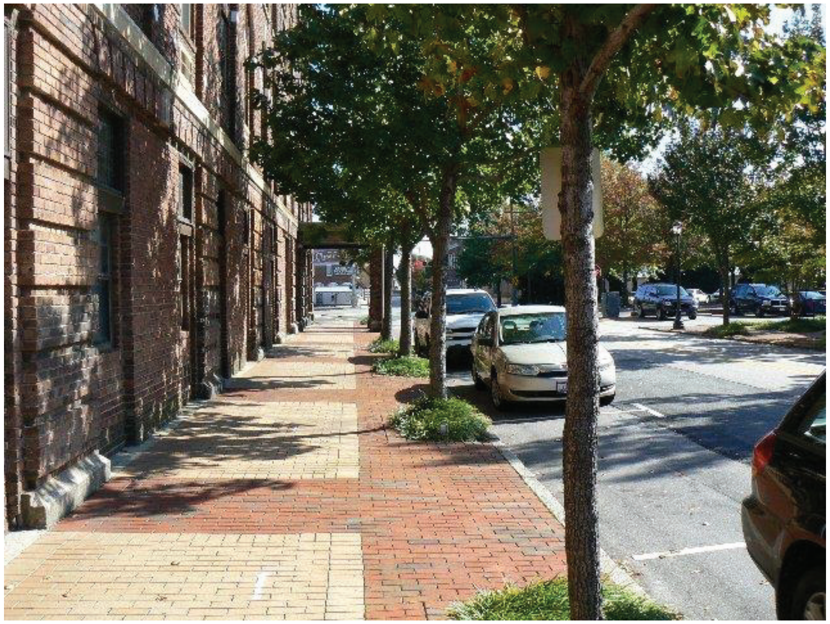


Figure 5. Evenly spaced trees along the street right-of-way in North Carolina. Source: actrees.org

The third mitigation scenario converts surface parking lots (7.9 acres for the entire downtown area, and 1.1 acres for the study area), classified as “roads” in the land cover dataset, to grass in order to simulate new pocket parks. Converting concrete to grassland decreases the amount of heat that is trapped and consequently released over time. Urban pocket parks - a term used to define greenspace that is smaller than typical neighborhood parks - provide a multitude of social, cultural, and economic benefits. Urban pocket parks often provide space for community events and can be a relief from everyday urban life. Pocket parks that are designed properly can also aid in the placemaking of a city by incorporating unique, local features or materials into the construction of the park. The Pappajohn Sculpture Park located in downtown Des Moines has become a signature, central downtown location that features a wide expanse of greenspace and local art (Figure 6). This scenario is similar to the street trees scenario in that the impervious area associated with roads is decreased. However, since urban pocket parks typically do not feature large tree masses, the added shade factor of the previous scenario is not observed in this mitigation strategy.

Figure 6. John and Mary Pappajohn Sculpture in Des Moines, Iowa. Source: ag-architects.com

The final mitigation scenario is a combination of the previous 3 strategies. In this best case scenario, 2 streets within the study area are fully tree-lined, 1 new pocket park is created, and all buildings are painted with white roofs. For the downtown area, the combined mitigation scenario incorporates tree cover and greenspace targets recommended in the Sioux City Downtown Greenspace Plan (refer to Page 68). Applied at a larger scale, this scenario would certainly require broad investment from many private firms, the City of Sioux City, and local residents. Some private businesses, however, have already taken strides to improve the aesthetics of downtown, with the added benefit of reducing the UHI effect. For example, the MidAmerican Energy building, located within the study area of this research, already has a lighter-tinted roof and a well-maintained greenway south of the building that provides excellent shade through several large, healthy trees.

RESULTS

Each mitigation scenario was executed for both the 4-block study area and the entire Sioux City downtown area. Table 1 below details how the percentage of solar radiation is reflected and absorbed with each mitigation scenario. The goal of the mitigation scenario, as previously stated, was to increase reflection and decrease absorption. Table 1 also shows the average UHI magnitude over the course of 1 day as well as the degree change between the current magnitude and UHI magnitudes predicted for each scenario. The UHI magnitude represents the average difference in hourly temperatures between the simulated downtown conditions and the historical temperatures recorded from the City of Denison on the same day.

Table 1. Changes in the UHI effect for mitigation scenarios in the study area. Source: authors.

Study Area	**Reflection**	**Absorption**	**UHI Magnitude**	**UHI Change**
Current Urban	12%	88%	4.53°C (8.15°F)	-
White Roof Scenario (All roofs painted white)	33%	67%	3.71°C (6.68°F)	-0.84°C (-1.51°F)
Street Trees Scenario (0.75 acres of cover)	19%	81%	4.16°C (7.49°F)	-0.37°C (-0.66°F)
Pocket Park Scenario (1.1 acres of grass)	12%	88%	4.57°C (8.23°F)	0.04°C (0.07°F)
Combined Scenario	39%	61%	3.39°C (6.10°F)	-1.14°C (-2.05°F)

As expected, the combined scenario produced the largest reduction in the UHI effect, a change of nearly 1.14 degrees Celsius (-2.05°F) from the current conditions within the study area. The primary gains in UHI reduction in the combined scenario came from the implementation of white roofs, accounting for about 73 percent of the total reduction. Both the white roof and street trees scenarios provided additional reductions as well. The goal of increasing reflectivity and decreasing absorption is best achieved through the installation of white roofs, where total reflection of solar radiation is 33 percent and absorption is 67 percent. The pocket park scenario is the only mitigation strategy that did not significantly mitigate the UHI effect.

Table 2 below shows the extent to which the UHI effect was mitigated for each scenario within the entire downtown area. In general, the UHI magnitude was lessened across the downtown area in comparison to the findings for the study area. However, the findings are consistent among scenarios between the study area and the downtown area. The combined scenario produced the largest UHI change, the white roof scenario produced the greatest reduction in absorption and increase in reflection, and the pocket park scenario did not generate any mitigation of the UHI effect. Figure 8 shows the 4 mitigation scenarios depicted across 24 hours for the entire downtown area.

Table 2. Changes in the UHI effect for mitigation scenarios in the entire downtown area. Source: authors.

SSMID Area	**Reflection**	**Absorption**	**UHI Magnitude**	**UHI Change**
Current Urban	13%	87%	4.54°C (8.17°F)	-
White Roof Scenario (all roofs painted white)	24%	76%	4.10°C (7.38°F)	-0.44°C (0.79°F)
Street Trees Scenario (9.8 acres of cover)	19%	81%	4.33°C (7.80°F)	-0.21°C (0.38°F)
Pocket Park Scenario (7.3 acres of grass)	13%	87%	4.55°C (8.19°F)	0.01°C (0.01°F)
Combined Scenario	30%	70%	3.91°C (5.74°F)	-0.63°C (1.13°F)

Table 2 above shows how the UHI effect was mitigated for each scenario within the entire downtown area. In general, the UHI magnitude was lessened across the downtown area in comparison to the findings for the study area. However, the findings are consistent among scenarios between the study area and the downtown area. The combined scenario produced the largest UHI change, the white roof scenario produced the greatest reduction in absorption and increase in reflection, and the pocket park scenario did not generate any mitigation of the UHI effect.

The results of this research were referenced against historical temperature trends in order to provide accuracy to the predictions of the model. For the following comparisons, weather patterns from June 8th, 2015 were utilized in which a clear typical summer day occurred. Historical weather conditions are not available for the City of Sioux City; the closest national weather monitoring station is in Sergeant Bluffs, a city south of

Sioux City. In comparison to the City of Sergeant Bluffs, an average of 1.99 degrees Celsius (3.58°F) was calculated between the predicted current urban temperatures and weather trends observed in Sergeant Bluffs. Although the Sergeant Bluffs monitoring station is the closest in proximity to downtown Sioux City, the city is much less urbanized than downtown Sioux City and may not be the most suitable city for comparison. Thus, in comparison to Omaha, Nebraska, a medium-sized Midwestern city with a closer degree of urbanization in comparison to Sioux City, the accuracy of the predictions made in this research are greatly improved. The average difference in predicted temperatures in this research to observed temperatures for Omaha was 0.81 degrees Celsius (1.45°F). This comparison is more likely an accurate representation of the UHI effect with regards to urbanization and impervious surfaces.

OTHER UHI MITIGATION TECHNIQUES

Techniques not included in this analysis but are effective in combating heat island effects include utilizing green roofs and incorporating “cool paving” into streets, sidewalks, and landscapes. Green roofs incorporate plants and a planting medium on top of buildings. They can provide significant amounts of insulation for buildings, which can help reduce energy costs. These systems are able to retain stormwater and improve water quality by providing an infiltrating filter media via plant roots. Most relevant to this analysis, green roofs utilized extensively throughout a city can aid in the reduction of UHI effects. Traditional asphaltic rooftops are significantly hotter in temperature whereas green roof temperatures are typically much cooler.[11] This is because plants utilized on green roofs provide shade and evapotranspire moisture through their leaves using energy from the

[11] Gartland, Lisa. *Heat Islands: Understanding and Mitigating Heat in Urban Areas*. London: Earthscan, 2008.

sun. Likewise, temperatures above the roof are lower because more heat is absorbed by plants. A green roof is pictured in Figure 7.

Figure 7. Green roof with various native species on Chicago City Hall. Source: greenroofs.com

While green roofs on every building in an urban area is not practical due to cost as well as difficulty with retrofitting existing buildings, they can be very effective when used as part of a comprehensive UHI reduction strategy that may incorporate more cost effective measures such as the methods discussed in the preceding section. A model produced for Toronto predicted that if green roofs were incorporated on 10 percent of rooftops in the city, air temperatures could decrease by up to 2.8 degrees Celsius (5.04°F).[12] Thus, incorporating green roofs into an existing network of heat island mitigation strategies can be very effective.

There are several "cool paving" techniques that can also be incorporated in urban areas. These techniques either increase the solar reflectance of pavement or increase their ability to store water. Regardless, cool paved surfaces have shown a temperature

[12] Ibid., 2008.

decrease of 15 degrees Celsius (27°F) compared to traditional dark paving surfaces.[13] Concrete and asphalt can be lightened and cooled in many ways. Light pigment or aggregate can be added to asphalt mix in order to increase the solar reflectance of the asphalt. Concrete pavements can achieve a reflectance of as high as 80 percent by using lighter-colored aggregates and cement binders (as shown in Figure 8).[14] Cool paving techniques should be modeled in the future for their potential impact to UHI mitigation because they directly address the albedo of large surface areas such as roads and parking lots.

Figure 8. Temperature change in different colored pavements. Source: Heat Island Group.

Asphalt or concrete can also be made cooler by making it as porous as possible. By allowing rainwater to drain through the pavement surface and be stored in the layers below, water can evaporate and cool pavement during sunny weather. Porous pavement can be made by leaving fine particles out of the pavement mix, which leaves void spaces that can subsequently be occupied by water. Block pavers with rocks, soil, grass, or plants incorporated in gaps are another means by which to cool pavement by allowing water to

[13] Ibid., 2008.
[14] Ibid., 2008.

drain and evaporate through the pavement surface. In many cases, porous pavement systems are effective in low-traffic areas and must be adequately maintained and cleaned in order to prevent dirt and litter from clogging pore spaces.

Cool paving can be used in urban areas to combat heat island effects by reducing the quantity of heat that is transferred from the pavement surface to the air. Since pavement is a significant contributor to UHI effects, utilizing cool paving techniques can be very effective in reducing temperatures. The effect of widely applied cool paving would be very similar to the change realized in the white roof scenario presented in this analysis. Likewise, cool paving systems that incorporate porous media can help reduce heat island effects by storing and evaporating water while simultaneously improving the conveyance of stormwater runoff in urban areas.

DISCUSSION

The results shown in this analysis serve as a template for Sioux City and other cities looking to address heat islands. More importantly, it serves as a reminder for cities with regards to the effects that urban design decisions can have on heat islands and their associated negative consequences. It is clear from the findings of this research as well as existing research presented earlier in this report that current urban design practices are creating significant problems related to public health, building and infrastructure maintenance, and environmental quality. Despite the positive results obtained from the various scenarios in the project area, it is clear that a holistic approach, focused on directly addressing reflectivity, encompassing a number of mitigation strategies must be employed in order to significantly reverse heat island effects. Likewise, the ability for cities to comprehensively retrofit their existing built environment has shown to be costly in the midst of fiscal struggles.

This points to the need to incorporate adequate design regulations and codes on new construction in order to mitigate UHI effects on a site specific level before it is manifested in the overall heat island picture. In order to maintain sustainable urban climates, a policy framework must be in place to improve street-level comfort and reduce UHI intensities. This encompasses building, subdivision, and zoning codes that support appropriate building forms, shading, streetscaping, and urban forestry. For Sioux City, this involves planting new trees in downtown as well as improving soil quality and other environmental factors in order to ensure that trees live to a mature age. It also involves incorporating more greenspace into their urban landscape. This could be in the form of pocket parks, green walls or roofs, streetscape and sidewalk improvements that incorporate cool paving techniques and green features, or by adding permeable pavement and green buffers to existing surface parking lots in downtown.

Based on the analysis presented in this report, it is clear that while adding white roofs and street trees are effective stand-alone efforts to combat UHIs, a comprehensive approach combining various mitigation strategies would yield the best results. While the pocket park scenario showed a virtually negligible effect on the overall UHI effect on both the study area and downtown scales, development of pocket parks is still encouraged in order to make downtown greener and more attractive to residents, workers, and visitors of the area. In addition, utilizing shade trees and as much permeable surface area as possible in a pocket park is a way to increase their ability to mitigate UHIs.

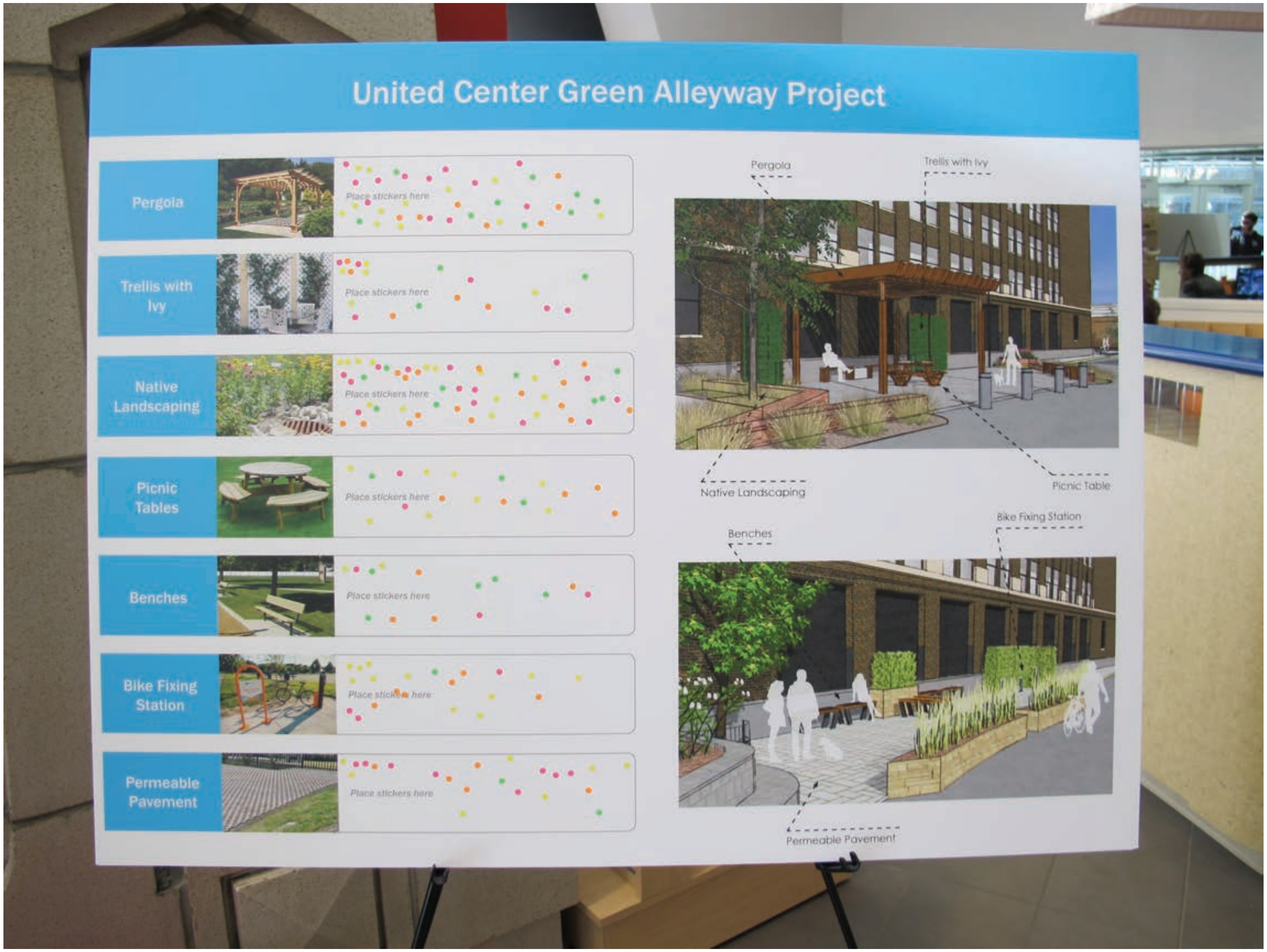

Greenspace Ideas and Concepts
Green wall located at a public parking garage near Jackson and 5th Street
Place stickers here
Green roof on the top deck of a public parking garage located near Jackson and 5th Street
Place stickers here
Enhancement to public park outside of the Sioux City Public Museum
Place stickers here
Native prairie landscaping enhancement along Perry Creek bike trail
Place stickers here
Bio-swale intended for rainwater infiltration located along 6th Street
Place stickers here
Parking lot adjacent to 4th Street with vegetated rainwater detention area near sidewalk
Place stickers here


