Sustaining Infrastructure and Natural Areas in Shoreview Parks

ESPM 4041W: Problem Solving for Environmental Change

Report 6/8 Prepared for the City of Shoreview by:

Will Clausen– Project Leader
Becky Dorff
Larissa Gonring
Tanner Kraft
Erin McGee

December 17, 2009

University of Minnesota

Table of Contents

List of Figures

Acknowledgments

A special thanks to Gary Chapman, Jerry Haffeman, and Gene Kruckenberg for help in acquiring park and trail data and information, and Andy Jenks and Matt Baker for GIS assistance. Thank you to Tom Wesolowski for providing information on parking lots in the park system, Rob Warwick, Kathleen Nordine, and Tessia Melvin for volunteering their time and knowledge of Shoreview, and Lindsey Kraft for technical expertise. Thanks to Walter Dziedzic, Doug Taubman, Chris Walup, Ken LaCasse, and Steven Kummer for offering information on the different maintenance practices in surrounding cities.

Executive Summary

Shoreview, Minnesota, is located in an area with a wealth of natural resources and aesthetic beauty. Lakes, wetlands, and streams are particularly abundant in the area and a source of pride for many residents. Within Shoreview are ten city parks which are owned and operated by the Parks and Recreation division of the city government. The primary purpose of this land is to provide areas for active recreation for citizens.

The purpose of this study was to indentify recommendations that would improve the ecological and economic sustainability of Shoreview parks, and that would insure that future generations will be able to enjoy the parks in the way they are today. To meet these ends, management strategies that balance the needs of nature and the needs of park users were identified and elaborated on. Inventories were conducted to determine the current state of Shoreview parks. Vegetation health and diversity, infrastructural quality, and current maintenance protocols were the primary foci of the inventories.

Reviews of secondary sources, case studies, and interviews with appropriate companies and departments were conducted to establish possible recommendations. “Hotspots” were mapped within the parks to prioritize areas of importance where changes are most needed and would have the greatest impact.

Based upon an assessment of the resource and related research, recommendations were developed for green (vegetation) and gray (infrastructure) management that reduce the negative externalities caused by park use and park maintenance, while sustaining the aesthetic quality and usability of the park.

Recommendations:
- Pervious pavements
- Increased use of natural buffer strips
- Utilizing site-tolerant plants
- Reduced paved areas
- Increased shading on pavement
- More effective and efficient use of land
- Park specific maintenance protocols to meet the need of unique conditions

Introduction

Parks and open spaces tend to be viewed in a positive light for their natural characteristics, especially in urban and suburban settings. They serve as a place for people to connect with and enjoy the environment, as well as provide important ecological services. However, the way in which a park is managed and maintained greatly influences its true impact on the natural world. Because community parks exist for the enjoyment of humans, and because human activity is often at odds with the natural world, there is a need to establish management practices that minimize the impact that park users have. High impact areas of parks include parking lots and trails near water, where excessive runoff caused by impervious surfaces and pollutants from cars and humans are greatest. Large playing fields, where chemicals and fertilizers are often used to maintain the quality of the playing surface, impact the surrounding environment. Finally, maintenance and repair schedules for trails and other hard surfaces have budgetary and environmental sustainability implications that must be addressed.

Ideally, from an ecological point of view, parks would function simply as open natural habitat areas. However, the best course of action to assure the sustainability of Shoreview parks in the future is to establish management strategies that balance the needs of nature and the needs of park users. Parks cannot be sustained financially without people visiting them; however, parks cannot be sustained if management and use do not consider ecological systems. When park systems are not maintained in a sustainable manner it can lead to the degradation of the environment. When these areas become unbalanced, the privilege of using them for recreation and enjoyment may be lost.

Management techniques vary by purpose for each park. For example, all “ballfield” parks are managed similarly. However, no special management plan exists for any one specific ballfield park, which may result in the undue expenditure of resources. Individual management schemes may be more appropriate if parks are delegated for specific purposes (e.g., sanctioned league ball), or if parks include valuable habitats or lower frequency of use.

The focus of this study was to develop a plan to sustain natural and resilient areas in urban parks that have green appeal and require minimal maintenance. This was done through an inventory assessment and analysis of physical aspects of Shoreview’s park, enabling Shoreview to generate a landscaping plan that enhances the parks’ natural beauty while advocating sustainability. As an example, the uses and conditions of the trails and parking lots were analyzed in an effort to create a management plan that requires minimal maintenance while being environmentally friendly. Based on this issue and others, a plan was developed to make Shoreview’s parks more sustainable so fewer resources are pumped into the system, while maintaining the valued quality of biotic (living) and abiotic (nonliving) infrastructure.

Recommendations were focused on improving and maintaining green infrastructure in such a way that minimizes the impact it has on gray infrastructure and vice versa. To that end, this study advocates the use of native and site-tolerant plants for landscaping needs and promotes newer and better alternatives for impervious surfaces for areas such as trails and parking lots.

Class Vision Statement

"We envision a sustainable Shoreview: a city that balances social equity, economic vitality, and environmental integrity in order to maintain and improve the quality of life for current and future residents. We aim to further enable Shoreview by:

- *Providing relevant tools and information*
- *Encourage an active and aware citizenry*
- *Addressing perceived barriers to action*
- *Fostering responsible and collaborative resource management*

Our project strives to empower sustainable behavior and policy changes that will establish Shoreview as a model for other communities."

Project Vision Statement

"In order to maintain or enhance the aesthetic values and services provided by its environment, the city of Shoreview will promote sustainable development and practices for the preservation, design and maintenance of its natural and constructed surroundings. Developments and practices should promote community well-being while protecting and restoring the natural environment on which people, economies, and ecological systems depend."

Methods

Study Area Description

Ramsey County is located on the eastern side of Minnesota and is the smallest county in the state in terms of its area. The City of Shoreview, a second-ring suburb of the metropolitan area, is located on the northern edge of Ramsey County (figure 2). Shoreview officially became a city on January 1, 1974, through an act of the State Legislature. With a population of over 14,000 at the time, the residents voted to enact the current Council-Manager form of government. From this time and through the 1980s, the City of Shoreview grew very rapidly, only slowing down in the 1990s when less land was available for development. Shoreview is currently home to 26,374 inhabitants as determined by the City of Shoreview.

Figure 1: Location of MN, USA.

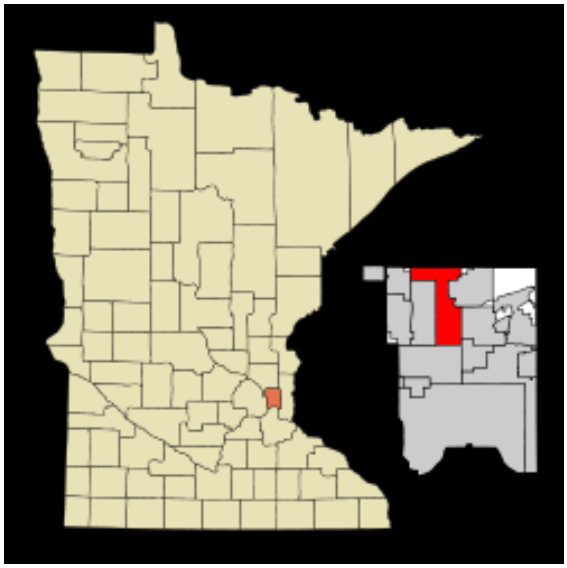


Figure 2: Location of Ramsey County, MN, and the city of Shoreview within Ramsey County.

Acknowledged for its abundance of lakes, wetlands and open spaces, Shoreview is home to various city and county parks, which spark the interests of its residents by providing a beautiful environment to engage in a variety of activities. With 11 lakes and 1,400 acres of park land and open spaces, this city is well equipped to meet the recreational needs of its residents. Shoreview's parks are spread out across the city but the extensive trail system and boulevards throughout the city makes travelling to, from, and among the parks incredibly simple. This study concentrates on Shoreview's city parks and trails.

Methods

Several different methods were used to assess the green (natural vegetation) and gray (infrastructure, e.g., trails, buildings, parking lots) qualities of the parks in Shoreview. Many interviews were conducted to ensure the specific green and gray management needs of Shoreview were identified successfully. Visual evaluations of park resources were completed within three weeks during October for all city parks. Many different secondary sources were used to aid in the understanding of park management techniques.

Park Inventory and Assessment

An assessment survey was completed for all parks in order to achieve a complete understanding of the parks in Shoreview. The majority of the survey was an inventory, including a detailed report of characteristics that are present or absent in each of the parks. The survey examined a variety of factors including forest understory and overstory, trails, parking lots, water bodies, landscaping and plant buffers. An inventory documented park characteristics such as the presence of invasive species and shade, composition and age of forests, width of plant buffers, and distance from trails to plant buffers and waterbodies.

An assessment determined the quality of park attributes. A copy of the survey can be found in (Appendix A). Certain factors not included in the survey were assessed by interpreting data from the inventory. Other attributes used to infer qualitative information included the composition/age of forests, the presence of invasive species, storm water retention ponds and shade on pavement.

Some management practices are better than others at improving or maintaining water quality, preventing soil erosion, and reducing pollutants. By measuring certain attributes, such as the width and location of plant buffers, qualitative measurements from the inventory were inferred based on a sustainable landscaping perspective.

This survey was created in a manner which enabled researchers to compile a consistent evaluation of each of the parks. A total of three people surveyed all the parks. At any one time two people surveyed each park in an effort to reduce bias and error. As a result, two different surveys are available to consult when determining recommendations for each park. To see the survey, refer to Appendix A.

Hot Spots

Certain areas of parks have greater importance than other areas when considering the sustainability of the park system. Recognizing this, a mapping system was formulated to illustrate areas within each park which were deemed to be hot spots, or areas of importance.

Hot spots were identified within the parks and determined by the following ranking system:

- Tier 1- Areas that have great influence on the sustainability of parks.
- Tier 2- Areas that have some influence on the sustainability of parks.

Hot spots were evaluated based on a variety of environmental concerns such as: water quality, soil degradation, soil compaction, plant diversity, and land use conditions (see Appendix E). The purpose of creating these hotspot maps is to give Shoreview officials a guide for directing funding and to show where consideration for future sustainable planning is needed. Given the realities of a limited amount of funding, it is important to recognize where money should be spent to best improve the sustainability of the park system. The maps provide a visual guide to areas deemed to be Tier 1 spots and are color coded to specify the reason that each area is included.

Areas were mapped in terms of importance by set criteria formulated by secondary research reviews (ex. width along roads and parking lots) and by firsthand accounts gained from our park surveys and interviews (ex. forest diversity, areas prone to flooding).

Secondary Source Research

Technical Websites

Pervious surfaces and site-tolerant plant species were researched in order to provide a summary of information to Shoreview decision makers. Pervious surface resources were used to weigh the pros and cons, study differences between pavement options, and identify where in Shoreview's parks pervious concrete would be most beneficial both economically and environmentally. Similarly, the site-tolerant resources were used to find the kinds of plants that would be most successful in Shoreview's community parks.

The Ramsey County website aided in estimating the percentages of green and gray areas in the parks in Shoreview. This website provided a Geographic Information Systems (GIS) program that made this estimation as accurate as possible. The measurement tool was used to find the length of the trails and the areas of the buildings and parking lots. To find the area of the trails, we multiplied the lengths by eight because this was the most common width of the trails in Shoreview.

Management Case Study: (Maplewood Mall and parks)

Maplewood staff engineer, Steven Kummer, was interviewed regarding Maplewood's pervious pavement projects. Maplewood has pervious asphalt parking lots in their public works building as well as one city park, Geranium Park. The Maplewood Nature Center has pervious pavers installed in the parking lot. In order to meet Ramsey-Washington Metro Watershed District (RWMWD) infiltration requirements, a bituminous trail with 3-foot wide pervious paver edger was constructed along McKnight Roadd. Kummer responded to questions regarding to the durability, strength, and environmental benefits of Maplewood's pervious pavement projects.

Management Case Study (Santa Monica, CA: garden/garden comparison)

A report evaluating the differences between traditional and native gardening was examined to gain a better understanding of benefits gained when gardening with native vegetation. In 2003, the City of Santa Monica, CA, began a project called Garden\Garden. It was designed to encourage city residents and the local landscaping community to adopt sustainable garden practices. The city wished to promote practices that would, among other things, conserve water and energy, reduce waste and also decrease urban runoff. This project was designed to advertise the differences in management and maintenance requirements between traditional gardening and gardening with native vegetation. Although this study took place in California, it offers valuable insight to the maintenance needs of both native and traditional gardening and landscaping practices.

Management Case Study (Edgewater Park, Minneapolis)

In 1993, the City of Minneapolis acquired some historic property along the Mississippi River in the northeast portion of the city where the Edgewater Inn used to sit. In order to foster community pride and environmental stewardship, this area was developed into a park that displays active, responsible management practices for valued natural areas. One measure taken was the installation of a low maintenance, handicapped-accessible, permeable surface for the trail system. Walt Dzeitzic, Commissioner of District 1 Minneapolis Parks and Recreation, answered questions to evaluate the success of the permeable surfaces within this park.

Consulted Professionals

Interviews with parks and recreation professionals and decision makers were conducted to begin the research process and gain information on park conditions, management practices, and desired improvements. Most interviews were done over the phone or by e-mail and were informal with no documented questions and responses. Nevertheless, these personal communications were valuable in developing a problem statement and research objectives.

Different city meetings were attended to meet decision makers, learn about community concerns in Shoreview as well as learn about past and current environmental projects Shoreview has accomplished. The company, Bonestroo, was contacted to obtain information on pervious concrete and alternatives to asphalt. Information regarding cost of installation and maintenance techniques of four different types of pervious concrete/asphalt was obtained through this contact. Likewise, Professor Eric Watkins of the Department of Horticulture at the University of Minnesota was contacted regarding drought-tolerant turf grass. He provided information regarding the toughness of the turf grass and made suggestions of different mixtures which would work best in various park settings.

Park and Recreation officials from several neighboring communities (Maplewood, New Brighton, and Vadnais Heights) were contacted. Questions were asked about maintenance protocols that each community practices in their city parks (see

appendix F). Shoreview was contacted with the same list of questions. Responses from the three communities were then reviewed along with the response from Shoreview in order to gain an understanding of how maintenance protocol in Shoreview parks compares to park maintenance protocol in surround communities. The purpose of conducting these interviews was to determine if improvements needed to be made in Shoreview in order to achieve a similar level of sustainability as nearby communities, or if there was an opportunity for Shoreview to take initiative in the region in terms of sustainable park maintenance protocol.

Findings

Green Infrastructure

In order to evaluate the needs of each park, an inventory and assessment was done to examine a variety of park attributes. Observations and assessments were made on a number of different green characteristics within the parks in an effort to understand the quality of park structure and maintenance from a sustainability perspective.

Swales/ Buffer Strips

It was found that a key element was lacking in nearly all the parks, which was the presence of vegetated swales and buffer strips. Vegetated swales are long, narrow landscaped depressions. They are primarily used to convey storm water runoff on the land's surface while also providing water quality treatment. Only one of the parks, Rice Creek, contained a plant buffer surrounding its parking lot. Vegetated swales are different from buffer strips in that they are planted in a depression. Swales allow for more water to be absorbed by the vegetation and infiltrated into the soil than buffer strips since they are planted in a depression. Swales and buffer strips were also lacking along roads and highways. Native plant buffers surrounding water bodies were found to be very common and generally in good condition.

Forest Biodiversity

Biodiversity within the forests of Shoreview city parks was found to be relatively good, with the majority of parks having over seven different species of trees. Seven different tree species were counted at Ponds, Sitzer, and Wilson parks. Rice Creek was found to be the least diverse of all the parks, having only five different tree species were counted.

Invasive Species

The majority of forests within the parks were found to have invasive species. Identified species include buckthorn, garlic mustard and honeysuckle. These three invasive species were evaluated due to their prevalence in Minnesota and ability to outcompete native plant communities. It was found that buckthorn was the most commonly identified invasive plant in Shoreview Parks. McCullough Park had especially high numbers of buckthorn present in its forest, encompassing approximately fifty percent of the forest understory.

Athletic Field Turf

The turf grasses that are used on the athletic playing fields were obtained from the Building and Grounds Superintendent, Gary Chapman, and found to be a blend of four different varieties:

"Athletic Pro II"
25% Abbey Kentucky Bluegrass
25% Guinness Kentucky Bluegrass
25% Quest III Perennial Ryegrass
25% Pennant III Perennial Ryegrass

A number of high quality, low maintenance grasses have been identified (Metropolitan Council Best Management Practice Manual): http://www.metrocouncil.org/environment/Watershed/bmp/CH3_RPPHousLandscape.pdf

Fine leaved fescue varieties:

- Creeping red fescue
- Chewings fescue
- Hard fescue
- Tall fescue

Kentucky blue grass varieties:

- Aquila
- Monopoly
- Park
- Argyle
- Nassau
- Ram I
- Kenblue
- Newport
- Rugby

Plant and use characteristics of common KBG varieties:
Plant characteristics

- Medium to medium-dark green color, medium texture, growth habit rhizomatous but taller and more upright. Will go dormant during hot, dry periods; recovers when moisture supplied.
- Dormancy does have physiological limits that, once exceeded, do not allow recovery.

Use characteristics

- Little to no shade tolerance, lower wear tolerance than improved types More drought-tolerant than many improved types. Lower moisture and fertility requirements than most improved types.
- Example varieties: Park, Kenblue, South Dakota Certified, and "Common."