Green Parking Lot Design
Public Art
Increased Seating
Tree Islands
Stormwater Retention
Permeable Pavers
Grass Striping
Parking Separation
Place stickers here
Tree Islands
Increased Seating
Public Art
Stormwater Retention
Permeable Pavers
Grass Striping
Parking Separation


Pierce Street Greenscaping
Flowered Strips
Place stickers here
Native Grass Strips
Place stickers here
Increased Shade Trees
Place stickers here
Permeable Concrete
Place stickers here
Bike Racks
Place stickers here
Trail Wayfinding
Place stickers here
Public Seating
Place stickers here
Native Grass Strips
Increased Shade Trees
Flowered Strips
Permeable Concrete
Bike Racks
Trail Wayfinding
Public Seating


Children's Museum Pocket Park Concepts
Human Sundial
Gazebo
Large Playground
Picnic Tables
Bike Racks
Amphitheatre
Bird Feeders
Place stickers here
Picnic Tables
Bike Racks
Gazebo
Children's Museum
Human Sundial
Large Playground
Bird Feeders
Amphitheatre


Children's Museum Pocket Park Concepts
Entrance Pergola
Pond with Bridge
Native Grass / No-Mow
Small Playground
Public Art
Edible Gardens
Diverse Tree Species
Place stickers here
Children's Museum
Public Art
Entrance Pergola
Native Grass/No-Mow
Edible Gardens
Diverse Tree Species
Pond with Bridge
Small Playground


United Center Green Alleyway Project
Pergola
Trellis with Ivy
Native Landscaping
Picnic Tables
Benches
Bike Fixing Station
Permeable Pavement
Place stickers here
Pergola
Trellis with Ivy
Native Landscaping
Picnic Table
Benches
Bike Fixing Station
Permeable Pavement

Raw Community Open House Results:

The following numbers represent the number of stickers placed next to each amenity at our Community Open House as well as the percentage of the total amount of stickers on a given poster that each amenity received.

Pierce Street Greenscaping		% of Total
Flowered Strips	31	17.2%
Native Grass Strips	43	23.9%
Increased Shade Trees	21	11.7%
Permeable Concrete	13	7.2%
Bike Racks	15	8.3%
Trail Wayfinding	31	17.2%
Public Seating	26	14.4%
Total	**180**	

Greenspace Ideas and Concepts		% of Total
Green Wall	20	9.2%
Green Roof	63	29.0%
Enhancement to Museum Park	43	19.8%
Native Prairie Landscaping @ Perry Creek trail	45	20.7%
Bioswale	33	15.2%
4th Street Buffer Strip	13	6.0%
Total	**217**	

Children's Museum Park (No Pond Alternative)		% of Total
Human Sundial	38	15.6%
Gazebo	23	9.5%
Large Playground	44	18.1%
Picnic Tables	25	10.3%
Bike Racks	24	9.9%
Amphitheatre	48	19.8%
Bird Feeders	41	16.9%
Total	**243**	

Children's Museum Park (Pond Alternative)		% of Total
Entrance Pergola	30	11.8%
Pond w/Bridge	56	22.0%
Native Grass/No-Mow	38	14.9%
Small Playground	15	5.9%
Public Art	34	13.3%
Edible Gardens	35	13.7%
Diverse Tree Species	47	18.4%
Total	**255**	

Children's Museum Park (Total All Alternatives)		% of Total
Human Sundial	38	7.6%
Gazebo	23	4.6%
Large Playground	44	8.8%
Picnic Tables	25	5.0%
Bike Racks	24	4.8%
Amphitheatre	48	9.6%
Bird Feeders	41	8.2%
Entrance Pergola	30	6.0%
Pond w/Bridge	56	11.2%
Native Grass/No-Mow	38	7.6%
Small Playground	15	3.0%
Public Art	34	6.8%
Edible Gardens	35	7.0%
Diverse Tree Species	47	9.4%
Total	**498**	

Green Parking Lot Design		% of Total
Public Art	43	20.9%
Increased Seating	24	11.7%
Tree Islands	34	16.5%
Stormwater Retention	36	17.5%
Permeable Pavers	29	14.1%
Grass Striping	11	5.3%
Parking Separation	29	14.1%
Total	**206**	

United Center Green Alley		
Pergola	40	21.4%
Trellis with Ivy	19	10.2%
Native Landscaping	52	27.8%
Picnic Tables	18	9.6%
Benches	14	7.5%
Bike Fixing Station	22	11.8%
Permeable Pavement	22	11.8%
Total	**187**	

General Comments from Open House:

Verbal Comments:

- Angle parking is difficult for deliveries downtown
- Pavers might freeze in Iowa winter, could crack easily
- Need more shade trees in downtown
- Playground equipment isn't used that often; hasn't been proved to increase exercise

Comments from Marker Board:

- "I think with the parking garages there is adequate parking allowing more space being dedicated to beautifying and adding value to Sioux City."
- "City needs to maintain sidewalks and planters existing currently downtown."
- "No pavers, gathers ice and snow, difficult to remove"
- "More larger trees"
- "No children's equipment – not ness"
- "Fountain"
- "Focus on drought hardy, native, prairie, pollinator-supporting plants (flowers and grasses) – low to now maintenance."
- "Agreed with number 1. More seating and shade to make walking more pleasant."
- "More trees/plantings at 3rd + Douglas / Pearl."
- "Recycle / sustainability park – compost garden."
- "Recycle receptacles through Downtown (Paper, plastic, etc.)"
- "Take out the marking meters – many people do not conduct retail trade downtown because of them."
- "Use movable tables / chairs in plaza-type areas"
- "Look at excess I-29 acres (when I-29 is complete) to enhance the city!"
- "Drinking fountains."
  "Highway 20, Welcome to Sioux City."

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Bioswales

In many cases, the most significant maintenance issue for bioswales is to maintain vegetation in a way that is visually appealing, although appeal is subjective. Occasional weed control may need to be performed. We don't recommend that turf grass be used in an urban bioswale, but if turf grass is used a minimum height of 4 inches must be maintained in order to filter and capture pollutants. If native grasses or other vegetation is used, it will need to either be burned if code permits or dormant vegetation will need to be mowed and removed annually. In addition, swales need to be inspected annually for bare soil or scour erosion or sediment accumulation. Sediment will need to be removed periodically. Finally, accumulated trash and debris must be removed (www.iowastormwater.org, 2014).

Permeable Pavement

Maintenance of permeable pavers is relatively minimal, but there are a few considerations that must be made in order to ensure that permeable pavement systems maintain an optimal level of effectiveness throughout their useful lives. Grass pavers require normal watering and mowing schedules as turf systems. Due to the joints and gaps in permeable pavement systems, periodic removal of materials that could potentially clog the system is required. This includes organic materials such as leaves. In addition, periodic vacuuming and low-pressure washing using street sweepers designed for parking lots should be used to clear the void space in the pavers at least quarterly or as often as local conditions require (Pine Hall Brick, 2011). Finally, the segmental nature of permeable pavers makes replacing a damaged surface much easier than replacing a traditionally paved surface in that pavement components can be removed and reinstalled following repairs.

In some cases, permeable pavements may be less desirable than traditional pavements due to freeze-thaw cycles and other winter-related issues. There are several techniques regarding snow removal that should be carefully considered. Use of sand or ash should be avoided so as to avoid clogging the pavement. For grass or gravel pavers, the blade must be lifted to clear the surface. Plows should be fit with a rubber edge and kept between ¼ and ½ inch above the pavement surface, and many manufacturers recommend that skids be placed on the corner of plow blades (Urban Design Tools, 2016). Rotary brushes and snow blowers may also be used to clear snow. Use of salts for deicing is permitted but is likely to cause efflorescence of the pavement surface for a period. Magnesium chloride can be used to avoid efflorescence (Pine Hall Brick, 2011).

Urban Prairies

When looking to develop prairies in urban areas, there are a few construction and maintenance issues that must be considered. Prairie plants grow best in open spaces with full access to sunlight. Additionally, areas with minimal root competition from trees is desirable, especially with ash or maple trees. Knowing the type of soil and drainage capacity at a site and selecting native species that will flourish given the soil conditions of the site is critical for long term prairie health. We recommend consulting the Introduction to Iowa Native Prairie Plants handbook from the Iowa State University Extension to determine which plants would be most appropriate for Sioux City.

When preparing a large site for prairie development, it is important to remove all existing vegetation at the site in order to increase the likelihood that the prairie will succeed. In order to prepare a site, there are three primary techniques. The first techniques is to put a dark plastic sheet or tarp over the grass for at least two months in order to kill the grass and to subsequently till the area. The second technique is to turn the soil on site and cultivate it every few weeks for the duration of a growing season so that weeds are brought to the surface and seeds from other plants at the site are killed. The third and most common technique is to use herbicides containing glyphosate to kill all existing vegetation.

Once an appropriate prairie plant species is selected, the next step is to determine whether the prairie should be started with seeds or plants. Seeding is the cheaper alternative, although it will take several years for plants to mature. Direct planting is more expensive, although prairies will establish themselves much more quickly and may flower after the first year. Either way, seeding or planting should be done between May 20th and June 20th in order to avoid winter frost and summer heat. Seeds should be placed evenly by hand or by spreader and can optionally be watered in order to improve germination. Covering the site with a thin, clean straw mulch can prevent drying out, reduce exposure to wind, and is recommended to prevent erosion on slopes.

With regards to maintenance, the most significant task in the first few years of a prairie will be weed control. The most common tactics in urban prairies are weeding and mowing to control weeds. Mowing is good on smaller sites, especially during the first few years after seeding to control weeds that grow more quickly than prairies. In the first few years, mowers should be set between 4 and 8 inches high to avoid cutting prairie plants. After a few years, mowing once a year in the early spring will help maintain the prairie.

Burning is the optimal method of managing a large prairie, as it promotes plant growth by removing competition and recycling nutrients. However, this is dependent on city ordinances regarding prairie burning and should only be considered until at least three years after the prairie is planted. Burning in April or early May is typical to reduce competition with weeds and to take advantage of the soil heating up more quickly. It is also important to burn prairies in portions over several years in order to increase the chances of survival for insects, animals, and birds that inhabit the prairie.

For more detailed instructions regarding construction and maintenance of prairies, please consult Kyhl, et. al., listed in the References section.

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Sioux City Rooftop Garden

May 6, 2016

Phillip Gregory, Emily Hannan, and Jacob Preuschl

UNIVERSITY OF IOWA
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING
Project Design & Management (CEE:3084:0001)
Final Design Report - spr2016

TABLE OF CONTENTS

Executive Summary

We are Prestige Worldwide, a student group at the University of Iowa tasked with determining if the Discovery Parking Garage in downtown Sioux City, IA was capable of handling a green roof on top of the structure. We are appreciative for the opportunity to analyze the structure and explore rain garden designs in an effort to be a cog in the larger green initiative in Sioux City.

This project is part of a larger initiative by the city to create more green space in its downtown area. The discovery parking garage was tabbed as the best option due to its central location, low usage of the parking spots on the top floor, and connectivity to the city's skywalk system. The design procedure included modeling the structure, designing a rain garden based on the floor plan of the garage, and converting that garden to applicable loads in the structural model to see if the structure had enough capacity to handle the designed garden and loads.

Our first garden design included terraces with plants and bushes native to Sioux City as well as areas of turf with benches and picnic tables and walkways. To protect the roof, a system is needed between the growing media for the plants and grasses and the roof. This system includes a waterproofing membrane directly on the roof, a drainage layer, and a filter layer to keep roots and soil from infiltrating the drainage layer.

To see if the structure could handle the design, we compiled the weight of these components and grouped them with live loads due to foot traffic and estimated wind loads and applied them to the structural model. On the model we checked a critical section where the slab, beam, and columns would experience the greatest forces and moments. We obtained the largest bending moment for the beams and computed the strength of the section. We determined that based off the flexural strength of the section and the maximum bending moment in the beam, the beams would not be able to handle the weight of the designed garden.

We explored a variety of options to find a suitable solution to the design objective. Structural modification such as fiber-reinforcement around the beam could have been a feasible option, except the direction of the maximum moment would cause failure in the top of the beam which is inaccessible. Another option was to construct more columns on the level below the roof to give the beam more support and thus more strength to support a garden, but that would take another floor of the parking garage out of service. This option is also very costly based on materials needed in a complete structural modification as well as labor due to the physical constraints making construction difficult. Finally, we checked the strength of the slab on the roof and found that the slab could not handle the load either. Slabs are more difficult to structurally modify. After consulting with structural engineering professor at the University of Iowa, it was deemed virtually not feasible to restructure the slab, deeming a roof garden not feasible for this structure.

Since the parking garage could not handle the garden we designed, we developed a new design that only consisted of turf, walkways, and the thinnest layer of soil based on various industry accepted standards. This design option represented the smallest load that a rooftop garden would require. We reiterated the process based on the new design; calculated the loads, calculated the bending moments and extreme forces in the beams and slab, and checked these values against the strength of the critical sections. We reached a similar solution to the first design, that the beams and slabs cannot handle the weight of the simplest garden.

While the Discovery Garage is not a viable option for a roof garden, the designs we developed are a very appealing option for a building with the capacity to support it. The first garden design offers interactive areas for community members to share and enjoy. The picnic tables offer a place for community members to have lunch. The location of this garage make it accessible based on its proximity to the hospital, downtown, and skywalk system. There is an area which we left open to give an opportunity for a piece of local art. This has the opportunity to become a local landmark, and giving the community an opportunity to have say in the aesthetic of the space will give them a sense of ownership which will yield a better taken care of space. There is also a multipurpose area which could be used by local restaurants for dining or for public or private events. The native plants will demand little maintenance and were chosen for their ability to withstand cold winters, hot summers, and intense wind conditions that we would expect to see on top of a parking garage in the Midwest. This will lower the city's cost of upkeep and could bring in foot traffic to local businesses for the summer, spring, and fall months. Beyond the economic benefits, a green roof on a suitable building would create cleaner runoff, efficient drainage, and increased green space in urban areas have been shown to increase air quality and cool urban hot spots.

The second alternative offers similar benefits, while lacking some of the flashier design components like terracing and multipurpose areas. This could still act as an interactive space for a future design and would be easily applied if designed for based on the reduced loading and ease of construction. The modifications methods mentioned above would be costly and are not explored in depth in the report below based on their lack of feasibility and cost compared to benefits for the intended purpose of contributing a lot cost garden to the series of green projects being developed in the Sioux City area.

Prestige Worldwide would like to thank you again for the opportunity to contribute to a truly great movement taking place in Sioux City. While a garden may not be feasible for the designated structure, the described designs would both be valid for future green roof projects on suitable structures.

This report was written in response to the City of Sioux City's request for a structural analysis of the Discovery parking garage and subsequent design for a rooftop garden. In this report we will discuss the background of the project along with design objectives, approaches using applicable manuals, standards, constraints, challenges, and societal impacts. The preliminary development of alternatives will be touched on and afterwards, the selection process for the best alternative and final design details with cost and construction estimates.

2. Problem Statement

In an effort to create a greener environment in an urban area, the City of Sioux City has created a project to turn locations around the city into green spaces. One of these proposed locations is the rooftop of a 753 spot parking garage located in the middle of downtown. Planners favored this structure because it is in a central location downtown and across the street from a large medical facility that has close to no green space of its own. One issue with the location is that the planning committee is not sure if the structure can withstand the extra applied loads from the soil, vegetation, and any other design elements. The design objective for Prestige Worldwide was to analyze the parking garage to determine the maximum load associated with a rooftop garden that the structure can carry. Once the maximum load is found, Prestige Worldwide can design a suitable green space within the maximum threshold.

3. Evaluation and Design Objectives

The specific design objectives include creating a green space that the community will utilize and is structurally sound, functional in the Midwestern climate, and economically viable. With these objectives in mind, the design was focused primarily on engineering a structurally viable garden design to compliment the ongoing green initiative in Sioux City. The aesthetics and functionality, while critical to success and effectiveness of the project, were secondary objectives.

To make a successful garden design applicable, we needed to create an accurate and usable structural model to yield successful analysis. The structural capacity of the parking structure was the governing task. The objectives of the analysis was to accurately model the structure, identify critical sections, and to yield easily communicable results based on the success or failure of the applied loadings from the garden design. The codes used to make this structural analysis possible are discussed below in section 4.

4. Design Standards

ASTM is the American Society of the International Association for Testing and Materials. We utilized their standards for living systems when developing the rooftop garden. ASTM is widely accepted in the United States. We also used the German FLL Green Roof Guidelines' Standard, which similarly helped develop our garden to a standard (Breuning & Yanders, 2012). Specifically, ASTM standard E2397 is the Standard Practice for Determination of Dead Loads and Live Loads associated with Green Roof Systems ("ASTM E2397/E2397M - 15: Standard Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems", 2015). ASTM also utilizes the FLL-guidelines in their standards. The supplier we contacted for our cost estimate and design loadings, Rooflite, used FLL as a design tool for any living roof system, eco roof, granular drainage system, drainage board system, modular green roof system or for selecting green roof plants.

When modeling the parking garage, we used LRFD load combinations to apply factors to the dead, live, and wind loads. These factors change service loads so they are comparable to ultimate member strength which adds a safety factor. Of the seven load combination equations, combination four was the only one used and is shown in Appendix A. Once the stresses and moments in the beams, columns, and slabs using the model, the strength of the section was checked using American Concrete Institute, ACI, standards and procedures. The standards and procedures developed by ACI show how to determine the strength of beams, columns, slabs, and other concrete sections in flexure, compression, tension, torsion, and axial force. Within the terraced garden design there are retaining walls to create the terracing effect. To create a more aesthetically pleasing appearance, interlocking landscaping blocks from VERSA-LOK will be used. These blocks will be placed on a compressed sand pad at a short depth beneath the surface of the soil. The dimensions of the retaining wall were checked for the factor of safety against overturning and sample calculations can be found in Appendix A.

5. Constraints

This project had few restrictions and guidelines concerning the potential design. There were no budget limitations, but as with any project, limiting the cost as much as possible is favorable. Since the objective was to create green space where there previously was not one, there are little to no negative environmental considerations except for emissions from equipment used during construction. There were also few negative societal impacts that needed to be take into account, especially since the top floor of the parking garage is rarely used in its current state.

One main limitation was the load that the garage can handle. Since the garage is already built, and has sustained weathering and damage the extra load it can support may be limited. This inhibited the breadth of garden design that was available. The lack of structural capacity was a constraint because modifying the structural components of the garage is not feasible both from a structural and cost stance.

Another constraint was the inability to change the footprint of the garage. We had to take the floor plan and slopes as given which limited our design due to lack of space. This physical constraint limited design options and thus creativity to implement some potential purposes the garden could serve to the community of Sioux City.

6. Challenges

Challenges that came about during the design process included the ability to make the design cost effective, constructability based on physical limitations, and complimenting the engineering demands with aesthetics that would create an appealing space for a diverse community. The challenges by no means limit the feasibility of our design, but instead caused loopholes to jump through to deliver Sioux City a satisfying product.

While there were no budgetary constraints, cost effectiveness was always a part of the design so as to make the design more appealing to the municipality of Sioux City and not take momentum away from the community-wide green initiative by using a majority of the city funds. Material cost and constructability put a bind on cost effectiveness, as the closest supplier for the garden system and soil we had contact with was located in Chicago, Illinois. To limit costs future maintenance costs, we used native plant species found on the Sioux City website ("Recommended Rain Garden Native Plants", 2014) that are known to be hearty and drought-resistant. To limit costs we also chose not to modify the existing structural components of the garage. This would potentially allow for a larger, more diverse garden, but for the extreme cost and difficulty in construction, we decided not to pursue this alternative.

Constructability is a challenge because of the physical constraints of the location of the garage. For spreading and handling of soil, a front loader will not be able to travel to the top floor because of the clearance in the garage. This would introduce the challenge of getting a crane downtown to deliver the soil and plant materials. Since the roadways are narrow, urban roadways, there would need to be detours developed for the duration of its use. If no heavy machinery would be able to be used for moving soil, the soil and plants would have to be placed by hand by a landscaping crew which would take more time and thus a far greater expense.

Aesthetics also became a problem due to the orientation of the beams on the seventh level. The beams had limited structural capacity, so the heavier areas of our design needed to be located on beams that had more capacity. This altered what could have been a more functional or aesthetically pleasing garden. A design objective was to make the space appealing to a wide range of community members because of its location next to businesses downtown, the hospital, and connection to the skywalk system. Engineering a safe yet functional space became a challenge, but certainly did not stop us from implementing the strategies discussed in the meetings with the University of Iowa Urban Planning group and Sioux City representatives.

7. Societal Impacts

Some negative societal impacts this project might include the inconvenience of construction on the community and users of the garage. Since this project is located in an urban area, there will be a lot of traffic throughout the day to the local areas of commerce. Construction on the roof of this garage could shut down traffic lanes for deliveries, causing inconveniences as well as potential noise to the local community. Traffic flow in the garage could also be disrupted. Another negative impact will be the decreased revenue caused by refunctioning a floor of the parking garage. This will take away parking spots and subsequently potential public revenues.

Positive societal impacts are more plentiful and revolve around increased green space for the community. This will serve as a public area and could become a piece of a larger green space initiative that revitalizes and invigorates the spirit of public spaces for this community. Green spaces like these can become monuments and create more closely knit communities. Other positive impacts on the local community include the potential to subcontract work with local businesses to construct the garden. This will bring in local dollars and jobs for a short period of time, and maintenance will create jobs and work in the long term. Having a space to eat lunch for people in the community could also increase the foot traffic through nearby restaurants. Environmentally, green roofs have been proven to create clean runoff, control drainage, and cool hot spots that occur in urban areas.

8. Development of Alternative Solutions

The City of Sioux City, Iowa commissioned Prestige Worldwide to perform a structural analysis on the Discovery Parking Garage to determine the garage's ability to support a rooftop green space. The rooftop green space is a part of a larger plan to make downtown Sioux City more inviting and green.

The Discovery parking garage is located in the heart of downtown Sioux City on Jones Street as show in Figure 3. The Discovery garage is connected to the Sioux City Hotel complex, as well as a system of skywalks that runs throughout downtown Sioux City. A site visit was conducted to visually inspect the parking structure to familiarize ourselves with the structure in relation to the given plans. Prestige Worldwide was provided a conditions report that was conducted in 2014. The conditions report stated that there are no major structural issues. The visual inspection yielded similar results supporting the conditions report. After the site visit, the analysis began. First, Prestige Worldwide determined the maximum loading the parking structure could safely support. This was done by constructing a model on Autodesk Robot as show in Figures 1 and 2. Next the rooftop garden was designed including soil type, thickness and aesthetic design. With the garden designed the loads were calculated and applied to the model. This acted as a double check ensuring the structure can safely withstand the additional loads applied by the rooftop garden. The model analyzed three critical components of the parking structure which included an exterior column, a corner column and an interior beam. These components were analyzed for shear, flexural and axial strength which was in turn checked against the capacities of those components. Prestige Worldwide used the accepted design standards laid out in the ACI 362.1 R97 Guide for the Design of Durable Parking Structures and PCI Parking Structures: Recommended Practice for Design and Construction to analyze the parking structure.

While developing the structural model, a preliminary garden design was drafted. This is shown below in option one. It includes terrace features and a designated area for small community events and potentially local art. When applying the loads for the preliminary design, it was determined that the structure did not have the capacity for the extra features. We then developed a second, more minimalistic alternative that could still function as a green space but not include more alluring features. This alternative is given below as option 2. Both alternatives will be discussed in depth as well as the decision making process PWW went through to make conclusions and recommendations.

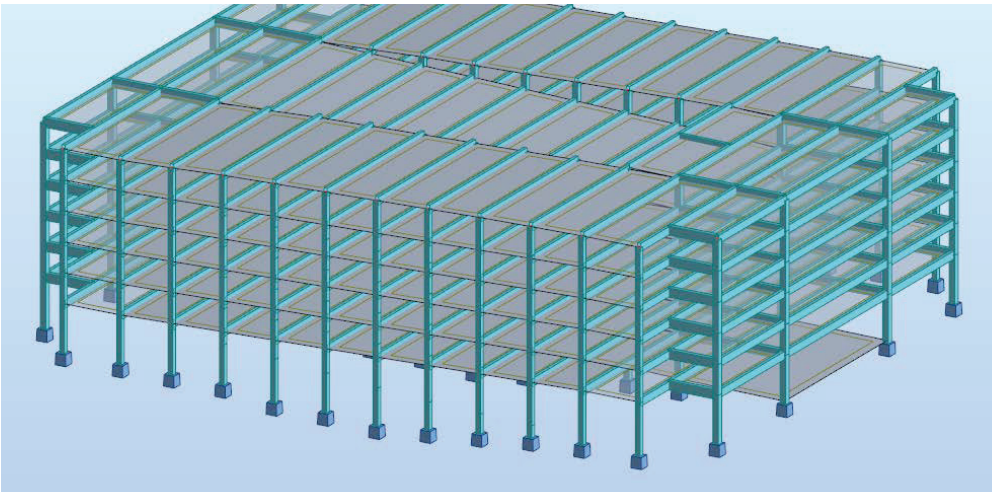


Figure 1: Discovery parking garage Robot model: isometric view

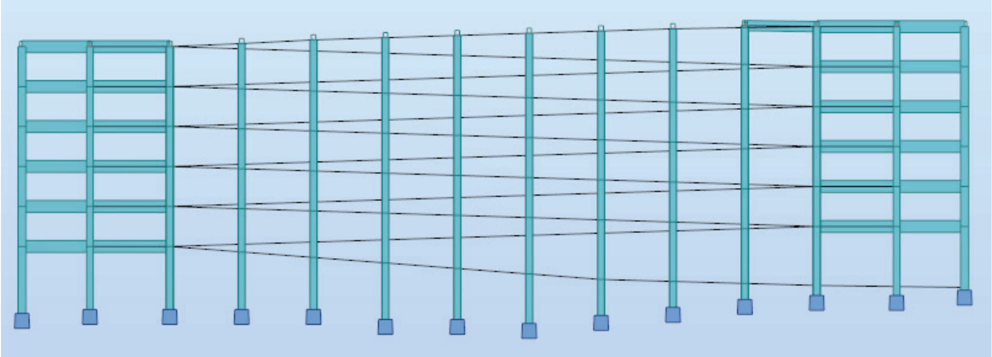


Figure 2: Discovery parking garage Robot model: south elevation view

9

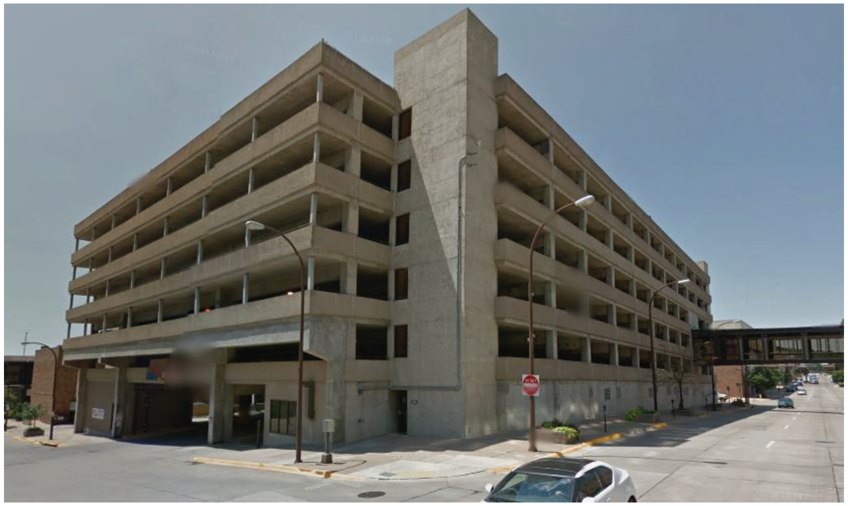


Figure 3: The Discovery parking garage in downtown Sioux City, Iowa

Option 1: Full Garden Design

Our first option includes walkways from each entrance to the roof (three stairwells and one combined stairwell and elevator entrance) wrapping around in a circular fashion. The annotated plan view is shown below in Figure 4. This design offers an additional area for people to park on the ramp from the sixth floor to the roof and have easy access to the garden. There are areas for picnics on the west end, northeast, and southeast corners of the rooftop. There is terracing wrapping around the north and south traffic barriers between the ramps. Each terrace will require a 2 foot tall retaining wall structure. The terraces will be constructed of inter-locking landscaping blocks that conform to the aesthetics and hold back the load created by soil behind it. On the east end of the garage there is a communal multipurpose area. This could be used for local restaurants to hold events, or could be rented by the public for similar events. It could also serve as extra seating for lunch goers and community members looking to enjoy the view. There is also an opportunity for a small piece of local art just west of the multipurpose area.

The reason we made many of the design decisions we did was to make the area as functional and interactive as possible. By giving the public opportunities to hold events, make memories, and influence the way it looks, they will be more attached to the space and it has a greater chance to have a lasting impact on the community. The parking spaces leading up to the garden make it easy to access, which would encourage the community to utilize the space for more activities. The separated dining areas will encourage multiple groups of lunch goers or picnickers to be encouraged to share the space while still having their own space. The design decision to add terracing came from a suggestion at a conference with the University of Iowa Urban Planning group. This offered an area to include native perennial plants that could add variety of colors and style to the aesthetics. The multipurpose area was chosen to encourage local businesses to interact with the new garden. Having this area will offer a supplemental opportunity for summer, spring, and early fall programs to bring in more business. There was also a small area west of the multipurpose area that could be utilized by a small piece of local art. This could be a keystone piece and could greatly increase public input to the success of the garden.

The design decisions were made in an effort to create opportunity for the community to interact, while also taking pride in a new green area. We want to offer as much space to be functional, aesthetics to be appealing, and opportunity to encourage a sustained sense of ownership.

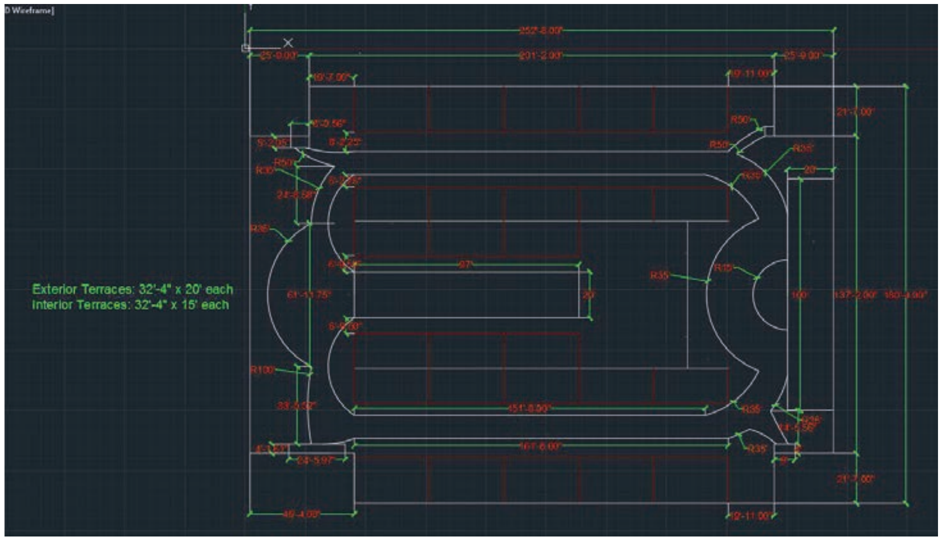


Figure 4: Plan View of Proposed Garden Design, Option 1

Option 2: Minimal Garden Design

This design option has the same walkway style and layout as well as the same grasses as the first design option. The difference in this option is that there will be no terracing or multipurpose area, instead there will be turf in place. This is to reduce the loads on the garage in areas where the loads were previously extreme and potentially unsafe based on the structural model we are analyzing.