Plant and use characteristics of improved KBG varieties (examples listed on previous page):
Plant characteristics

- Medium dark to dark green color. Medium to medium coarse texture. Low spreading growth habit. Broad disease tolerance or resistance.
- Vigorous rhizomatous growth giving good stand density.

Use characteristics

- Little to no shade tolerance. Good wear tolerance and recovery potential from injury. Higher maintenance requiring ample water and fertilizer for optimum health. Need for more frequent dethatching.
- Poor soil conditions (i.e., compaction, water-logging) increases vulnerability to various root disease.

Plant and use characteristics of fine-leaved fescues:
Plant characteristics

- Chewings, Hard and Sheep fescues are all bunch-type grasses. Creeping Red is rhizomatous but less so than Kentucky bluegrass. Medium to slow growth rates. Medium to dark green color.
- Fine to very fine in texture.

Use characteristics

- Shade-tolerant. Drought-tolerant. Low moisture and fertility tolerant. Less tolerant of high wear conditions.
- Does not mow well in pure stands, better mixed with bluegrasses.

Plant and use characteristics of turf-type perennial ryegrass:
Plant characteristics

- Bunch-type growth habit.
- Moderate to rapid growth rate, good rooting potential.
- Germinates quickly allowing for rapid establishment, “nurse” crop role.
- Turf-types are medium to medium-fine in texture.
- Medium to dark green color with shiny leaf undersides.
- Can complete excessively in mixed seedings.

Use characteristics

- Performs best in medium to high-maintenance programs.
- Drought tolerance.
- Little to no shade tolerance.
- Can encounter rust problems under low N fertility and normal water.
- Mixes well with improved Kentucky bluegrass varieties.
- Tends to be thin, become clumpy and coarser texture under low maintenance.

Landscaping

Grass vegetation that is used along the roads and boulevards in Shoreview was identified as a “Salt Buster mix”, a mixture of:

25% Salty Alkaligrass
25% Park Kentucky Bluegrass
25% Slender Creeping Red Fescue
25% Fairway Crested Wheatgrass

"Salt Buster" is a seed mixture that has been used on Highway 96 medians and boulevards. The city has used it in some bare spots on the islands at the Community Center. Shoreview is also using a number of ornamental grasses and herbaceous perennials: Karl Forester, Autumn Joy Sedum, May Night Salvia and several varieties of daylilies. This information was obtained from Gary Chapman.

A variety of sustainable landscaping grasses and plants have been identified and divided into two categories: salt-tolerant and drought-tolerant plants:

Common Name	**Scientific Name**
Mancos columbine	*Aquilegia micrantha*
Karl Foerster reed-grass	*Calamagrostis acutifolia*
Helen Allwood pinks	*Dianthus pulminarious*
Little Boy Blue pinks	*Dianthus x*
Common woody aster	*Machaeranthera xylorrhiaz*
Little bluestem	*Schizachyrium scoparium*
Barren strawberry	*Waldsteinina fragarioides*

Figure 3: Herbaceous plants with high salt tolerance.
(Source: Sustainable Urban Landscape Series and St. Croix River Crossing Project.)

Common Name	**Scientific Name**
Clustered Fescue	*Festuca paradoxa*
Stella D'oro Daylily	*Hemerocallis*
Crevice Alumroot	*Heuchera micrantha*
Evening Primrose	*Oenothera caespitosa*
Sedum "Autumn Joy"	*Sedum spectabile*
Parairie Mallow	*Sphaeralcea coccinea*
Soapweed	*Yucca glauca*
Big Bluestem	*Andropogon gerardii*
Indian Grass	*Sorghastrum nutans*

Figure 4: Herbaceous plants with moderate salt tolerance. (Source: Sustainable Urban Landscape Series and St. Croix River Crossing Project.)

Common Name	**Scientific Name**
Quaking Aspen	*Populus tremuloides*
Black Cherry	*Prunus serotina*
Alder	*Alnus incana*
Paper Birch	*Betula papyrifera*

Figure 5: Small trees with moderate salt tolerance. (Source: Sustainable Urban Landscape Series and St. Croix River Crossing Project.)

Common Name	Scientific Name
American Hazelnut	*Corylus Americana*
Chokecherry	*Prunus virginiana*
Gray Dogwood	*Cornus racemosa*
Staghorn Sumac	*Rhus typhina*
Downy Serviceberry	*Amelanchier arborea*
Arrowwood Viburnum	*Viburnum dentatum*
Juneberry	*Amelanchier spp.*
Nannyberry Viburnum	*Viburnum lentago*
Northen Bush Honeysuckle	*Diervilla lonicera*

Figure 6: Shrubs with with moderate salt tolerance. (Source: Sustainable Urban Landscape Series and St. Croix River Crossing Project.)

Common Name	Scientific Name	Exposure
Evergreen Trees and Shrubs		
Common Juniper	Juniperus communis	S
Creeping Juniper	Juniperus horizontalis	S
Eastern Red Cedar	Juniperus virginiana	S
Eastern White Pine	Pinus strobes	S
Jack Pine	Pinus banksiana	S
Red Pine	Pinus resinosa	S
White Spruce	Picea glauca	S/Psh
Herbaceous Perennials		
Aster	*Aster spp.*	S/Psh
Black-eyed Susan	*Rudbeckia hirta*	S
Butterflyweed	*Asclepias tuberose*	S
Wild Blue Indigo	*Baptisia australis*	S/Psh
Gayfeather	*Liatris spp.*	S
Hosta	*Hosta spp.*	Psh/Sh
Little Bluestem	*Schizachryium scoparium*	S
Pasqueflower	*Pulsatilla patens*	S
Primrose	*Oenothera spp.*	S
Red Stonecrop	*Sedum moranense*	S/Psh
Prairie Dropseed	*Sporobolus heterolepsis*	S

* S=Sun; Psh=Part shade; Sh=Full shade

Figure 7: Evergreen trees, shrubs,and herbaceous perennials with drought tolerance. (Source: Sustainable Urban Landscape Series and St. Croix River Crossing Project.)

In 2003, the city of Santa Monica, CA established a project called Garden/Garden which examined the differences between traditional gardening and sustainable/native gardening. Although this project was established in California, it examines the benefits gained when gardening with native plants as opposed to exotic species. Gardening with native plants in Minnesota is expected to produce similar results.

The following practices were used in each of the gardens:
Sustainable Practices in the Native Garden (NG)

- No chemical herbicides or insecticides (per Santa Monica City policy).
- Climate-appropriate native California plant palette, designed to replicate the chaparral of the Santa Monica mountains.
- Low-volume drip irrigation.
- Weather-sensitive irrigation controller .
- Dry creek bed and infiltration pit for capturing storm water runoff and groundwater recharge.
- Wildlife habitat for local and migratory fauna.

Practices in the Traditional Garden (TG)

- No chemical herbicides or insecticides (per Santa Monica City policy) but occasional use of blood meal.
- Exotic plants from Northern Europe and the Eastern United States.
- Standard, user-controlled sprinkler irrigation system.
- No provision for runoff mitigation.

Construction was completed in March 2004. From 2004 to 2008, the city tracked costs, labor hours, plant growth, water consumption, green waste production, and other environmental factors for both gardens. The following outlines the findings made after monitoring (TG= traditional garden, NG= native garden) (A Comparison in Santa Monica):

- Water Use (gallons): Each garden is separately metered. Water consumption was recorded at two-month intervals until November 2004, after which it was recorded monthly.
  TG = 283,981 gallons/year
  NG = 64,396 gallons/year
  Difference = 219,585 gallons/year or 77% less water use for NG
- Green Waste (pounds):
  TG =647.5 pounds/year
  NG = 219.0 pounds/year
  Difference = 428.5 pounds/year or 66% less waste produced from NG
- Maintenance Labor (US dollars):
  TG = $223.22/year
  NG = $ 70.44/year
  Difference = $152.78 dollars/year or 68% less spent on labor for the maintenance required for NG

Park Maintenance Protocol

Shoreview park maintenance was found to have protocol fairly consistent with the park protocol of neighboring communities (Maplewood, New Brighton, and Vadnais Heights). However, some notable differences were found in the other communities.

New Brighton mows only one time per week for all areas unless flooded. Maplewood has a mowing schedule that varies from park to park, and is influenced by droughts. Shoreview mows all athletic fields twice per week, and all other turf areas once per week.

Playing fields received more maintenance (mowing, irrigation, fertilizer, and pesticide) across all contacted communities. This is due to the fact that despite being subjected to more stress than nonplaying area turf, there is a need for the turf in these areas to look and perform just as well as the turf that receives less stress.

Management of flood-prone areas was an important factor. Shoreview has no protocol that specifies what is to be done with flooded or saturated areas on playing fields. Maplewood is considering installing a tile system in one park that is particularly prone to flooding. All communities have park areas that are prone to flooding and are maintained on a regular basis. The consensus among the three communities was that areas are simply left alone until flooding subsides. Vadnais Heights utilizes small equipment (hand mowers and weed whips) in flooded areas.

Vegetative buffer strips surrounding bodies of water within city parks is an area in which Shoreview fairs well compared to the other communities contacted. We found all bodies of water within in Shoreview parks to have a buffer of adequate width and quality. Maplewood is currently evaluating their bodies of water before implementing buffer strips throughout the city. New Brighton has buffer strips, but only at an average width of 2-3 feet.

Gray Infrastructure

Findings on gray infrastructure were attained through inventory, assessment, and research through various websites and secondary sources such as case studies, technical websites, and consulted professionals. They were directed toward finding sustainable solutions in Shoreview's city parks.

Trails

The total square foot area of trails in Shoreview parks was attained from Shoreview officials (see Appendix D). Of these parks, Rice Creek Fields, McCullough, and Bucher contain the largest area of asphalt trails, whereas Ponds and Sitzer contain the lowest square foot area of asphalt trail. An inventory of the percent gray cover was made at all Shoreview's city parks (see Appendix F). Percent cover of gray infrastructure was highest in Rice Creek Fields and Shoreview Commons; lowest percent cover of gray is in Lake Judy, Ponds, and McCullough. An assessment was made of the quality and shading on trails. The overall conditions of the trails range from average to good. These observations were made based on cracking, bumps, and overall uniformity. Overall, there is very little shading on trails in the Shoreview's parks.

It was found through research that there is a direct relationship between Pavement Condition Index (PCI) and Tree Shade Index (TSI) indicating that increased tree canopy cover along trails will enhance the lifetime and quality of the asphalt trails (McPherson and Muchnick 2005). Shallow rooted trees planted too close to concrete or asphalt can crack or cause irregular surfaces. Therefore, planting trees with deep roots and about 10 feet away from surface cover is a key aspect in trail design. Trees with large canopy cover and will also enhance quality and decrease maintenance on the trail. According to Shoreview parks manager, the asphalt trails need to be resealed about every 5-6 years. Shoreview does not use de-icing salt on asphalt park trails but snow plowing is used for snow removal.

Parking Lots

Shade for parking lots in city parks was assessed, as was the presence of storm water retention ponds. It was found that there is generally a low degree of shading in parking lots. Two parks, Sitzer and Rice Creek Field, do not contain a storm water retention pond. Snow removal techniques for parking lots in Shoreview parks include de-icing salt as well as snow plowing.

There are many benefits of tree canopy cover on parking lots, such as storm water management, air quality, and decreasing heat island effect. Tree cover facilitates in storm water management by slowing, absorbing, and filtering rainwater. Their leaf surfaces intercept rainwater and root systems essentially “drink” water from the ground, thereby allowing more water to infiltrate into the soil. Trees also act as natural filters to remove air pollutants such as ozone, nitrogen oxides, sulfur dioxides, and ammonia. The aesthetic value is a significant factor to recognize, especially in a park setting as it appeals to the general public.

Pervious Pavement

Impervious pavements, particularly parking lots, channel automobile fluids, salt, and various other particles as runoff into the nearest water source. This runoff pollutes water and damages surrounding plants that are not tolerant of these chemicals. In contrast, pervious pavement allows water and contained particles to percolate into the soil. This allows for microorganisms to break down and process certain pollutants that would otherwise be contaminating water sources. Two studies conducted on the long-term pollutant removal in pervious pavements suggest high pollutant removal rates. The results of these studies are below:

The light color of pervious pavement absorbs less heat from solar radiation than darker pavements, and the porous property allows for less heat storage, effectively reducing heat island effects in urban areas. Trees planted along pavements also play a role in reducing the heat island effect. Pervious pavements provide a more ideal environment for successful tree growth by allowing air and water to enter the soil.

Study Location	Total Suspended Solids (TSS)	Total Phosphorus (TP)	Total Nitrogen (TN)	Chemical Oxygen	Metals
Prince William, VA	82	65	80	—	—
Rockville, MD	95	65	85	82	98-99

Figure 8: Effectiveness of porous pavement pollutant emoval,* % by mass. (Source: http://www.pervious pavement.org/benefits,%20environmental.htm)

The cost and maintenance of four different types of pervious pavement was attained from Bonestroo Inc. (see appendix). The cost of pervious pavement installation ranges from $8-12 per square foot. This is much higher than the cost of regular asphalt at $19 per square yard and an additional $10 per square yard if a gravel base is needed. To reseal asphalt costs $2.50 per square yard. Costs for installation of impervious asphalt were received from Tom Wesolowski of Shoreview. Therefore, identifying areas that would benefit the most environmentally and economically is important. It has been noted through research that areas of high runoff are most benefited by pervious pavement. Parking lots have been noted in research findings as areas of high runoff and therefore hot spots for pervious pavement.

Due to their porous nature, pervious pavements eliminate the need for de-icing salt and sand, however, plowing may still be necessary in times of heavy snowfall. Sweeping pervious pavements is necessary to prevent clogging and breakdown of aggregates. This should be done a few times during autumn when fallen leaves are present and once in the spring and summer.

The durability of pervious pavement has been researched, and results show that overall it is less durable than impervious pavement and cannot sustain high levels of traffic. Neighboring city, Maplewood has successful pervious pavement structure in the parking lots of the public works building and Geranium Park. Both lots were constructed in 2007, and it was noted by Maplewood staff engineer that the structural stability of the parking lots is not an issue and runoff has reduced by at least 25% with pervious lots. The parking lot of the Public Works Building has shown significant unraveling on the upper surface of the lot mostly in areas of heavy use. Staff engineer, Steve Kummer, believes that it is due to failing shear strength in the asphalt pavement itself and not a subgrade failure. Kummer mentioned that if they were to re-do the projects, they would only construct a partial pervious lot to avoid unraveling or popping out of aggregate particles. Maplewood is known as a leader in storm water pollution prevention and is a good example for what Shoreview can do to reduce runoff and keep waters clean.

There are many factors that play into the design of pervious pavement. One major player is soil type, the ultimate support layer beneath the slab. Special precautions need to be made for clay and soils of high expandability. These precautions add to the financial investment necessary for use of pervious pavement. However, it is still

possible to implement pervious pavement successfully under these precautionary conditions. The modulus of subgrade reaction (k) is used as primary input for pavement design. It estimates the support of the layers beneath the pavement. It is suggested that k-values not exceed 200 pounds per cubic inch and it is generally suitable for k-values between 150-175 pounds per cubic inch. The chart below indicates soil types and their corresponding k-values.

Type of Soil	Support	*k* Values psi/in^3 (MPa/m)	CBR	R-Value
Fine-grained soils in which silt and clay-size particles predominate	Low	75 to 120 (20 to 34)	2.5 to 3.5	10 to 22
Sands and sand-gravel mixtures with moderate amounts of sand and clay	Medium	130 to 170 (35 to 49)	4.5 to 7.5	29 to 41
Sands and sand-gravel mixtures relatively free of plastic fines	High	180 to 220 (50 to 60)	8.5 to 12	45 to 52

Figure 9: Subgrade soil types and range of approximate *k* values. (Source: http://www.perviouspavement.org/structural%20design.htm)

As shown above, a soil type dominated by sand/ sand-gravel with moderate amounts of sand and clay are best suited for using pervious pavement without added precautions. It is known through research that soils of gravels and sand have much faster infiltration rates than loamy and clay based soils.

A soils map of Shoreview parks was examined to identify areas of high potential for pervious pavements (Appendix C). Those areas of high infiltration rates and corresponding sandy-based soils were identified in the following parks: Sitzer Park, Bucher Park, Shamrock Park, and Rice Creek Fields. Those areas of high runoff were identified in the following parks: McCullough, Bucher, Commons, Bobby Theisen, and Lake Judy.

Recommendations

Green Infrastructure

- Plant vegetated swales of native perennial plants around parking lots.
- Use sustainable landscaping practices.
- Use sustainable turf grasses and maintenance practices on playing fields.
- Manage invasive species to promote native biodiversity.
- Establish park specific maintenance protocol.

Vegetated Swales

Planting vegetated swales of native perennial plants around parking lots has many benefits. Not only does it enhance the physical beauty of the park, but it provides the environment with functional advantages too. Vegetation is an effective and attractive way to reduce the amount of runoff entering storm water drainage systems. The vegetation itself can catch and store large amounts of water which are later evaporated back into the atmosphere. A significant amount of storm water can be evaporated from tall grasses, wildflowers, shrubs and trees. Deep rooted prairie plants are especially effective at creating channels in the soil which increase infiltration rates. Shallow rooted turf grasses are not as effective and should be substituted for deep rooted native plants whenever possible.