This alternative still offers multiple spaces for lunch and picnics and even more green space. This design is simpler, but achieves the design objectives of creating a functional space for the community while being cost effective and incorporating native, low maintenance plant species into the aesthetics. This will offer opportunities for the community to include different types of local art into the design. Some options include murals on the large concrete facades of the stairwells or exterior traffic barriers. This will also create a sense of ownership for the community and can deter graffiti in some cases.

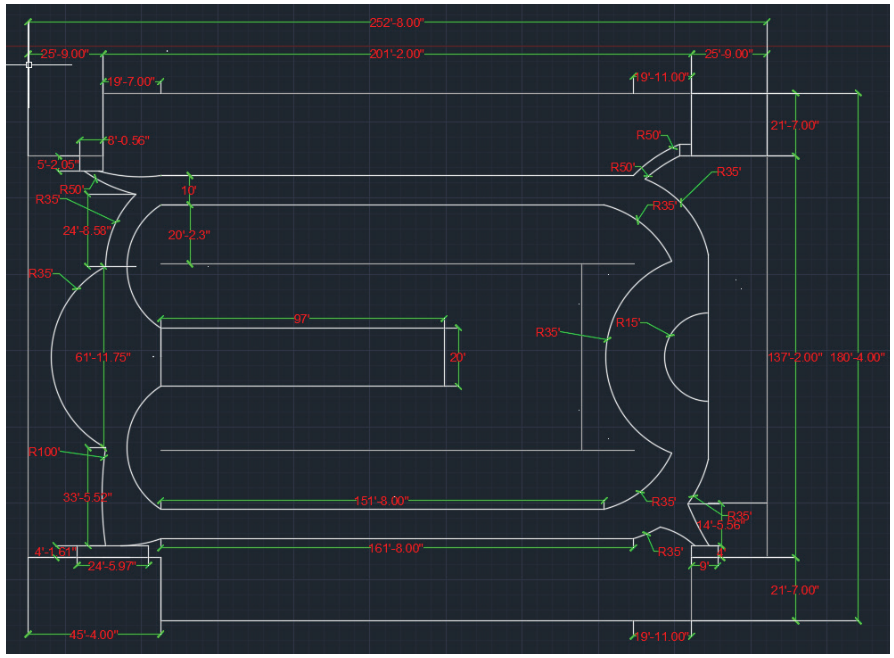


Figure 5: Plan View of Proposed Garden Design, Option 2

9. Selection Process

The selection process was governed by the feasibility and structural strength of the garage. Option 1 was ideal because of the interactive features it offered, but ran into problems with the structural model. Option 2 offered a minimalistic, yet functional, version to give a design that can be proven structurally viable based on our modeling and analyses.

Option 1 and option 2 both offered a variety of native wild life to the Sioux City area that will require little to no maintenance. This makes both alternatives appealing economically and functionality-wise so that the plants will be essentially self-sustaining in an environment exposed to extreme heat in the summers, extreme cold in the winters, and harsh winds throughout. This resilience was critical in our design to show that the green initiative won’t put a large demand on the city in sustained funding.

The ultimate deciding factor was the structural strength of the critical component, or the weakest component of the garage. After completing the designs of both garden options the loads were calculated and applied to the Robot model. The results of this model were then compared to the strength capacity of the slab. The applied loads from both Option 1 and Option 2 were unfortunately too great for either the slab or beams in flexure. While the question was to see if a garden could be built on the structure as it is, we still explored the option to structural modify the garage to try to reach a solution. This option proved too costly and hardly viable based on physical constraints and scope of the project. The cost of the strategies greatly outweighed the benefits. Based on these findings, we decided that the Discovery garage is not suitable for a roof garden, but the designs that we created would still be great choices for a new garage built to have enough capacity for a garden. The design details shown below describe execution option 1 for a new garage.

While option 1 offered a variety of extra components, it could not be built based on our structural evaluation of the garage. Option 2 offers a functional, simplistic, and open space that offers a lot of similar areas for the community that option 1 did, only at a lower cost and assurance of success. There will be areas for lunch, overlooking the city, and green spaces that will attract potential consumers to the nearby businesses.

10. Design Details

The preferred garden design is option 1 which consists of a walkway circling the entire top level bordered by plants and terraces on the sloped lengths. A drawing of the design can be seen above in figure 4. This offers more features and if a garage could be built to have enough capacity to support this garden, it would be preferred over option 2.

Each terrace contains native grasses and plants such as prairie smoke, black-eyed Susan, and little bluestem. Native, hearty plants were chosen because they are the most resilient and require less maintenance ("Recommended Rain Garden Native Plants", 2014).While the chosen plant species function in the space for aesthetic purposes, there are many engineering and cost benefits of the design. Prairie smoke was chosen for its use as a good border. It will only grow to 1 foot tall and can separate the walkways from turf areas without being blown away by harsh winds on top of the garage. This will save maintenance costs in the long term and benefit the space by bringing color and creating separate spaces. Black eyed Susan is a larger, more vibrant plant that can create some excitement for garden goers. It is biennial, so while it won't create useful space year round, it will be a more special occasion when they bloom and bring a bright feel to the space aside from the deeper colors of the prairie smoke and little blue stem. Little bluestem is our most functional choice, as it is a native grass that lasts all winter. This will encourage people to use the garden later into the fall and earlier into the spring. Mulch will be spread around the plants to hinder weed growth to further reduce maintenance. It will also slow moisture evaporation, break down into the underlying soil gradually and thereby improve the soil's texture, and helps moderate soil temperatures. This will increase the quality of the soil, the success of plant growth and yield, and will pay for itself over time. The functions of much of the planting strategies is to lower costs, and by designing the plants in the arrangement that we did, create a more effective garden in relation to the ultimate design objectives while limiting cost in the long term.

Each terrace will require a 2 foot tall retaining wall. The terraces will be constructed of inter-locking landscaping blocks that conform to the aesthetics of the garden and stone walkways. The ramp leading to the lower level will also have multiple terraced sections as seen in the plan drawing. At the lower elevation landing there is turf with picnic tables and benches for people to sit, relax, eat lunch, or enjoy the atmosphere.

At the higher elevation landing there is a multipurpose area which is a very functional space. It will have stone floor, same aesthetic as the walkways and landscaping bricks, and will have areas to eat and serve to function as a venue for local restaurants or small public or private events.

The rooftop garden system consists of multiple layers to protect the current structure, provide adequate drainage, and be conducive to growing hearty plants. The general components can be seen in Figure 6. The layer separating the concrete deck and the garden is the waterproofing layer made of a thick PVC membrane. This layer protects the structure from water infiltration which will eventually wear the concrete and reduce its structural capacity. This could lead to failure, so the waterproofing membrane is a critical step. Overall a roof garden will mitigate the current ponding problems on the roof and should lengthen the life span of the garage, but only if the waterproofing effectively separates the garden from the deck. Next is the drainage layer. This layer allows water to percolate through the soil and then be transported to the garage's existing drainage system. The drainage layer, based on the systems Rooflite Supply offer, includes more pervious soils and aggregates that will effectively let water percolate to the drains and they also offer 1 ½" channel drains. Channel drains are a triangular opening that will act as a guide for water to travel through so it doesn't sit in the soil during heavy storm events. Above the drainage layer is the separation fabric which lets water through but separates the growing media from the drainage layer so as to contain root growth. It is made of one or two layers of non-woven geotextile and includes a root inhibitor like copper or a mild herbicide. Finally, above the filter layer is the growing media. This area is different than regular soil because of its rich mineral content to encourage healthy plant growth and sustained life in tough conditions. For turf areas this layer will be about 6 inches and for the perennials and taller grasses it will be about 16 inches (Wark, 2003).

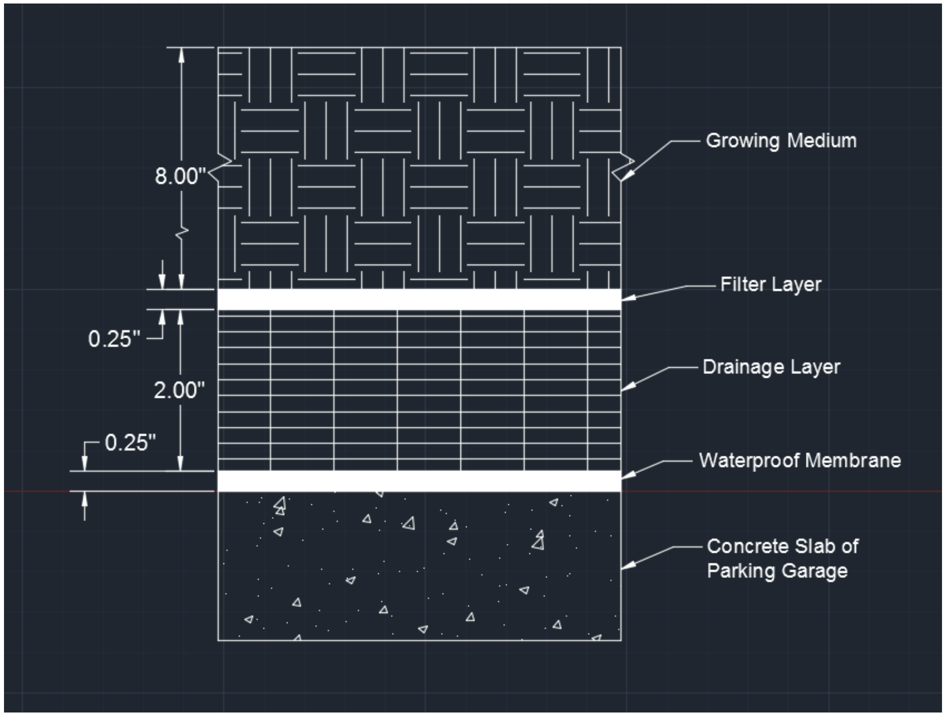


Figure 6: General components garden cross section

11. Cost and Construction Estimates

For the design option 1, the total construction cost was estimated at $451,500. To reference the details of the estimate, see Appendix C. While this design is the most costly, it is also the most involved when it comes to construction due to its various components. Since neither design option could be feasible built on the chosen structure, this cost estimate represents the cost of building design option 1 on a new garage structure with sufficient capacity.

The supplier we referenced in cost and load estimation offers 2 variations of soil delivery and application to rooftop. They described a "bulk" material delivery in where a crane could raise the blocks to the top of the structure and a "loose" material delivery which including pneumatic placement of soil into designated areas. The loose delivery method was more feasible as it would be a challenge to fit a crane downtown due to physical constraints, and could cause problems for traffic for the duration of the loading. The rates given in Appendix B include the cost of equipment, labor for spraying, and cost of materials. The rest of the materials given are based on areas from the AutoCAD model given above in figure 4, and rates based on the most logical references and suppliers based in nearby Northwestern Iowa or Eastern Nebraska. Labor was estimated assuming that the construction team would include four laborers and one supervisor at any given time. There are physical restrictions when it comes to getting heavy equipment on the roof of the garage, so we assumed that the components will be created by hand based on small deliveries via work trucks. While this will increase the labor costs due to longer hours, it will save on rental costs of heavy machinery, costs of creating and signing a detour for downtown traffic, and the potential of permanently damaging the roof by overloading it. The pay rates for labor were derived from work experience in a similar market. The total cost of labor was calculated as the total team hours per task multiplied by the rate of the five person team working one hour ($70+$70+$70+$70+$85).

In terms of construction phasing, the project should be fairly linear and able to be completed handily with 5 workers at a time. Waterproofing of the roof of the garden will need to take place first. This is independent of other processes and governs all other progress. The soil cannot be placed without the membrane being in place, neither can the components be built. Once the waterproof membrane is in place, the soil can be sprayed into place using pneumatic placing. This should be a relatively quick process, as the supplier delivers the soil and sprays it based on the specifications given. After the soil is settled, the components can begin being placed. The terracing should be built first, so that the soil has time to settle and be fully compacted before the walkways and grasses are laid into place. The terracing blocks can be delivered to the roof via maintenance truck and set in place by the laborers one block at a time. This will be tedious, but overall more feasible than prefabricating the terraces or ordering machinery. Once the terraces are in place, the sequence of events is not limited. The stone walkways could be laid before or after the laying of plants, grasses, seeding, and mulch. The last step to construction would be placing the amenities including picnic tables, benches, and whatever is to be laid in the multipurpose area.

Option 2 will include similar cost estimate strategies, but the phasing will be even simpler by taking out the various components offered in option 1. This will lower labor costs and drastically lower the material costs. With these lower costs and loads, different construction strategies may be employed such as larger teams working at the same time, or possibly small machinery to make the processes more efficient.

12. Conclusions

Based on our in depth structural model and analysis of the Discovery Parking Garage and design loads for a developed and minimalistic garden, we recommend that a roof garden not be built on top of this structure. Both alternatives were explored, analyzed, and were proven to fail based on the current condition of the structure. While the designs are not feasible on this structure, they are fully functioning designs to be employed on a future garage that has the structural capacity to carry the calculated loads. The design objectives and requests were met in the structural analysis and garden design realms in the delivered calculations, figures, and narratives. We hope the insight provided can be useful in Sioux City decision making and can offer constructive conclusions that can forward the current green initiative and urban planning in the community as a whole.

lerson, McRae. "Design and Development of a Roof Garden." McCaren Designs, Inc., n.d. Web. 14 Apr. 2016. <http://www.mccaren.com/pdfs/RooftopGardenManual.pdf>.

;TM E2397/E2397M - 15: Standard Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems." *ASTM* (2015): n. pag. *ASTM Compass*. ASTM International, July 2015. Web. 5 Apr. 2016.

uning, Jorg, and Andrew C. Yanders. "Introduction to the FLL Guidelines for the Planning, Construction and Maintenance of Green Roofing."*Green Roofing Guideline* (2008): n. pag. *Green Roof Technology*. Jörg Breuning & Green Roof Service LLC, 6 Feb. 2012. Web. 1 Apr. 2016.

commended Rain Garden Native Plants." *Sioux City*. City of Sioux City, 2014. Web. 14 Apr. 2016.

paration Fabric/Filter Fabric." *Rooflite Certified Green Roof Media*. Rooflite, Sept. 2016. Web. 11 Apr. 2016. <http://www.rooflitesoil.com/uploads/documentation/Technical%20Documents/SPECIFICATIONS/PDF%20Versions/rooflite-separation-fabric.pdf>.

ecifications: Rooflite Drain." *Rooflite Certified Green Roof Media*. Rooflite, Sept. 2016. Web. 11 Apr. 2016. <http://www.rooflitesoil.com/uploads/documentation/Technical%20Documents/SPECIFICATIONS/PDF%20Versions/rooflite-drain.pdf>.

ecifications: Rooflite Semi-intensive." *Rooflite Certified Green Roof Media*. Rooflite, Sept. 2015. Web. 11 Apr. 2016. <http://www.rooflitesoil.com/uploads/documentation/Technical%20Documents/SPECIFICATIONS/PDF%20Versions/rooflite-semi-intensive.pdf>.

rk, Christopher G., and Wendy W. Wark. "Green Roof Specifications and Standards: Establishing an Emerging Technology." *The Construction Specifier* 56.8 (2003): n. pag. The Construction Specifications. Web. 11 Apr. 2016.

LRFD Load Combination 4

$$1.2 \times Dead\ Load + 1.6 \times Wind\ Load + 1.0 \times Live\ Load$$

For loads along the critical beam analyzed in alternative 1:

- The dead load consists of the load from the terraced soil and roof garden system, the turf soil and roof garden system, the retaining wall and the slab weight which are all multiplied by the tributary area between beams.

$$Dead = \left(\left(117\ \frac{lb}{sf} + 9.667\frac{lb}{sf} + 0.03\ \frac{lb}{sf}\right) \times 9ft\right) + \left(\left(52\ \frac{lb}{sf} + 9.667\frac{lb}{sf} + 0.03\ \frac{lb}{sf}\right) \times 10ft\right) + 153\frac{lb}{ft} + \left(115\frac{lb}{cf} \times 0.66667\ ft \times 19\ ft\right) = 3.367\frac{kip}{ft}$$

- The live load accounts for the human traffic on the garden and is mutliplied by the tributary area between beams.

$$Live = 50\frac{lb}{sf} \times 19\ ft = 0.950\frac{kip}{ft}$$

- The wind load is a standard value, but is converted to a point load which acts at the end of the beam. It is converted to a point load by mulitplying by the tributary area between beams and also the tributary area between floors.

$$Wind = 40\frac{lb}{sf} \times 19\ ft \times 5ft = 3.8\ kip$$

- Because the wind load is a point load, it cannot be added directly to the dead and live loads, but it is still multiplied by the load factor.

$$Wind = 1.6 \times 3.8\ kip = 6.08\ kip$$

$$Dead\ and\ Live = 1.2 \times 3.367\ \frac{kip}{ft} + 1.0 \times 0.95\ \frac{kip}{ft} = 5\ \frac{kip}{ft}$$

Retaining Wall Sample Calculations (Retaining Wall between Terraces)

Active Pressure of Backfill

$$P_a = 0.5 \times \gamma_{bf} \times H'^2$$
$$P_a = 0.5 \times 78 \frac{lb}{cf} \times (1.5833\ ft\ )^2 = 97.77 \frac{lb}{ft}$$

Weight per Unit Length of Each Component

$$w = \gamma \times area$$
$$\bar{x} = x\ distance\ to\ centroid\ of\ area$$

(There is a w and $\bar{x}$ for the soil behind the retaining wall, the stem of the retaining wall, and the base)

$$w1 = 78 \frac{lb}{cf} \times 0.25ft \times 1.33333\ ft = 26 \frac{lb}{ft}$$
$$\overline{x_1} = 0.25\ ft + 1\ ft + \frac{0.25}{2} ft = 1.375\ ft$$

Moment Driving Overturning

$$M_D = P_a \times \frac{H'}{3}$$
$$M_D = 97.77 \frac{lb}{ft} \times \frac{1.5833}{3} ft = 51.6\ \frac{lb - ft}{ft}$$

Moment Resisting Overturning

$$M_R = w_1 \times \overline{x_1} + w_2 \times \overline{x_2} + w_3 \times \overline{x_3}$$
$$M_R = \left(26\ \frac{lb}{ft} \times 1.325ft\right) + \left(153.33\ \frac{lb}{ft} \times 0.75\ ft\right) + \left(43.13\ \frac{lb}{ft} \times 0.75\ ft\right) = 183.09 \frac{lb - ft}{ft}$$

Factor of Safety Against Overturning

$$FS_O = \frac{M_R}{M_D}$$
$$FS_O = \frac{183.09 \frac{lb-ft}{ft}}{51.6 \frac{lb-ft}{ft}} = 3.55 > 3 \quad \text{(Design is sufficient)}$$

Column Strength Calculations

To calculate the strength capacity of a column a five point interaction diagram was constructed. First the critical column was identified through a Robot analysis of a frame. The critical column was identified as the exterior column A-2.

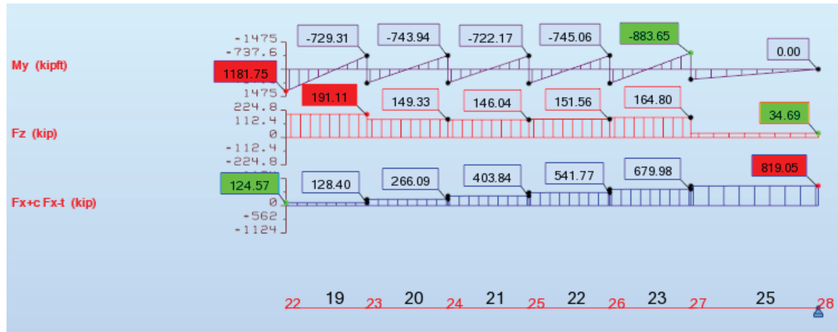


Figure 7: Robot Analysis of Column A-2

Column A-2 Strength Calculations:

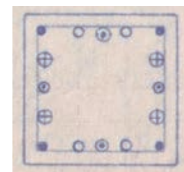


Figure 8: Column A-2 Reinforcement Cross Section

<u>Material Properties</u>

$Unit\ Weight\ of Light\ Weight\ Concrete\ (wc), wc = 115\ pcf$

$28\ day\ Compression\ Strength\ of\ Concrete\ (fcp), fcp = 4000\ psi$

$Yield\ Stress\ of\ the\ Reinforcing\ Steel\ (fy), fy = 60{,}000\ psi$

$Young's\ Modulus\ of\ Steel\ (Es), Es = 29{,}000{,}000\ psi$

$Young's\ Modulusof\ Steel\ (Ec), Ec = 33 * wc^{1.5} * \sqrt{fcp}\ psi$

$Reduction\ Factor\ (\phi), \phi = .9$

<u>Column Dimensions</u>

$Column\ Width\ (b), b = 20\ in$

$Column\ depth\ (h), h = 20\ in$

$Column\ Cross\ Sectional\ Area\ (Ac1), Ac1 = b * h\ in^2$

<u>Reinforcement Data</u>

$Diameter\ of\ bar\ group\ A, B, C\ (Dia1), Dia1 = 1.693\ in$

$Diameter\ of\ the\ Ties\ (dt), dt = .5\ in$

$Clear\ Cover\ (cc), cc = 1.5\ in$

$Cover\ (c0), c0 = cc + dt + .5 * Dia1\ in$

<u>Distances and Area's</u>

$Distance\ from\ the\ bottom\ to\ the\ Elastic\ Neutral\ Axis\ (ybar), ybar = 10\ in$

$Distance\ from\ the\ bottom\ to\ the\ centroid\ of\ the\ first\ row\ of\ rebar\ (ys1), ys1 = c0\ in$

$'' '' second\ row\ of\ rebar\ (ys2), ys2 = \frac{ybar + c0}{2}\ in$
$'' ''\ third\ row\ of\ rebar\ (ys3), ys3 = ybar\ in$
$'' ''\ fourth\ row\ of\ rebar\ (ys4), ys4 = \frac{(h - c0) + ybar}{2}\ in$
$'' ''\ fifth\ row\ of\ rebar\ (ys5), ys5 = h - c0\ in$
$Area\ of\ Steel\ in\ the\ first\ and\ fifth\ rows\ (As1), As1 = As5 = 11.25\ in^2$
$Area\ of\ Steel\ in\ the\ second, third\ and\ fourth\ rows\ (As2), As2 = As3 = As4 = 4.5\ in^2$
$Total\ Area\ of\ Steel\ Reinforcement\ in\ the\ Column\ (Ast), Ast = (2 * As1) + (3 * As2)\ in^2$

Calculation of the Interaction Diagram Point A, Axial Loading Only

Rectangular Column Eccentricity Reduction $Factor\ (eccFact), eccFact = .8$
$Used\ to\ Define\ the\ Equivalent\ Rectangular\ Stress\ Block\ (\beta), \beta = .85$
$Depth\ of\ the\ Elastic\ Neutral\ Axis\ from\ the\ compression\ face\ (c), c = 10\ in$
$Equivalent\ Rectangular\ Stress\ Block\ Depth\ (a), a = \beta * c\ in$
$Force\ of\ Concrete\ (Fc1), Fc1 = -.85 * fcp * Ac1\ kip$
$Design\ Flexural\ Strength\ at\ Point\ A\ (\phi Mna), \phi Mna = 0\ kip - ft$
$Design\ Axial\ Strength\ at\ Point\ A\ (\phi Pna), \phi Pna$
$$= \frac{eccFact * \phi * (Fc1 + (Ast * (-fy + .85 * fcp)))}{1000}\ kips$$

Calculation of Point B, setting the strain in the bottom most row of rebar to 0

$Ultimate\ strain\ of\ concrete\ (ecu), ecu = .03\ in/in$
$Compressive\ strain\ at\ the\ top\ (eh), eh = -ecu\ in/in$
$Strain\ in\ the\ bottom\ most\ row\ of\ rebar\ (et), et = es1 = 0\ in/in$
$Tensile\ Strain\ at\ the\ bottom\ (e0), e0 = \frac{et * h - eh * ys1}{h - ys1}\ in/in$
$Used\ to\ Define\ the\ Equivalent\ Rectangular\ Stress\ Block\ (\beta), \beta = .85$
$Depth\ of\ the\ Elastic\ Neutral\ Axis\ from\ the\ compression\ face\ (c), c = \frac{eh * h}{eh - e0}\ in$
$Equivalent\ Rectangular\ Stress\ Block\ Depth\ (a), a = \beta * c\ in$
$Force\ of\ Concrete\ (Fc1), Fc1 = -.85 * fcp * Ac1\ kip$
$Strain\ in\ the\ second\ row\ of\ rebar\ (es2), es2 = e0 * \frac{h - ys2}{h} + eh * \frac{ys2}{h}\ in/in$
$Strain\ in\ the\ forth\ row\ of\ rebar\ (es4), es4 = e0 * \frac{h - ys4}{h} + eh * \frac{ys4}{h}\ in/in$
$Strain\ in\ the\ fifth\ row\ of\ rebar\ (es5), es5 = e0 * \frac{h - ys5}{h} + eh * \frac{ys5}{h}\ in/in$
$rebarStress = sign(\epsilon s, i)\ (Min[Abs(Es\ \epsilon s, i), fy] - If[\epsilon s, i < 0, 0.85\ fcp, 0])\ kip/in^2$
$Force\ of\ the\ first\ row\ of\ rebar\ (Fs1), Fs1 = As1 * rebarStress[es1, Es, fy, fcp]\ kip$
$Force\ of\ the\ second\ row\ of\ rebar\ (Fs2), Fs2 = As2 * rebarStress[es2, Es, fy, fcp]\ kip$
$Force\ of\ the\ forth\ row\ of\ rebar\ (Fs4), Fs4 = As4 * rebarStress[es4, Es, fy, fcp]\ kip$
$Force\ of\ the\ fifth\ row\ of\ rebar\ (Fs5), Fs5 = As5 * rebarStress[es5, Es, fy, fcp]\ kip$

$Moment\ caused\ by\ the\ concrete\ (momFc), momFc = Fc1 * \left(ybar - \left(h - \frac{a}{2}\right)\right)\ kip - ft$

$Moment\ caused\ by\ the\ first\ row\ of\ rebar\ (momFs1), momFs1 = Fs1 * (ybar - ys1)\ kip - ft$

$Moment\ caused\ by\ the\ second\ row\ of\ rebar\ (momFs2), momFs2 = Fs2 * (ybar - ys2)\ kip - ft$

$Moment\ caused\ by\ the\ forth\ row\ of\ rebar\ (momFs4), momFs4 = Fs4 * (ybar - ys4)\ kip - ft$

$Moment\ caused\ by\ the\ fifth\ row\ of\ rebar\ (momFs5), momFs5 = Fs5 * (ybar - ys5)\ kip - ft$

$$\phi Pnb = \frac{\phi * (Fc1 + Fs1 + Fs2 + Fs4 + Fs5)}{1000}\ kip$$

$$\phi Mnb = \frac{\phi * (momFc + momFs1 + momFs2 + momFs4 + momFs5)}{12 * 1000}\ kip - ft$$

Calculation of Point C, setting the strain in the bottom most row of rebar to fy/Es

$Ultimate\ strain\ of\ concrete\ (ecu), ecu = .03\ in/in$

$Compressive\ strain\ at\ the\ top\ (eh), eh = -ecu\ in/in$

$Strain\ in\ the\ bottom\ most\ row\ of\ rebar\ (et), et = es1 = \frac{fy}{Es}\ in/in$

$Tensile\ Strain\ at\ the\ bottom\ (e0), e0 = \frac{et * h - eh * ys1}{h - ys1}\ in/in$

$Used\ to\ Define\ the\ Equivalent\ Rectangular\ Stress\ Block\ (\beta), \beta = .85$

$Depth\ of\ the\ Elastic\ Neutral\ Axis\ from\ the\ compression\ face\ (c), c = \frac{eh * h}{eh - e0}\ in$

$Equivalent\ Rectangular\ Stress\ Block\ Depth\ (a), a = \beta * c\ in$

$Force\ of\ Concrete\ (Fc1), Fc1 = -.85 * fcp * Ac1\ kip$

$Strain\ in\ the\ second\ row\ of\ rebar\ (es2), es2 = e0 * \frac{h - ys2}{h} + eh * \frac{ys2}{h}\ in/in$

$Strain\ in\ the\ forth\ row\ of\ rebar\ (es4), es4 = e0 * \frac{h - ys4}{h} + eh * \frac{ys4}{h}\ in/in$

$Strain\ in\ the\ fifth\ row\ of\ rebar\ (es5), es5 = e0 * \frac{h - ys5}{h} + eh * \frac{ys5}{h}\ in/in$

$fs,i = sign(\epsilon s,i)\ (Min[Abs(Es\ \epsilon s,i), fy] - If[\epsilon s,i < 0, 0.85\ fcp, 0])\ kip/in^2$

$Force\ of\ the\ first\ row\ of\ rebar\ (Fs1), Fs1 = As1 * rebarStress[es1, Es, fy, fcp]\ kip$

$Force\ of\ the\ second\ row\ of\ rebar\ (Fs2), Fs2 = As2 * rebarStress[es2, Es, fy, fcp]\ kip$

$Force\ of\ the\ forth\ row\ of\ rebar\ (Fs4), Fs4 = As4 * rebarStress[es4, Es, fy, fcp]\ kip$

$Force\ of\ the\ fifth\ row\ of\ rebar\ (Fs5), Fs5 = As5 * rebarStress[es5, Es, fy, fcp]\ kip$

$Moment\ caused\ by\ the\ concrete\ (momFc), momFc = Fc1 * \left(ybar - \left(h - \frac{a}{2}\right)\right)\ kip - ft$

$Moment\ caused\ by\ the\ first\ row\ of\ rebar\ (momFs1), momFs1 = Fs1 * (ybar - ys1)\ kip - ft$

$Moment\ caused\ by\ the\ second\ row\ of\ rebar\ (momFs2), momFs2 = Fs2 * (ybar - ys2)\ kip - ft$

$Moment\ caused\ by\ the\ forth\ row\ of\ rebar\ (momFs4), momFs4$
$= Fs4 * (ybar\ -\ ys4)\ kip - ft$
$Moment\ caused\ by\ the\ fifth\ row\ of\ rebar\ (momFs5), momFs5$
$= Fs5 * (ybar\ -\ ys5)\ kip - ft$

$$\phi Pnc\ = \frac{\phi * (Fc1\ +\ Fs1\ +\ Fs2\ +\ Fs4\ +\ Fs5)}{1000}\ kip$$

$$\phi Mnc\ = \frac{\phi * (momFc\ +\ momFs1\ +\ momFs2\ +\ momFs4\ +\ momFs5)}{12 * 1000}\ kip - ft$$

<u>Calculation of Point D, setting the strain in the bottom most row of rebar to .005</u>

$Ultimate\ strain\ of\ concrete\ (ecu), ecu = .03\ in/in$
$Compressive\ strain\ at\ the\ top\ (eh), eh = -ecu\ in/in$
$Strain\ in\ the\ bottom\ most\ row\ of\ rebar\ (et), et = es1 = .005\ in/in$

$$Tensile\ Strain\ at\ the\ bottom\ (e0), e0 = \frac{et * h - eh * ys1}{h - ys1}\ in/in$$

$Used\ to\ Define\ the\ Equivalent\ Rectangular\ Stress\ Block\ (\beta), \beta = .85$

$$Depth\ of\ the\ Elastic\ Neutral\ Axis\ from\ the\ compression\ face\ (c), c = \frac{eh * h}{eh - e0}\ in$$