Vegetated swales will work as an on lot infiltration system and are very similar to rain gardens. As water flows through a vegetated swale, it is slowed by the interaction with plants and soil, allowing sediments and associated pollutants to settle out. Some water soaks into the soil and is taken up by plants, and some may infiltrate further if native soils are well drained. Vegetated swales are relatively low-cost, simple to construct, and widely accepted as a storm water management strategy. Vegetated swales can be planted in a variety of ways ranging from mown grass to a diverse palate of grasses, sedges, rushes, shrubs, groundcovers and trees. They are typically built very shallow and contain runoff that is only a few inches deep.

By using a combination of salt and drought-tolerant plants, maintenance costs can be decreased while increasing functionality on the landscape. Use of salt-tolerant plants in areas that are near surfaces receiving salt treatments in the winter will reduce re-vegetation costs due to winter kill from salt. Drought-tolerant plants will decrease the need for irrigation during dry periods and will help save on maintenance costs. Vegetation for planting at the bottom of the depression should be tolerant of various water conditions. See plant lists in “findings” section. For more information on vegetated swales and how to design them, see “Best Management Practice Fact Sheet: Vegetated Swale” at:
http://www.dauphincd.org/swm/BMPfactsheets/Grassed%20Swale%20fact%20sheet.pdf
And also, “Stormwater Facility Strategy: Vegetated Swales” at:
http://www.flowstobay.org/documents/municipalities/sustainable%20streets/Ch%202/pg%2036-39%20Ch2%20.pdf

Advantages:

- Grasses, wildflowers, shrubs and trees catch water that is later evaporated, reducing runoff from storm water.
- Pollutants entering storm water ponds are reduced, improving water quality.
- Channels created by deep roots encourage infiltration.
- Wildlife habitat is created when planting with native vegetation.
- A variety of vegetation creates a more interesting and aesthetically pleasing landscape.

- Trees shade impervious surfaces, increasing the life of asphalt and keeping storm water cool, decreasing the urban heat island effect.
- Maintenance costs can be decreased by using salt and drought-tolerant plants.

Design:
- If soils are unsuitable, excavate to a depth of three feet and fill with a planting soil mix that is well drained and has an organic matter content of three to five percent.
- Plant vegetation in a depression six to eight inches deep and to a width of at least eight feet for efficient storm water management.
- Plant native, deep-rooted perennials over turf grasses whenever possible, especially surrounding parking lots and other impervious surfaces.
- Use plants that are both salt and drought-tolerant, or a combination of both to decrease maintenance costs.

Sustainable Landscaping

Sustainable landscaping works to establish healthy, more tolerant landscapes while reducing the need for intensive management. Many landscaping designs and maintenance practices can negatively impact runoff quantity and water quality. The incorrect application of fertilizers can increase nitrogen and phosphorus entering a water body, leading to increased algal growth. Pesticides and herbicides have been shown to contribute significantly to the impairment of water quality in streams, lakes and wetlands.

A naturally diverse landscape helps to reduce or eliminate the need for chemical inputs by discouraging outbreaks of disease and insects. By using plants that are adapted to the local soil conditions, (especially deep-rooted native varieties) it is possible to eliminate or significantly reduce the need for fertilizer, herbicides and pesticides. Deep rooted plants can take up and utilize nutrients at various levels in the soil while encouraging infiltration and preventing soil erosion. Native plants are adapted to the nutrient levels and chemistry of local soils, thus reducing the need for chemical inputs. In addition to improving water quality, using sustainable landscaping techniques can reduce time and money spent on maintenance, and provides aesthetic pleasure.

Trees are also an important component of sustainable landscaping. They offer many benefits such as carbon sequestration, improvement of air quality, pollution removal, soil erosion control, rainfall interception, and the facilitation of storm water infiltration and treatment. Large, mature trees provide the most benefit to ameliorating air pollution. By planting trees with a high relative leaf area and large canopy, the maximum amount of carbon sequestration and pollution removal can be attained. Trees in Minneapolis were found to be roughly four times more effective at removing air pollution on an individual basis as compared to shrubs. Trees can also be very effective at managing storm water. They intercept rainfall which can later be evaporated. Runoff water is drawn up through the roots and transpired through the leaves into the atmosphere, reducing the amount of storm water entering water

treatment facilities. By planting a variety of tree species, the risk of disease can be reduced and air and water quality can be improved while increasing biodiversity and offering natural beauty to the landscape.

Advantages:
- Native vegetation is aesthetically pleasing and often provides wildlife habitat.
- By using deep-rooted native vegetation, the needs for chemical inputs are reduced, thus reducing maintenance costs.
- Water quality and soil erosion can be improved by using native plants with deep roots.
- By using drought or site-tolerant plant species, maintenance costs can be reduced by reducing the need or frequency of irrigation or fertilization.
- Mature trees contribute to air and water quality improvements.

Design:
- Select plants that are best adapted for a specific site based on amount of sunlight, moisture availability, and soil type. This will reduce or eliminate the need for chemicals.
- Reduce or eliminate mown lawn areas which are not used for active recreation.
- For lawns, plant high quality, low maintenance varieties.
- Use salt-tolerant plant varieties near surfaces receiving salt treatments.
- Use drought-tolerant plants to minimize the need for irrigation.
- Plant a variety of tree species to reduce the risk of disease.
- Select trees that are native to the area to promote long lived mature trees.

Lawn Maintenance:
- Leave grass clippings on the lawn to retain moisture and provide nutrients to the soil. Sweep grass clipping off trails and pavement.
- Encourage deep rooting by watering seldom but thoroughly. Most grass only needs one inch of water per week, or a one inch sprinkling during a week without rainfall.
- Consider using creeping red fescue when seeding a lawn. It is an attractive, fine textured grass that requires minimal mowing.

Herbicide and Pesticide Management:
- Use slow release organic fertilizer when needed.
- Use pesticide alternatives such as insecticidal soap or natural bacteria.
- Utilize an integrated pest management program which balances natural mechanisms on a given site. This may mean ignoring less harmful pests and encouraging pests' natural predators.
- Use mulch around shrubs and gardens to discourage weed growth.

Sustainable Playing Fields

By using high quality and low maintenance grasses on playing fields, costs can be minimized by reducing the need for irrigation, mowing and chemical treatments. In

an interview with Professor Watkins, Department of Horticultural Science at the University of Minnesota, a mixture of tall fescue and Kentucky bluegrass was recommended. This combination is shade and drought-tolerant and does well under low moisture conditions. Its wear tolerance is lower than the currently used rye grass/Kentucky blue grass combination, but requires much less maintenance. Perennial rye grass tends to be thin, coarse and clumpy under low maintenance regimes. An evaluation of the use of playing fields should be done to determine which fields receive low, moderate and high use. Switching to a mixture of tall fescue and Kentucky bluegrass in playing fields that receive low to moderate use is recommended to reduce maintenance costs.

The key to establishing and maintaining sustainable turf grasses is reducing turf stress. Turf experiences stress from heat, drought, wetness, compaction, nutrient deficiencies or imbalances, and disease and pest infestations. To minimize stress on turf, a healthy soil environment, a diversity of species, low or stress free maintenance practices, an understanding of the local soil and climate conditions, and the use of biological pest controls should be established and maintained.

Advantages:
- Reduce maintenance costs
- Reduce stress on turf
- Reduce the need for chemical inputs
- Build better resistance against pests and diseases

Design:
- Use a mixture of grass varieties to utilize benefits from diverse turf. A single species is highly susceptible to becoming weedy and requires more nutrients and water than turf composed of multiple species.
- Mow to a height of two and a half to three inches and keep mower blades sharp to stimulate healthy turf growth, control weeds, and reduce the potential for diseases.
- Water infrequently, but to the depth of root penetration to stimulate healthy root growth, minimize turf stress, and reduce environmental conditions that favor root disease.
- Using high-quality mature compost instead of fertilizer provides turf plants with a balanced, slow-release of nutrients. It can be tilled into the soil or applied as a top-dressing.
- Applying compost every thirty days can provide effective control of some root pathogens and reduce weed infestation. It can suppress some soil borne fungal diseases as well as conventional fungicides. Compost can be applied as a liquid solution (compost tea) prepared by steeping high quality compost in water. For more information on compost tea and how to make it, see the Growing Solutions Inc. website at: http://www.growingsolutions.com/?gclid=CNGn7p36uJ4CFQsMDQodyEwelg

Vegetation Management

Managing invasive species can be a difficult task but is crucial for maintaining the health of any forest. Invasive species can contribute a number of negative environmental hazards such as disrupting ecosystem processes (natural succession and pollination for instance), changing hydrologic cycles and soil chemistry, contributing to soil erosion and outcompeting native plant communities. Invasive species are considered one of the biggest threats to global biodiversity, second only to habitat destruction. Maintaining a diverse natural landscape is important because it provides a multitude of services for everyone. A diverse plant community increases the health of a forest by providing the ecosystem with protection through genetic variation. The more genetically diverse a habitat is, the less likely it is to become vulnerable to diseases and die out. Genetic variation is important for human populations because it is a key contributor for much pharmaceutical, biotechnological, and agricultural advancement.