$Equivalent\ Rectangular\ Stress\ Block\ Depth\ (a), a = \beta * c\ in$
$Force\ of\ Concrete\ (Fc1), Fc1 = -.85 * fcp * Ac1\ kip$

$$Strain\ in\ the\ second\ row\ of\ rebar\ (es2), es2\ =\ e0 * \frac{h\ -\ ys2}{h} +\ eh * \frac{ys2}{h}\ in/in$$

$$Strain\ in\ the\ forth\ row\ of\ rebar\ (es4), es4\ =\ e0 * \frac{h - ys4}{h} +\ eh * \frac{ys4}{h}\ in/in$$

$$Strain\ in\ the\ fifth\ row\ of\ rebar\ (es5), es5\ =\ e0 * \frac{h\ -\ ys5}{h} +\ eh * \frac{ys5}{h}\ in/in$$

$fs, i\ =\ sign(\epsilon s, i)\ (Min[Abs(Es\ \epsilon s, i), fy]\ -\ If[\epsilon s, i\ <\ 0, 0.85\ fcp, 0])\ kip/in^2$
$Force\ of\ the\ first\ row\ of\ rebar\ (Fs1), Fs1\ =\ As1 * rebarStress[es1, Es, fy, fcp]\ kip$
$Force\ of\ the\ second\ row\ of\ rebar\ (Fs2), Fs2\ =\ As2 * rebarStress[es2, Es, fy, fcp]\ kip$
$Force\ of\ the\ forth\ row\ of\ rebar\ (Fs4), Fs4\ =\ As4 * rebarStress[es4, Es, fy, fcp]\ kip$
$Force\ of\ the\ fifth\ row\ of\ rebar\ (Fs5), Fs5\ =\ As5 * rebarStress[es5, Es, fy, fcp]\ kip$

$$Moment\ caused\ by\ the\ concrete\ (momFc), momFc =\ Fc1 * \left(ybar - \left(h - \frac{a}{2}\right)\right)\ kip - ft$$

$Moment\ caused\ by\ the\ first\ row\ of\ rebar\ (momFs1), momFs1$
$= Fs1 * (ybar\ -\ ys1)\ kip - ft$
$Moment\ caused\ by\ the\ second\ row\ of\ rebar\ (momFs2), momFs2$
$= Fs2 * (ybar\ -\ ys2)\ kip - ft$
$Moment\ caused\ by\ the\ forth\ row\ of\ rebar\ (momFs4), momFs4$
$= Fs4 * (ybar\ -\ ys4)\ kip - ft$
$Moment\ caused\ by\ the\ fifth\ row\ of\ rebar\ (momFs5), momFs5$
$= Fs5 * (ybar\ -\ ys5)\ kip - ft$

$$\phi Pnd\ = \frac{\phi * (Fc1\ +\ Fs1\ +\ Fs2\ +\ Fs4\ +\ Fs5)}{1000}\ kip$$

$$\phi Mnd = \frac{\phi * (momFc + momFs1 + momFs2 + momFs4 + momFs5)}{12 * 1000} \; kip - ft$$

Calculation of Point E, setting the strain in the bottom most row of rebar to .02

$Ultimate\ strain\ of\ concrete\ (ecu), ecu = .03\ in/in$
$Compressive\ strain\ at\ the\ top\ (eh), eh = -ecu\ in/in$
$Strain\ in\ the\ bottom\ most\ row\ of\ rebar\ (et), et = es1 = .02\ in/in$
$Tensile\ Strain\ at\ the\ bottom\ (e0), e0 = \frac{et * h - eh * ys1}{h - ys1}\ in/in$
$Used\ to\ Define\ the\ Equivalent\ Rectangular\ Stress\ Block\ (\beta), \beta = .85$
$Depth\ of\ the\ Elastic\ Neutral\ Axis\ from\ the\ compression\ face\ (c), c = \frac{eh * h}{eh - e0}\ in$
$Equivalent\ Rectangular\ Stress\ Block\ Depth\ (a), a = \beta * c\ in$
$Force\ of\ Concrete\ (Fc1), Fc1 = -.85 * fcp * Ac1\ kip$
$Strain\ in\ the\ second\ row\ of\ rebar\ (es2), es2 = e0 * \frac{h - ys2}{h} + eh * \frac{ys2}{h}\ in/in$
$Strain\ in\ the\ forth\ row\ of\ rebar\ (es4), es4 = e0 * \frac{h - ys4}{h} + eh * \frac{ys4}{h}\ in/in$
$Strain\ in\ the\ fifth\ row\ of\ rebar\ (es5), es5 = e0 * \frac{h - ys5}{h} + eh * \frac{ys5}{h}\ in/in$
$fs,i = sign(\epsilon s,i)\ (Min[Abs(Es\ \epsilon s,i), fy] - If[\epsilon s,i < 0, 0.85\ fcp, 0])\ kip/in^2$
$Force\ of\ the\ first\ row\ of\ rebar\ (Fs1), Fs1 = As1 * rebarStress[es1, Es, fy, fcp]\ kip$
$Force\ of\ the\ second\ row\ of\ rebar\ (Fs2), Fs2 = As2 * rebarStress[es2, Es, fy, fcp]\ kip$
$Force\ of\ the\ forth\ row\ of\ rebar\ (Fs4), Fs4 = As4 * rebarStress[es4, Es, fy, fcp]\ kip$
$Force\ of\ the\ fifth\ row\ of\ rebar\ (Fs5), Fs5 = As5 * rebarStress[es5, Es, fy, fcp]\ kip$
$Moment\ caused\ by\ the\ concrete\ (momFc), momFc = Fc1 * \left(ybar - \left(h - \frac{a}{2}\right)\right)\ kip - ft$
$Moment\ caused\ by\ the\ first\ row\ of\ rebar\ (momFs1), momFs1 = Fs1 * (ybar - ys1)\ kip - ft$
$Moment\ caused\ by\ the\ second\ row\ of\ rebar\ (momFs2), momFs2 = Fs2 * (ybar - ys2)\ kip - ft$
$Moment\ caused\ by\ the\ forth\ row\ of\ rebar\ (momFs4), momFs4 = Fs4 * (ybar - ys4)\ kip - ft$
$Moment\ caused\ by\ the\ fifth\ row\ of\ rebar\ (momFs5), momFs5 = Fs5 * (ybar - ys5)\ kip - ft$

$$\phi Pne = \frac{\phi * (Fc1 + Fs1 + Fs2 + Fs4 + Fs5)}{1000}\ kip$$

$$\phi Mne = \frac{\phi * (momFc + momFs1 + momFs2 + momFs4 + momFs5)}{12 * 1000}\ kip - ft$$

Interaction Diagram and Summary of Points Calculated

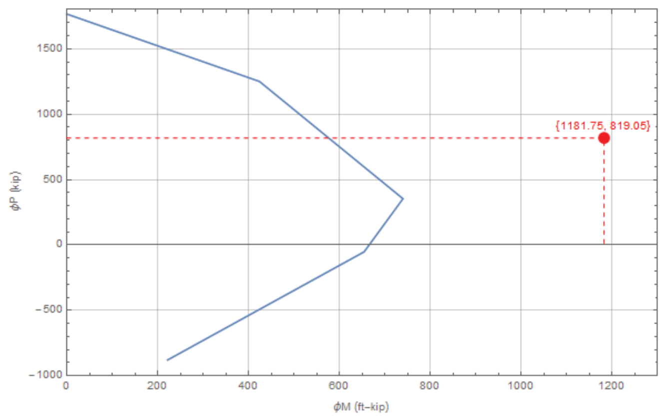


Figure 10: Interaction Diagram of Column A-2

$$\begin{pmatrix} 0 & 1766.75 \\ 423.887 & 1250.7 \\ 739.467 & 354.23 \\ 653.944 & -52.3522 \\ 221.697 & -878.879 \end{pmatrix}$$

Figure 9: Summary of the Point Calculated A-E

:

Beam Strength Calculations

Beam in Negative Moment Region Line 2 Sample Calculation

Dimensions of the beam

$$b = 15\ in, h = 36\ in, cover\ (co) = 2\ in, cover\ of\ outtermost\ row\ (cob) = 1.5\ in$$

Number of #10 rebar and dimensions

$$number\ of\ rebars\ (n) = 7, area\ of\ each\ \#10\ rebar = 1.27\ in^2$$
$$total\ area\ of\ rebar\ (As) = 8.89\ in^2$$

Concrete and rebar properties

$$concrete\ strength\ (fcp) = 4{,}000\ psi, maximum\ strain\ of\ concrete\ (ecu) = 0.003$$
$$rebar\ strength\ (fy) = 60{,}000\ psi, Young's\ modulus\ of\ steel\ (Es) = 29{,}000{,}000\ psi$$

Procedure to find the maximum design moment for a reinforced concrete beam

$$depth\ (d) = h - co = 36\ in - 2\ in = 34\ in$$

$$depth\ to\ bottom - most\ row\ of\ rebar\ (dt) = h - cob = 36\ in - 1.5\ in = 34.5\ in$$

$$Force\ in\ the\ steel\ (Fs) = As \times fy = 8.89\ in^2 \times 60{,}000\ psi = 533{,}400\ lb$$

$$Equivalent\ stress\ block\ depth\ (a) = \frac{Fs}{0.85 \times fcp \times b} = \frac{533{,}400\ lb}{0.85 \times 4{,}000\ psi \times 15\ in}$$
$$= 10.4588\ in$$

$$Yield\ strain\ of\ steel\ (ety) = \frac{fy}{Es} = \frac{60{,}000\ psi}{29{,}000{,}000\ psi} = 0.00207$$

$$Parameter\ to\ define\ the\ equivalent\ stress\ block\ (\beta) = 0.85$$

$$Distance\ from\ side\ in\ compression\ to\ neutral\ axis\ (c) = \frac{a}{\beta} = \frac{10.4588\ in}{0.85} = 12.3045\ in$$

$$Strain\ in\ the\ rebar\ (et) = \frac{ecu \times (dt - c)}{c} = \frac{0.003 \times (34.5\ in - 12.3045\ in)}{12.3045\ in} = 0.005411$$

$$Nominal\ flexural\ strength\ (Mn) = \frac{Fs \times (d - \frac{a}{2})}{1000 \times 12} = \frac{533{,}400\ lb \times (34\ in - \frac{12.3045\ in}{2})}{1000 \times 12}$$
$$= 1278.85\ kip - ft$$

$$Strength\ reduction\ factor\ (\varphi) = 0.9$$

$$Design\ Flexural\ Strength\ (Mr) = \varphi \times Mn = 0.9 \times 1278.85\ kip - ft = 1150.97\ kip - ft$$

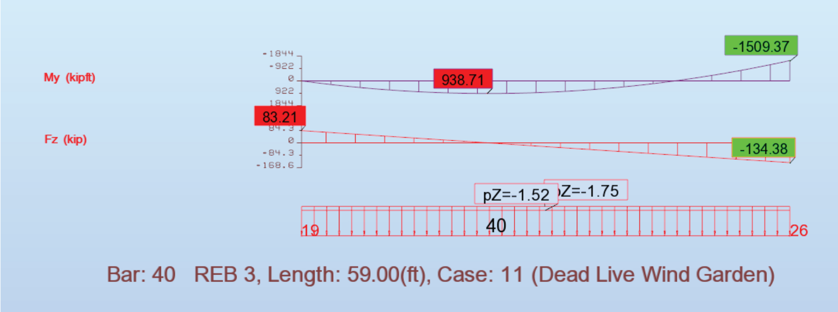


Figure 11: Robot Analysis of Critical Beam EB5 located on the 2nd floor

Slab Strength Calculations

To calculate the strength capacity of the slab, first the slab was catorized between one and two way action. Next, a one foot width of slab in the direction of one-way load transfer was taken and then applied with a uniformally distributed factored load. The maximnm applied shear, positive and negative moment were found using ACI coefficents. This value was then compared

$$Equivalent\ stress\ block\ depth\ (a) = \frac{Fs}{0.85 \times fcp \times b} = \frac{533{,}400\ lb}{0.85 \times 4{,}000\ psi \times 15\ in}$$
$$= 10.4588\ in$$

$$Yield\ strain\ of\ steel\ (ety) = \frac{fy}{Es} = \frac{60{,}000\ psi}{29{,}000{,}000\ psi} = 0.00207$$

$$Parameter\ to\ define\ the\ equivalent\ stress\ block\ (\beta) = 0.85$$

$$Distance\ from\ side\ in\ compression\ to\ neutral\ axis\ (c) = \frac{a}{\beta} = \frac{10.4588\ in}{0.85} = 12.3045\ in$$

$$Strain\ in\ the\ rebar\ (et) = \frac{ecu \times (dt - c)}{c} = \frac{0.003 \times (34.5\ in - 12.3045\ in)}{12.3045\ in} = 0.005411$$

$$Nominal\ flexural\ strength\ (Mn) = \frac{Fs \times (d - \frac{a}{2})}{1000 \times 12} = \frac{533{,}400\ lb \times (34\ in - \frac{12.3045\ in}{2})}{1000 \times 12}$$
$$= 1278.85\ kip - ft$$

$$Strength\ reduction\ factor\ (\varphi) = 0.9$$

$$Design\ Flexural\ Strength\ (Mr) = \varphi \times Mn = 0.9 \times 1278.85\ kip - ft = 1150.97\ kip - ft$$

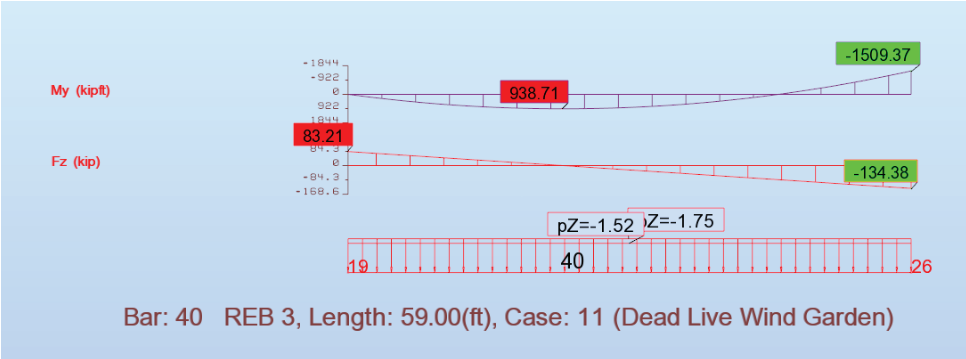


Figure 11: Robot Analysis of Critical Beam EB5 located on the 2nd floor

Slab Strength Calculations

To calculate the strength capacity of the slab, first the slab was catorized between one and two way action. Next, a one foot width of slab in the direction of one-way load transfer was taken and then applied with a uniformally distributed factored load. The maximnm applied shear, positive and negative moment were found using ACI coefficents. This value was then compared to the slab strength, which was calculated using the ACI equivalent rectangular stress block for concrete compression at ultimate method listed in ACI 318-14 Sections 22.2.2.3 and 22.2.2.4.

Slab Strength Calculations

Material Properties

$Unit\ Weight\ of Light\ Weight\ Concrete\ (wc), wc = 115\ pcf$
$28\ day\ Compression\ Strength\ of\ Concrete\ (fcp), fcp = 4000\ psi$
$Yield\ Stress\ of\ the\ Reinforcing\ Steel\ (fy), fy = 60{,}000\ psi$
$Young's\ Modulus\ of\ Steel\ (Es), Es = 29{,}000{,}000\ psi$
$Young's\ Modulusof\ Steel\ (Ec), Ec = 33 * wc^{1.5} * \sqrt{fcp}\ psi$

Dimensions of the Slab and Beams

$\boldsymbol{Base\ of\ the\ beam\ (bb), bb = 14\ in}$
$\boldsymbol{Height\ of\ the\ beam\ (hb), hb = 36\ in}$
$\boldsymbol{Thickness\ of\ the\ Slab\ (ts), ts = 8\ in}$
$\boldsymbol{Average\ Spacing\ of\ the\ beams\ \ (beamSpacing), beamSpacing = 18\ ft}$
$\boldsymbol{Beam\ Span, (L1), L1 = 59\ ft}$
$\boldsymbol{Checking\ for\ 1\ way\ action: \frac{L1}{20} \geq 2, True\ therefore\ it\ is\ a\ one\ way\ slab}$
$\boldsymbol{Clear\ Spans: 18\ ft\ span\ (Ln18) = 18 - \frac{bb}{12}}$
$\boldsymbol{= 16.833\ ft\ (also\ done\ for\ the\ 17\ and\ 20\ foot\ spans)}$

Reinforcement Data

$Diameter\ of\ bar\ group\ B, C\ (bar4Dia), bar4Dia = .5\ in$
$Diameter\ of\ the\ Ties\ (dt), dt = .5\ in$
$Clear\ Cover\ (cc), cc = 1.5\ in$
$Cover\ (c0), c0 = cc + .5 * bar4Dia\ in$
$depth\ of\ rebar\ (d), d = hb - c0\ in$

Calculate the Flexural Strength of the Slab

$depth\ (d) = ts - co = 8\ in - 1.5\ in = 6.25\ in$

$depth\ to\ bottom - most\ row\ of\ rebar\ (dt) = ts - cob = 8\ in - 1.5\ in = 6.25in$
$Area\ of\ Steel\ reinforcement\ (As) = As = \frac{unitSlabWidth * bar4Area}{barSpacing}$
$= 0.133\ in^2/12$ in width of slab

$Force\ in\ the\ steel\ (Fs) = As \times fy = 0.133\ in^2 \times 60{,}000\ psi = 8000\ lb$

$$Equivalent\ stress\ block\ depth\ (a) = \frac{Fs}{0.85 \times fcp \times b} = \frac{8000\ lb}{0.85 \times 4{,}000\ psi \times 12\ in}$$
$$= 0.1961 in$$

$$Yield\ strain\ of\ steel\ (ety) = \frac{fy}{Es} = \frac{60{,}000\ psi}{29{,}000{,}000\ psi} = 0.00207$$

$$Parameter\ to\ define\ the\ equivalent\ stress\ block\ (\beta) = 0.85$$

$$Distance\ from\ side\ in\ compression\ to\ neutral\ axis\ (c) = \frac{a}{\beta} = \frac{0.1961\ in}{0.85} = 0.2307\ in$$

$$Strain\ in\ the\ rebar\ (et) = \frac{ecu \times (dt - c)}{c} = \frac{0.003 \times (6.25\ in - 0.2307\ in)}{0.2307\ in} = 0.0815\ in/in$$

$$Nominal\ flexural\ strength\ (Mn) = \frac{Fs \times (d - \frac{a}{2})}{1000 \times 12} = \frac{8000\ lb \times (6.25\ in - \frac{0.1961 in}{2})}{1000 \times 12}$$
$$= 4.1013\ kip - ft$$

$$Strength\ reduction\ factor\ (\phi) = 0.9$$

$$Positive\ Design\ Flexural\ Strength\ (MrPos) = \phi \times Mn = 0.9 \times 4.1013\ kip - ft$$
$$= 3.6912\ kip - ft$$
$$\boldsymbol{Negative\ Design\ Flexural\ Strength\ (MrNeg) = \phi * Mn = 0.9 \times 4.1013\ kip - ft}$$
$$\boldsymbol{= 3.6912\ kip - ft}$$

<u>Calculate the Shear Strength of the Slab</u>

$$\boldsymbol{\lambda = 1}$$

$$\boldsymbol{Shear\ Resistance\ of\ the\ Concrete\ slab, Vc = \frac{2 * \lambda * \sqrt{fcp} * 12 * d}{1000} = 9.49\ kip}$$
$$\boldsymbol{Shear\ Reinforcement\ requirement\ check,}$$
$$\boldsymbol{Vu < .5 * Vc, True, Therefore\ no\ shear\ reinforcement\ is\ required.}$$

LRFD Design Load Applied to the Slab Calculations

<u>Calculate the Uniformly Distributed Factored Load</u>

$$slabWeight = \left(\frac{ts}{12}\right) * wc = \left(\frac{8}{12}\right) * 115 = 76.667\ psf$$
$$Superimposed\ Live\ Load, ll = 61.7\ psf$$
$$Distributed\ Dead\ Load, wd = \frac{(slabWeight) * 1}{1000} = .0767\ kip/ft$$
$$Distributed\ Live\ Load, wl = \frac{ll * 1}{1000} = .0617\ \ kip/ft$$

$$Distributed\ Factored\ Loading, wu = 1.2 * wd + 1.6 * wl\ kip/ft$$

<u>Use the ACI coefficients to determine the Design Moments and Shear Force</u>

$$Maximum\ applied\ positive\ moment, MuPos = wu * \frac{15.83^2}{11} = 4.35\ kip - ft$$

$$Maximum\ applied\ positive\ moment, MuPos = wu * \frac{18.83^2}{12} = 5.64\ kip - ft$$

$$Maximum\ applied\ shear\ force, Vu = \frac{1.15 * wu * 15.83}{11} = 1.74\ kip$$

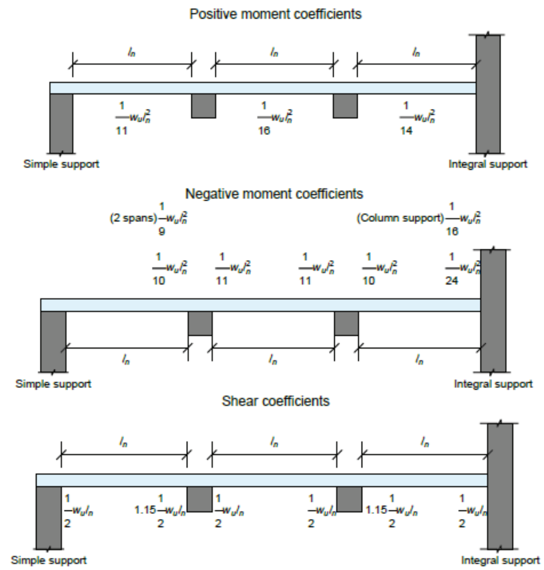


Figure 12: ACI Design Shear and Moment Coefficients

LRFD Design Load Applied to the Slab Calculations

Materials				
Item	**Quantity**	**Unit**	**Cost Estimate ($) per unit**	**Total Material Cost ($)**
Loose Soil Material and Delivery*	1,350	CY	$150.00	$202,500
Prairie Smoke	1,000	SF	$0.02	$20
Black-eyed Susan	5,000	SF	$0.02	$100
Little Bluestem	10,000	SF	$0.02	$200
Turf	12,000	SF	$0.80	$9,600
Mulch	150	CY	$30.00	$4,500
PVC Waterproofing Membrane	40,000	SF	$1.50	$60,000
Stone walkway	9,755	SF	$4.00	$39,020
Landscaping Bricks (retaining Wall)	5,700	Per	$4.50	$25,650
Landsaping caps	1,300	Per	$4.23	$5,499
Base of Multipurpose area	2,000	SF	$5.00	$10,000
Picnic Tables	6	Per	$300.00	$1,800
Benches	6	Per	$415.00	$2,490
				$361,500

Labor (time based on crew and days spent)**				
Item	**Quantity**	**Unit**	**Cost Estimate ($) per unit**	**Total Labor Cost ($)**
Waterproofers	80	Team hrs	365	$29,200
Planting (Plants / grasses / mulch)	8	Team hrs	365	$2,920
Laying Stone	60	Team hrs	365	$21,900
Assembling Terraces	95	Team hrs	365	$34,675
Installing tables / benches	4	Team hrs	365	$1,460
				$90,000
			TOTAL COST	**$451,500**

*includes cost of pnuematic placement

**Assuming 4 Laborers and 1 Supervisor working at $70 and $85 per hour respectively

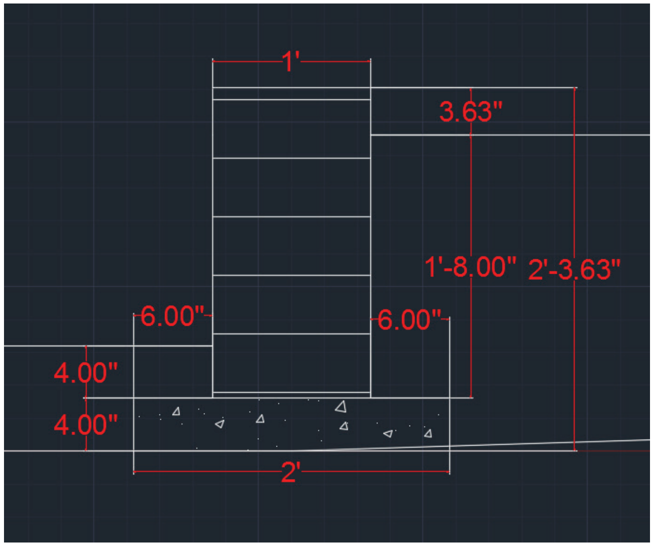


Figure 13: Retaining Wall structure between end terraces and turf areas

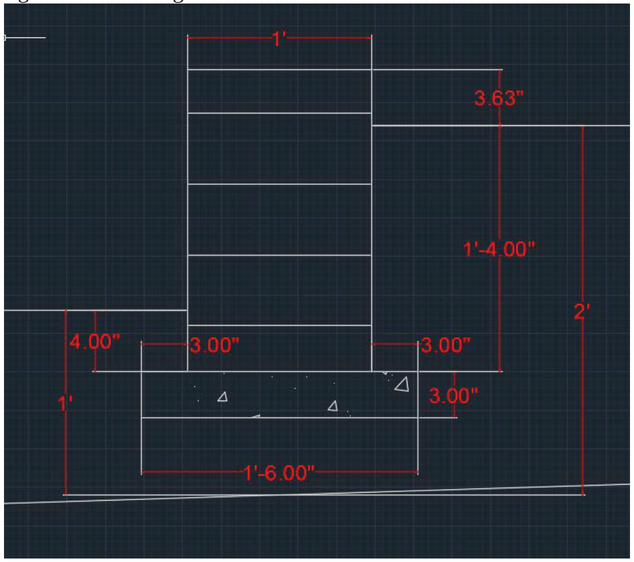


Figure 14: Retaining wall structure between terrace levels

Type of Infrastructure	Cost Estimates Low	Medium	High	Unit
Site Preparation				
Soil Analysis	$500.00	$1,500.00	$2,500.00	EACH
Soil/Site Amendment	$50.00	$0.75	$1.00	/SQFT
Topsoil	$248.00	$324.00	$400.00	/ACRE
Infrastructure				
Porous Asphalt	$0.50	$0.75	$1.00	/SQFT
Porous Concrete	$2.00	$4.25	$6.50	/SQFT
Permeable Brick Paver	$3.00	$8.00	$15.00	/SQFT
Stormwater Detention Area	$26,600.00	$41,600.00	$56,600.00	/ACRE-FT
Sidewalk Bioswale	$6.18	$8.16	$10.17	/CUFT
Vegetation				
Fruit Trees	$320.00	$485.00	$650.00	/EACH
Large Tree (8-9')	$50.00	$120.00	$190.00	/EACH
Prairie Grass Seed Mix	$20.00	$35.00	$50.00	/LBS
Shrubs	$20.00	$25.00	$30.00	EACH
No-mow lawn seed-mix	$9.00	$18.00	$27.00	/LBS
Amenities				
Bike Rack	$200.00	$350.00	$500.00	EACH
Park Bench	$250.00	$400.00	$550.00	EACH
Pergola	$900.00	$3,295.00	$7,400.00	EACH
Picnic Tables	$798.00	$879.00	$945.00	EACH
Trash or Recycle Bins	$299.00	$421.00	$515.00	EACH
Compost Bins	$2,500.00	$3,250.00	$4,000.00	EACH
Gazebo	$740.00	$7,210.00	$20,000.00	EACH
Stone Path	$25.00	$35.00	$45.00	/SQFT
Bird Feeders	$10.00	$60.00	$110.00	EACH

Sources

1. http://www.homeadvisor.com/cost/architects-and-engineers/test-soil/
2. http://www.homedepot.com/s/compost%2520bins?NCNI-5
3. https://extension.umd.edu/sites/default/files/_docs/programs/master-gardeners/Howardcounty/Baywise/PermeablePavingHowardCountyMasterGardeners10_5_11%20Final.pdf
4. http://www.cityofchicago.org/content/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf
5. http://www.water.rutgers.edu/Projects/Sussex/Detention%20Basin%20Retrofits%20and%20Maintenance.pdf
6. http://extension.oregonstate.edu/douglas/sites/default/files/documents/hort/costtoraisefruittree.pdf
7. http://www.americanmeadows.com/grass-and-groundcover-seeds/northeast-native-grass-seed-mixture
8. http://www.americanmeadows.com/grass-and-groundcover-seeds/no-mow-lawn-grass-seed
9. http://www.kaypark.com
10. http://www.homeadvisor.com/cost/outdoor-living/build-an-arbor-pergola-or-trellis/
11. http://www.homedepot.com/s/compost%2520bins?NCNI-5
12. http://www.homeadvisor.com/cost/outdoor-living/build-a-gazebo/
13. http://www.homeadvisor.com/cost/outdoor-living/install-a-patio-or-pathway/
14. http://www.birdfeeders.com/store/wild-bird-feeders?start=22&sortby=Price

APPENDIX H: GRANT OPPORTUNITIES

		GRANT OPPORTUNITIES RELATED TO GREENSPACE OR ENVIRONMENTAL PROTECTION AND CONSERVATION			ELIGIBILITY	
		GRANT NAME	FUNDING ORGANIZATION	PROGRAM DESCRIPTION	CITY	PRIVATE OR NON-PROFIT ORGS
LOCAL	1	Fund for Siouxland	Siouxland Community Foundation	Intended for community betterment, citizen participation, parks & recreation	●	●
LOCAL	2	Junior League of Sioux City	Siouxland Community Foundation	Addreseds community needs through the participation of trained volunteers	●	●
LOCAL	3	Women United Program Grant	United Way of Siouxlxland	One-time grants for special programming needs, such as playground equipment or tutors.		●
LOCAL	4	Small Grant Program	Missouri River Historical Development	Non-profit agency dedicated to promoting Sioux City and Woodbury County through community grants	●	●
LOCAL	5	Special Grant Program	Missouri River Historical Development	Non-profit agency dedicated to promoting Sioux City and Woodbury County through community grants	●	●
LOCAL	6	Micro-Grant	The Gilchrist Foundation	Brining green spaces, parks, wildlife and conservation efforts into the lives of Siouxland residents	●	●
LOCAL	7	Project Grant	The Gilchrist Foundation	Brining green spaces, parks, wildlife and conservation efforts into the lives of Siouxland residents	●	●

HOME-OWNERS	AMOUNT	GRANT CYCLE	APPLICATION DATE	WEBSITE
	$5,000 maximum	Annually	January 15	http://www.siouxlandcommunityfoundation.org/fund-for-siouxland/
	$1,000 maximum	Annually	January 15	http://www.siouxlandcommunityfoundation.org/junior-league-of-sioux-city-mildred-anderson-grant-program/
	$500 - 2,500	Annually	Octber 23	http://www.unitedwaysiouxland.com/leadership-groups-women-united.php
	$10,000 maximum	Annually	Mid- February	http://mrhdiowa.org/grants/
	$25,000 - $250,000	Annually	Mid-July	http://mrhdiowa.org/grants/
	$5,000 maximum	Rolling	Rolling	http://thegilchristfoundation.org/applications/micro-grant/
	Varies	Rolling	Invite Only	http://thegilchristfoundation.org/applications/project-grant/

GRANT OPPORTUNITIES RELATED TO GREENSPACE OR ENVIRONMENTAL PROTECTION AND CONSERVATION					ELIGIBILITY	
		GRANT NAME	FUNDING ORGANIZATION	PROGRAM DESCRIPTION	CITY	PRIVATE OR NON-PROFIT ORGS
STATE	1	REAP (City Parks and Open Space)	Iowa Department of Natural Resources	Parkland expansion and multi-purpose recreation developments	●	●
STATE	2	REAP (Private/Public Open Space Acquisition)	Iowa Department of Natural Resources	Cost-share land acquisitions with private organizations		●
STATE	3	REAP - (Conservation Education Program)	Iowa Department of Natural Resources	Programs that teach people of all ages about their environment	●	●
STATE	4	REAP - (Roadside Vegetation)	Iowa Department of Natural Resources	Establishment of attractive gateways into cities, demonstration and research projects	●	●
STATE	5	Land and Water Conservation Fund	Iowa Department of Natural Resources	Cost-share for outdoor recreation area development and acquisition	●	
STATE	6	State Revolving Fund (SRF)	Iowa Department of Natural Resources & Iowa Finance Authority	Low-interest loans for financing for stormwater infrastructure improvements	●	●
STATE	7	Vision Iowa - River Enhancement	Iowa Economic Development Authority	Promote and enhance recreational opportunities on and near rivers or lakes within cities.	●	●
STATE	8	Vision Iowa - Community Attraction and Tourism	Iowa Economic Development Authority	Assistance for projects that will provide recreational, cultural, entertainment and educational attractions	●	●
STATE	9	State Recreational Trails Fund	Iowa Department of Transportation Authority	Funds to establish recreational trails in Iowa for the use, enjoyment and participation of the public	●	●