By reducing the abundance of invasive species in the forests of Shoreview's Parks, the natural beauty and functionality of this habitat can be improved. There are a variety of methods that can be used to address this issue. Manually removing invasive and unwanted plants by pulling, mowing or applying herbicides has been shown to be effective, but can be labor-intensive and costly. Removing invasive species can take a lot of time and effort, but can be very beneficial for human and natural communities. With patience and persistence, the quality of forests within Shoreview parks can be improved and sustained.

Advantages:

- Protection of water resources and soils.
- Nutrient storage and cycling.
- Pollution breakdown and absorption.
- Medicinal resources and pharmaceutical drugs.
- Future resources.
- Diversity in genes, species and ecosystems.

Design:

- Recruit the community to assist with the removal of invasives. Schools and boy/girl scout troops are frequently looking for activities to engage children and teens.
- Start with areas that the public visits more often in an effort to spark an interest and gain more public support and assistance. Commons Park has been identified as a high traffic area which is in need of invasive species control.
- Place signage in areas which are being managed or planning to be managed in order to educate the public on your efforts and to gain support and assistance.
- Use herbicides in limited quantities and only in areas which are highly infested or difficult to remove as they can harm organisms and kill native plants.
- Use prescribed burning techniques where possible, this method has been shown to be very effective, but can be dangerous in residential communities.

Park Specific Maintenance Protocol

Acknowledging that each individual city park within Shoreview has unique characteristics, it follows that each city park within Shoreview should receive different maintenance in order to keep it functioning to meet its purpose. It is both economically inefficient and damaging to the environment to have a singular maintenance protocol for the entire park system. The primary reasons for establishing park-specific maintenance protocols are twofold. First, it should improve efficiency of maintenance, and in turn save the city money. If it is determined that a park is not being used very often, it is recommended to reduce the maintenance costs put into that park. For instance mowing less often, eliminating mowing in some areas of the park, clearing the trails less often. The second reason is that it should decrease the negative effect that maintenance of the parks has on the environment. Unnecessary mowing wastes gasoline and can compact and erode soil, while fertilizer and pesticides applied at levels beyond the necessary amount degrade water quality. It is also important to consider travel time for each of these two factors. Though travel times and associated costs vary, unnecessarily frequent visits inevitably raise travel expenses and increase the potential for environmental damage, thereby wasting city resources.

Two steps need to be taken before effective park-specific maintenance protocols can be established. First, data from the Park Users group on trends in type of uses and amount of use for specific parks should be reviewed. Shoreview parks are designed to accommodate the recreational needs of citizens of Shoreview and neighboring communities. Given the large number of Ramsey County parks in Shoreview that serve as places for passive recreation, Shoreview city parks are given the charge of providing places for active recreation. However, understanding exactly how the parks are used and how often they are used are important criteria to determine how Shoreview can best maintain the quality of the parks. Shoreview management personnel should be able to identify parks that are rarely used or used for only very specific purposes (refer to Park Users Study).

The second step that needs to be taken is to establish which parks, and even more specifically, which areas within specific parks are particularly sensitive. Refer to the hotspots maps, and soil infiltration capacity map to determine areas where maintenance practices will need to be reformed.

As an example of combining the two sets of data to establish specific protocol, consider the small baseball field in Commons Park north of the pond. The baseball field is used exclusively by young children. Its outfield commonly has areas of standing water due to the close proximity to the pond and the poorly drained soil on which it sits. The city-wide protocol calls for this area to be mowed twice a week. We highly recommend at the very least limiting the amount of mowing in this area. The fact that it is used by very young children should be reason enough to reduce the need for mowing, but the physical condition of the land also favors reducing maintenance.

Similar reasoning should be applied to all areas. Factors to consider when establishing differences in parks are: park uses (i.e., sports, picnics, walking, playground use), park popularity (i.e., number of people using the park), temporal (i.e., times of day, or times of year that certain parks or areas of parks are used), soil type, and proximity to important bodies of water.

Specific recommendations:

- Change mowing of playing fields schedule from twice per week to once per week for all parks.
- Removal, relocation, or at minimum reduced maintenance of the baseball field north of the pond in Commons Park. The outfield is commonly flooded due to poorly drained soils and proximity to the pond. It is recommended to allow this area to be converted to natural vegetation.
- Incorporate land from above recommendation with the flooded area northwest of the pond in Commons Park to create a showcase miniature wetland ecosystem. Having land suited to this habitat in the most commonly used park in the city is a great way to educate citizens. Plant a mix of showy and nonshowy native water-tolerant shrubs, forbs, and grasses. Possible species include red-osier dogwood (*Cornus stolonifera)*, buttonbush (*Cephalanthis occidentalis*), blue flag iris (*Iris versicolor*), joe-pye weed (*Eupatorium maculatum*), sedges (*Carex spp.*), bulrush (*Scirpus spp.*), and jewelweed (*Impatiens capensis*).
- Greatly reduce maintenance of Ponds Park, or eliminate maintenance there altogether either by transferring responsibility to nearby residents, or closing the park and restoring the space to a natural area. Further details can be found in the Gray Recommendations section.
- Utilize area north of the parking lot in Shamrock Park. In association with parking lot reconstruction, create a holding pond in this area to allow for infiltration of runoff water from the parking lot.
- Develop management plan to address sudden loss of oak tree stand in Shamrock Park. This area has been noted as a signature area in the park and is the only area that provides valuable shade. However, it is susceptible to sudden loss given that the stand is made of only one species, and all of approximately similar age.

Gray Infrastructure

Construct partial pervious asphalt parking lots and simultaneously plant trees along perimeter of each partial pervious lot, however give priority to the following parks: (parks are listed in order of importance)

- Rice Creek Fields
- Commons
- Sitzer
- Shamrock
- Bucher
- Bobby Theisen.

Remove forested asphalt trails and replace with crushed limestone in the following parks: (parks are listed in order of importance)

- Rice Creek Fields
- McCullough
- Wilson
- Lake Judy

Plant trees along trails in all parks, however, give priority to the following: (parks are listed in order of importance)

- Bucher
- Bobby Theisen
- Shamrock

Survey and evaluate use of Ponds Park. Turn maintenance of Ponds Park over to residents in the area. Supply equipment for maintenance.

Discussion

Gray recommendations were made through careful analysis of findings to implement sustainable practices into the maintenance of Shoreview's gray infrastructure in city parks while keeping in mind budgetary constraints. The recommendations are listed in order of importance for both efficient management and environmental benefits.

Pervious pavement parking lots will show significant improvements in storm water management and is, therefore, the most important when considering these recommendations. The most desirable approach to using pervious pavement is to combine this strategy with landscape-based storm water management whenever possible. Therefore, we recommend constructing partial pervious pavement lots as well as planting trees with large canopy cover along the perimeter of the lots. However, priority should be given to the following parks: Rice Creek, Commons, Bucher, Bobby Theisen, Shamrock, and Sitzer. Pervious asphalt is the least expensive of the four types of pervious pavements examined and analyzed. Rice Creek Fields is ranked high on the list for a pervious parking lot because of its high percent gray cover, high runoff potential, and lack of storm water retention pond.

It is important to note that these parks were analyzed for pervious pavement based on the infiltration rates of the soils, which can be associated with the type of soils as well as the percent gray cover. Commons is an important park to implement a pervious parking lot as it is in the center of the city and has a relatively high percent gray cover. Its location, being near the library, City Hall, and community center, gives it the opportunity to educate the public on pervious pavement and its environmental benefits. Bucher, Bobby Theisen, Shamrock, and Sitzer are equally important in terms of implementation of pervious pavement in parking lots.

However, to further analyze the need for pervious pavement, a water quality test should be done for the remaining parks water retention ponds. A soil analysis should

be made of the subsurface material before implementation of any pervious pavement projects to ensure lasting quality. Those subsurfaces with sandier soils will cost less than soils with high clay content and expandability properties. This will reduce runoff significantly in each park, reducing water pollutants and flooding.

Planting trees along the asphalt trails is recommended in all trails but priority should be given to Bucher, Shamrock, Bobby Theisen, and Lake Judy. There is very little shade on the trails in Bucher and Bobby Theisen, therefore these parks should be given priority in this regard. Planting trees along the asphalt trails will provide shade enhancing the quality of the trail by reducing cracking and the need to be re-sealed as frequently. Trees will play a role in reducing flooding or puddling on the ball fields as well as improving air quality, increasing carbon storage, and improving infiltration. It is recommended to plant trees with large canopy cover, deep rooting systems, and those that are generally long-lived. Tree species biodiversity is also an important aspect of planting urban trees to avoid disease and further enhance the natural resource services. Trees should be planted about 10 feet from asphalt trails to avoid surface disturbance. It is recommended under Bonestroo inc. best management practices for city trees that at least 50% of street, sidewalks, and parking lots be shaded within 15 years of development.

We recommend removing asphalt trails in only the forested areas of Rice Creek, Wilson, and McCullough due to their large area of total asphalt trails. Replacing the asphalt with crushed limestone will enhance infiltration and decrease maintenance in the long term of Shoreview park trails. Rice Creek in particular has a high percent cover of gray infrastructure, creating an environment of high runoff. Removing asphalt trails can be done at the time when they are due for maintenance. If built properly, crushed stone trails can meet the Americans with Disabilities Act (ADA) Accessibility Guidelines. Bikers and walkers will still be able to enjoy these trails most of the year due to the highly compactable nature and formation of hard, smooth surfacing from crushed stone. Overall trail grade averages of less than 6% and laid to a depth of 4-5 inches will provide the most user friendly experience and offer the most sustainable natural trail surface if crushed stone, such as limestone, are to be used. With proper sub-grade preparation and drainage, the crushed stone trail should remain stable for many years in all weather conditions. An 8-foot wide contractor-built crusher fine trail in Denver area costs around 4-5$ per foot. It was found through the parks user survey (given by other park group) that nobody who had taken the survey uses the trails for rollerblading; therefore, this will likely not infringe residents' leisure activities. The asphalt trails leading to buildings, parking lots, and ball fields will remain for the purposes of heavy use and its impacts, therefore, only trails in forested or open space areas are recommended for removal. A downside to this is in the winter, complete snow removal will not be possible therefore residents wishing to walk along trails in winter will have to be prepared for walking through some snow. Setting a snow-blower intake deck to one inch off the pavement will allow Shoreview to safely clear most of the snow from trails. Clearing fallen branches and any graffiti along the trails will still need to be done, however, overall

maintenance will be reduced. In the long term, this will provide for a more natural and sustainable environment.

The recommendation for Ponds Park is based on the location and usage of the park in comparison to the maintenance, cost, and detrimental effects to the natural environment. This park is very difficult to find, as the sign is not visible when driving on Sherwood Drive. Ponds Park is designed so that only the surrounding houses utilize this park. It is located in the backyards of about 10 residents therefore its availability and accessibility is low to others residents not directly connected to it. The playground and small field attract mainly small children. Therefore, if nearby residents do not have small children the likelihood of them using this park is low. Hence, it is recommended that Shoreview give this park up to the residents who share a backyard with the park. If these residents would like to keep the park in its current condition, then it is recommended that they accept responsibility for its upkeep including mowing the lawn, shoveling or plowing the trails, and maintaining the playground. The city can achieve this by providing all necessary equipment, on-site training for maintenance, and respond to any questions or issues the residents may encounter. If residents opt out of maintaining the park, it is recommended to remove the asphalt trails on the next scheduled repair date, plant more trees and native plants, and allow the playground to stay until it wears and needs to be removed. In this regard, the park will still provide aesthetic value for nearby residents.

Conclusion

Sustaining parks and natural areas in Shoreview not only improves the quality of life for current inhabitants, but also creates mass appeal to green-minded individuals and may attract new residents to the city. Synergistic recommendations, stated above, all aim to increase the sustainability of gray and green infrastructure based on relevant scientific literature, interviews with community leaders, and data gathered by the research team.

Sustainability, in the context of parks and natural areas, speaks to the management protocol under which each park is maintained. Lowering the impact of gray on green infrastructure is vital to long-term goals for Shoreview park managers. Likewise, treating identified problems with green infrastructure can lower total maintenance costs by making vegetation more resistant to stress from dynamic park conditions. Amending maintenance protocol to lower the total costs associated with park maintenance, reducing pollution runoff with strategically placed pervious pavement, and planting site-suited vegetation are viable ways for Shoreview to move towards a green and sustainable future.

References

Beckerman, J. 2006. Salt Damage on Plants. *Yard and Garden Line News* January.

Bellows, B. 2003. Sustainable Turf Care. *Appropriate Technology Transfer for Rural Areas*. November 2009 http://www.washoeet.dri.edu/docs/Turfcare.pdf.

Boone, T. 2004. Trail Design and Contstruction. *Nation Trails Training Program*. December 2009 http://www.americantrails.org/resources/trailbuilding/ArtCrushedStone.html.

Chapman, G. 2005. *Information on Current Grass Usage Will Clausen*. October 2009.

City of Shoreview. 2005. Needs Assessment and Improvement Recommendations: Shoreview Parks.

Dauphin County Conservation District. Best Managementment Practices Fact Sheet: Vegetative Swale. December 2009 http://www.dauphincd.org/swm/BMPfactsheets/Grassed%20Swale%20fact%20sheet.pdf.

Grabosky, J., and E. Gilman. 2004. Measurement and prediction of tree growth reduction from tree planting space design in established parking lots. *Journal of Arboriculture* 30(3):154-164.

Growing Solutions, Incorporated . Compost Tea Systems from Growing Solutions. December 2009 http://www.growingsolutions.com/?gclid=CNGn7p36uJ4CFQsMDQodyEwelg.

McPherson, E.G. 2001. Sacramento's Parking Lot Shading Ordinance: Environmental and economic costs of compliance. *Landscape and Urban Planning* 57:105-123.

McPherson, E.G., and J. Muchnick. 2005. Effects of street tree shade on asphalt concrete pavement performance. *Journal of Arboriculture* 31(6):303-310.

Metropolitan Council. 2009.Urban Small Sites Best Management Practice Manual. Metropolitan Council. November 2009 http://www.metrocouncil.org/environment/Watershed/bmp/manual.htm.

Minneapolis Park and Recreation Board. Edgewater Park. December 2009.

Minnesota Department of Transportation, Wisconsin Department of Transportation. 2007. St. Croix River Crossing Project. *Fill Visual Quality Manual*. November 2009 http://www.dot.state.mn.us/metro/projects/stcroix/pdfs/visqman/Chapter%202.pdf

National Ready Mixed Concrete Association. 2009. National Ready Mixed Contrete Association. September 2009 http://www.perviouspavement.org/benefits.htm.

Passeport, E., et al. 2009. Field study of the ability of two grassed bioretention cells to reduce storm-water runoff pollution. *Journal of Irrigation and Drainage Engineering* (2009):505-510.

Ramsey County. GIS Database. November 2009. http://maps.metro-inet.us/RamseyCoGIS/CXviewer.htm.

Randrup, T.B., E.G. McPherson, and L.R. Costello.2001. A review of tree root conflicts with sidewalks, curbs, and roads. *Urban Ecosystems* 5:209-225.

San Meteo Countywide Water Pollution Prevention Program. 2009. *Sustainable Streets Guidebook*. December 2009 http://www.flowstobay.org/ms_sustainable_guidebook.php.
Scott, K.I., J.R. Simpson, and E.G. McPherson. 1999. Effects of tree cover on parking lot microclimate and vehicle emissions. *Journal of Arboriculture* 25(3):129-142.
Stormwater Facility Strategy: Vegetated Swales. *San Mateo County Sustainable Green Streets and Parking Lots Guidebook.* December 2009 http://www.flowstobay.org/documents/municipalities/sustainable%20streets/Ch%202/pg%2036-39%20Ch2%20.pdf.
Sustainable Sites Initiative. 2008. *garden\garden: A Comparison in Santa Monica*. December 2009 http://www.sustainablesites.org/cases/show.php?id=1.
University of Michigan. Threats to Global Biodiversity. December 2009 http://www.globalchange.umich.edu/globalchange2/current/lectures/biodiversity/biodiversity.html.
University of Minnesota. 2006. *Cool Season Grass Selection*. December 2009 http://www.sustland.umn.edu/maint/coolseas.htm.
University of Minnesota. 2009. *Drought-Tolerant Plants*. November 2009 http://www.arboretum.umn.edu/droughttolerantplants.aspx.
University of Minnesota. 2006. *Nutrition, Soils, Fertilizers and Compost.* September 2009 http://www.sustland.umn.edu/maint/nutrition.html.
University of Minnesota. *Sustainable Urban Landscape Information Series*. Regents of the University of Minnesota. September 2009 http://www.sustland.umn.edu.