HOME-OWNERS	AMOUNT	GRANT CYCLE	APPLICATION DATE	WEBSITE
●	$300,000 maximum	Annually	April 15	http://www.iowadnr.gov/Conservation/REAP/REAP-Funding-at-Work/City-Parks-Open-Spaces
	Determined by site	Annually	April 15	http://www.iowadnr.gov/Conservation/REAP/REAP-Funding-at-Work/Open-Spaces-Protection
	$26,000 average; $3,500 mini-grants	Bi-Annually	May 15, November 1	http://www.iowadnr.gov/Conservation/REAP/REAP-Funding-at-Work/Conservation-Education
●	Varies	Annually	June 1	http://www.iowadnr.gov/Conservation/REAP/REAP-Funding-at-Work/Roadside-Vegetation
	$200,000 assistance ceiling	Annually	March 15	http://www.iowadnr.gov/About-DNR/Grants-Other-Funding/Land-Water-Conservation-Fund
	Varies	Quarterly	Rolling	http://www.iowasrf.com/audience/
	Varies	Quaterly	Oct., Jan., April, July 15	http://www.iowaeconomicdevelopment.com/Community/VisionIowa
	Varies	Quaterly	Oct., Jan., April, July 15	http://www.iowaeconomicdevelopment.com/Community/VisionIowa
	Varies	Annually	July	http://www.iowadot.gov/systems_planning/fedstate_rectrails.htm

Appendix

		GRANT OPPORTUNITIES RELATED TO GREENSPACE OR ENVIRONMENTAL PROTECTION AND CONSERVATION			ELIGIBILITY	
		GRANT NAME	FUNDING ORGANIZATION	PROGRAM DESCRIPTION	CITY	PRIVATE OR NON-PROFIT ORGS
FEDERAL	1	Outdoor Recreation Legacy Partnership Program	National Park Service	Matching support for projects that would acquire or develop public land for outdoor recreation purposes	●	
	2	Federal Recreational Trails Fund	Federal Highway Administration	National program to provide funds to states to allocate grants for trails and trail-related projects	●	●
	3	Brownfields Cleanup Grant	Environmental Protection Agency	National EPA program for creation of greenspace, recreational use, or natural habitat restoration	●	●
	4	Wetland Program Development	Environmental Protection Agency	Offered to EPA Region 7 states for building or refining a wetland program	●	
	5	CDBG Sustainable Community Demonstration	Housing and Urban Development & Iowa Economic Development Authority	Activities demonstrating comprehensive innovative approaches to support community sustainability	●	

HOME-OWNERS	AMOUNT	GRANT CYCLE	APPLICATION DATE	WEBSITE
	$250,000 floor, $750,000 ceiling	Annually	May 20	http://www.grants.gov/web/grants/view-opportunity.html?oppId=282085
●	$5,000 minimum	Annually	October	http://www.iowadot.gov/systems_planning/fedstate_rectrails.htm
	$200,000 ceiling	Annually	June	http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Contaminated-Sites/Brownfields
	$300,000 ceiling	Varies	May 5	http://www.grants.gov/search-grants.html?fundingCategories%3DENV%7CEnvironment
	$500,000 maximum	Annually	December 31	https://www.iowagrants.gov/insideLinkOpps.jsp?documentPk=1367513122166

Sioux City Comprehensive Plan

Sioux City's primary planning document is the comprehensive plan adopted in 2005. Downtown Viability and the "creation of place" is a key goal in the city's comprehensive plan. To improve the downtown environment, the plan calls for the creation of "connections between the various portions of downtown." The plan also calls for the development of a visual and functional connection between downtown and the riverfront area and the enhancement of the appearance of downtown in order to make it more marketable. The Comprehensive Plan will be updated in the upcoming months.

This Greenspace Plan identifies specific recommendations for downtown Sioux City, which can help the City meet the goals stated in its current comprehensive plan as well as help define new goals for the upcoming update.

Sioux City Municipal Code

Sioux City, IA code has a number of existing provisions that support this principles of this Green Space Plan and the overall incorporation of healthy, productive, and climate-appropriate green space into downtown Sioux City. Section 25.05.080.1 specifies a list of approved landscape plant species, which includes plants that are native, non-invasive, non-noxious, and that provide habitat for local migratory birds. The section also requires the implementation of Water Wise landscaping principles, which aim to conserve water and plant vegetation appropriate for the local soil and climate.

- Section 25.05.080.3 provides landscaping credit to developers that preserve existing trees canopy.

- Section 25.05.110.2 establishes priority areas for the protection of open spaces. The Missouri River, creeks, riparian areas, floodways, floodplains, and wetlands are listed at the top of the list. This section also states that open space "shall be organized so as to create integrated systems that connect with dedicated school lands, parklands, other open spaces, or public lands or trails.

- Section 25.05.090.1 requires that vehicular use areas be landscaped and contain a buffer at least eight feet in width. Parking lots are also required to be landscapes with at least one large deciduous tree for every 15 parking spaces. In addition, it states that tree island curbs "may include breaks to allow for stormwater flows into recessed landscape areas for detention and/or treatment."

- Section 17.40.050 provides a list of the official street tree species that may be planted in the city. The planting of species not on this list requires permissions from the city manager.

- Section 17.40.060 articulates that trees need to be planted specified distances away from all paved areas in order to promote the upmost health of the tree.

- Section 12.30.020 describes the City of Sioux City's stormwater maintenance fee program, which is tied to the area of the lot and as land use. The city utilizes a weighting factor based on the relative volume of stormwater runoff from a given parcel as a function of impervious surface cover. Under this structure, lots in which less rainfall is converted to runoff such as agriculture and residential users are charged less. Likewise, commercial and industrial users are charged a higher fee. If an appeal of this fee is submitted to the city by a property owner, the city may conduct an analysis of the lot in question. The new fee rate is then determined solely on the percentage of impervious area on the parcel in question and not on land use.

Complete Streets Policy & Active Transportation Plan

Sioux City's Complete Streets Policy was adopted in 2014, followed by the Active Transportation Plan in 2015. This plan and policy demonstrate Sioux City's commitment to creating viable networks and connections between Sioux City neighborhoods and city center for bicycle, pedestrian, and transit travelers. The same people that benefit from the complete streets policy and active transportation plan will also benefit from this Greenspace Plan.

GREENSPACE SIOUX CITY

THE UNIVERSITY OF IOWA
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

Greenspace for Downtown Sioux City

This survey is conducted by Urban and Regional Planning graduate students from The University of Iowa in partnership with The City of Sioux City, Downtown Partners Sioux City, and the Siouxland Interstate Metropolitan Planning Council (SIMPCO).

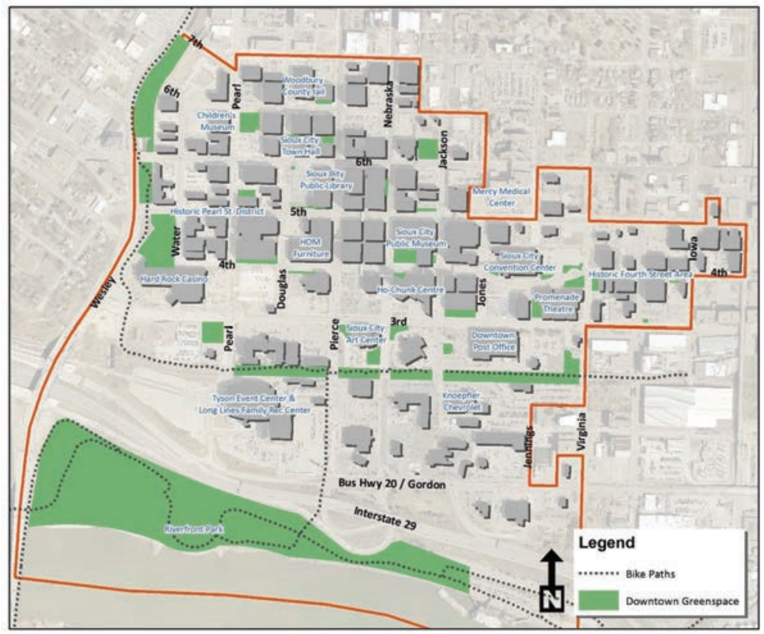
We would like to know about your usage of existing downtown greenspaces and your preferences about future greenspaces for downtown. We would also like to gauge your willingness to support changes.

Greenspace is defined as *"space that is partly or completely covered in vegetation and is available for recreational, entertainment, aesthetic, and biological uses,"* and can be located on public or private property. The results of this survey will be used to guide design and policy recommendations included in a Greenspace Plan for downtown Sioux City.

We welcome your input and your answers will be kept confidential. Thank you for your participation.

Existing Greenspaces

1: Here is a map showing existing downtown greenspace. Please circle the locations you visit and indicate in the margins “Daily,” Weekly,” “Monthly,” or “Yearly.”



2: Why do you typically visit greenspaces downtown? *(Check all that apply)*

☐ Biking
☐ Relax or meditate
☐ Business meetings
☐ Eat lunch during break
☐ Walking or jogging
☐ Family time
☐ I don't visit any
☐ Other ____

Future Greenspaces

3: How important are these amenities for downtown Sioux City?

	Important	Somewhat Important	No Opinion	Somewhat Unimportant	Unimportant
Outdoor lunch / dining space					
Places to sit or relax					
Small urban parks					
Playgrounds					
Edible gardens (food production)					
Public art					
Biking or walking trails					
Bike racks					
Space for community events					
Natural space for biodiversity					
Natural space for rainwater infiltration					
Natural features for cooling the environment					
Other ___________					

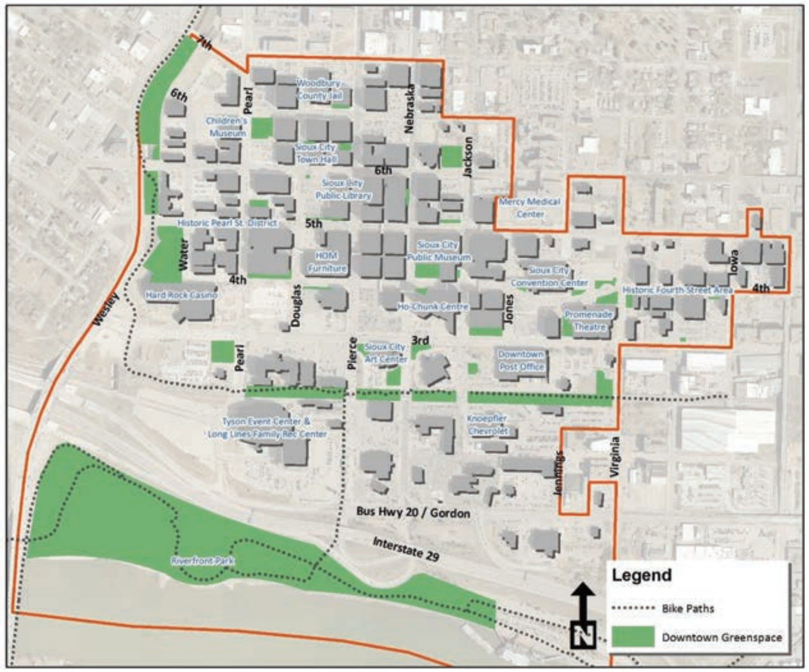
4: How important are these streetscape improvements for downtown Sioux City?

	Important	Somewhat Important	No Opinion	Somewhat Unimportant	Unimportant
More street trees					
Diverse street trees					
Greenspaces where rainwater can infiltrate (i.e. rain gardens or swales)					
Permeable pavement					
Grass or native plants					
Bike paths					
Tree planters					

5: If there were more greenspaces in downtown, would you:

	Definitely	Probably	No Change	Probably Not	Definitely Not
Enjoy working downtown more?					
Spend more time outdoors?					
Consider living downtown?					
Spend more time walking or jogging downtown?					
Spend more time downtown for recreation?					

6: Where would you like to see new greenspace? Please circle any locations on the map and indicate what you'd like to see in the space provided below.



7: What do you think about these greenspace designs?

1. Native species landscaping

☐ Strongly Like ☐ Somewhat Like ☐ No Opinion ☐ Somewhat Dislike ☐ Strongly Dislike

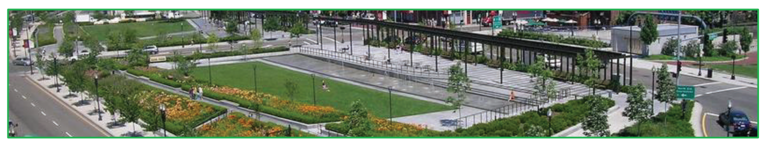
2. Playscaping

☐ Strongly Like ☐ Somewhat Like ☐ No Opinion ☐ Somewhat Dislike ☐ Strongly Dislike

3. Mowed, manicured lawn

☐ Strongly Like ☐ Somewhat Like ☐ No Opinion ☐ Somewhat Dislike ☐ Strongly Dislike

4. Linear parks



☐ Strongly Like ☐ Somewhat Like ☐ No Opinion ☐ Somewhat Dislike ☐ Strongly Dislike

5. Open waterscaping

☐ Strongly Like ☐ Somewhat Like ☐ No Opinion ☐ Somewhat Dislike ☐ Strongly Dislike

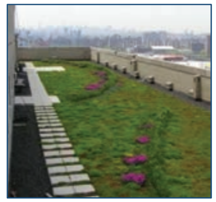
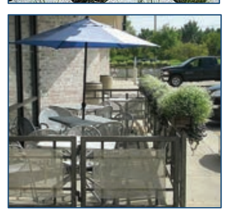
8: If more greenspaces are created downtown, how will businesses be affected?

	Very Positive Impact	**Positive Impact**	**No Change**	**Negative Impact**	**Very Negative Impact**
Customer satisfaction					
Employee satisfaction					
Ability to attract new customers					
Ability to attract new businesses					
Business visibility					
General downtown business climate					

9: If more greenspaces are created downtown, how will this affect quality of life?

	Very Positive Impact	**Positive Impact**	**No Change**	**Negative Impact**	**Very Negative Impact**
Walking or biking around downtown					
Downtown workers' quality of life					
Downtown residents' quality of life					

10: For each of these amenities, please indicate if you're interested and if you would support it at your place of business?

1. Green roof or garden		☐ Yes, I am interested.	☐ Yes, and I would support it financially.	☐ Yes, and I would fully fund it.	☐ No, I am not interested.
2. Green wall		☐ Yes, I am interested.	☐ Yes, and I would support it financially.	☐ Yes, and I would fully fund it.	☐ No, I am not interested.
3. In-sidewalk planters		☐ Yes, I am interested.	☐ Yes, and I would support it financially.	☐ Yes, and I would fully fund it.	☐ No, I am not interested.
4. Permeable pavement		☐ Yes, I am interested.	☐ Yes, and I would support it financially.	☐ Yes, and I would fully fund it.	☐ No, I am not interested.
5. Outdoor seating or dining		☐ Yes, I am interested.	☐ Yes, and I would support it financially.	☐ Yes, and I would fully fund it.	☐ No, I am not interested.

11: How many full time-equivalent (FTE) employees work in your place of business (including you)?

☐ ______________

12: Is your business space owned or leased?

☐ Owned ☐ Leased

13: Any additional input about the placement, type, and or design of greenspace in downtown?

Personal Information

Name ______________ Email ______________

Company ______________ Phone ______________

Thank you for taking the time to fill out our survey. Your input is greatly appreciated.

To learn more about the Greenspace Sioux City project and the planning process, we invite you to visit our website:

www.greenspacesc.wordpress.com