Appendix A: Park Survey

Park name:

Date:

Forest Assessment-

Overstory:

Number of tree species counted:

1-2 3-5 5-7 7+

Age of Forest:

Young Adult Old

Percent Dead Wood:

0-5 5-10 11-20 21+

Understory:

Presence of invasive species (buckthorn, garlic mustard, honeysuckle, etc.):

Yes No

If yes, rough percent abundance:

Presence of Poison Ivy, Poison Oak:

Yes No

Thickness of understory:

Thin Average Think

Trail Assessment-

Physical condition of trail:

Poor Average Good

Shade on trail:

Low Medium High

Proximity to body of water:

Near Far

If part of trail is near, how much:

Distance between trail edge and vegetation (feet):

0-1 1-2 2-3 3-4 4+

Parking Lot Assessment-

Shade on parking lot:

Low Medium High

Presence of stormwater retention pond:

No Yes

Landscaping Assessment-

Native plant buffer strips surrounding bodies of water:

No Yes

If yes, what is the width of the buffer:

Native plant buffer surrounding parking lots

No Yes

If yes, what is the width of the buffer:

Native plant buffer along roads, highways:

No Yes

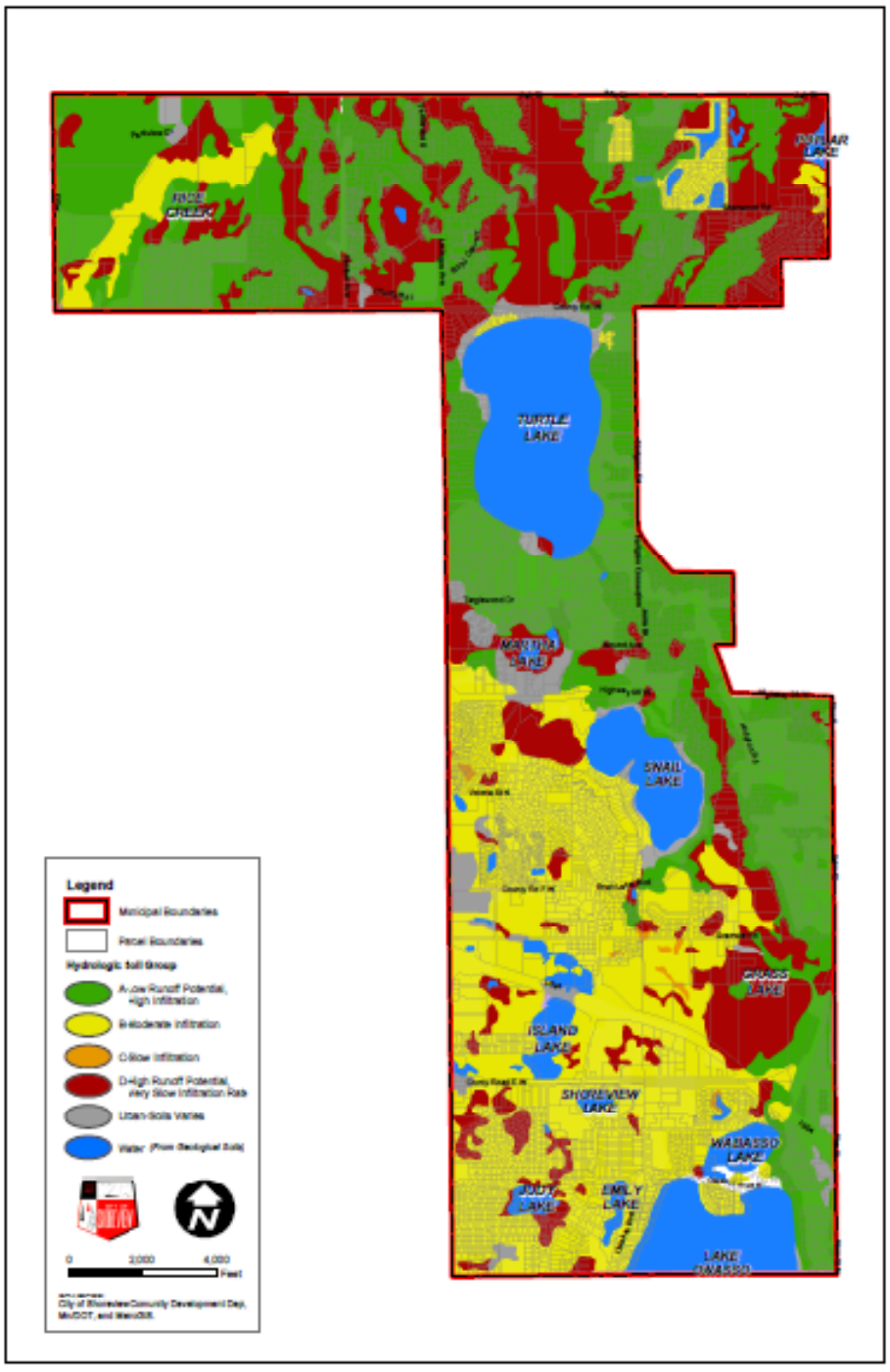
If yes, what is the width of the buffer:

Appendix B: Park Survey Averaged Results

	Bucher	Ponds	Lake Judy	McCullogh	Sitzer	Shamrock
Forest Assessment:						
Overstory:						
# tree species	7+	~5-7	7+	7+	~5-7	7+
Age of forest	Adult	Adult	Adult	Old	Adult	Adult
% dead wood	0-5	0-5	5	~5-10	~0-5	~0-5
Understory:						
Presence of invasive species	YES	NO	YES	YES	NO	YES
If yes, % abundance	1		5	50		2
Presence of Poison Ivy/ Poison Oak	NO	NO	YES	NO	NO	NO
Thickness of understory	AVERAGE	THIN	AVERAGE	THICK	Thin	THIN
Trail Assessment:						
Physical condition of trail	AVERAGE	AVERAGE	AVERAGE	AVERAGE	GOOD	AVERAGE
Shade on Trail	LOW	LOW	MEDIUM	HIGH	MEDIUM	MEDIUM
Proximity to body of water	Near	Near	NEAR	NEAR	FAR	NEAR
If part of trail is near, how much?	10%	20%	~20-30%	5%		~300-500ft
Distance between trail edge and vegetation (feet)	~3-4	~1-2	~2-3	~2	4+	~2-3
Parking Lot Assessment						
Shade on parking lot	LOW	NO Pking Lot	No Pking Lot	LOW	MEDIUM	MEDIUM
presence of stormwater retention pond	YES	YES	YES	YES	NO	YES
Ladscaping Assessment:						
Native plant buffer strips surrounding bodies of water	YES	YES	YES	YES	N/A	YES
If yes, what is the width		~10-15	~20	~5-15		~15-20
Native plant buffer along roads, highways	NO	YES	NO	NO	NO	NO
If yes, what is the width		~20				
Native plant buffer surrounding parking lots	NO	N/A	N/A	NO	NO	NO
If yes, what is the width						

	Wilson	Commons	Bobby Thiese	Rice Creek Fields
Forest Assessment:				
Overstory:				
# tree species	~5-7	7+	7+	~3-5
Age of forest	Adult	Adult	Adult	YOUNG
% dead wood	~5	~11-20	~5-10	~0-5
Understory:				
Presence of invasive species	YES	YES	YES	NO
If yes, % abundance	~10	5	~15	
Presence of Poison Ivy/ Poison Oak	NO	NO	YES	NO
Thickness of understory	AVERAGE	Thick	Thick	THIN
Trail Assessment:				
Physical condition of trail	AVERAGE	GOOD	GOOD	AVERAGE
Shade on Trail	MEDIUM	MEDIUM	LOW	LOW
Proximity to body of water	NEAR	NEAR	NEAR	FAR
If part of trail is near, how much?	~10%	5%	~10%	
Distance between trail edge and vegetation (feet)	4+	~3-4	~3-4	~2-3
Parking Lot Assessment				
Shade on parking lot	MEDIUM	MEDIUM	LOW	LOW
presence of stormwater retention pond	YES	YES	YES	NO
Ladscaping Assessment:				
Native plant buffer strips surrounding bodies of water	YES	YES	YES	N/A
If yes, what is the width	~15-20ft	15ft	~10-15ft	
Native plant buffer along roads, highways	NO	NO	NO	NO
If yes, what is the width				
Native plant buffer surrounding parking lots	NO	NO	NO	YES
If yes, what is the width				1/10 mile

Appendix C: Shoreview Soil Drainage Map



SEH

Soil Hydrologic Group
City of Shoreview, Minnesota

Figure 3

Appendix D: Park Trail Information

CITY PARKS		From	To	Comments	Orig Yr Constr	Yr Reconstr	Rating	Length (ft)	Width (ft)	Area
BUCHER PARK PATH					1989		C-	4,225	8	33800
COMMONS PARK PATH				check after construction	1990		C	1,285	8	10280
LAKE JUDY PARK PATH				sealcoat 1994	1989		B	1,759	8	14072
McCULLOUGH PARK PATH					1988		C+	4,911	8	39288
PONDS PARK PATH					1993		A	657	8	5256
RICE CREEK FIELDS		all paths in park			2000		A	5,659	8	45272
SHAMROCK PARK PATH		all paths in park		liquid road sealcoat 2006	1989		B	2,375	8	19000
SITZER PARK		connector	Galtier St	mill & overlay 2001	1989	2001	A	160	8	1280
SITZER PARK PATH				mill & overlay 2001	1989	2001	A	802	8	6416
SUMMER HOUSE PATH					2000		A	1,086	8	8688
THEISEN PARK PATH				mill & overlay 1999	1989	1999	A	1,698	8	13584
WILSON PARK PATH				mill & overlay 1998	1989	1998	A	2,801	8	22408
McCullough Board Walk		Park	Sherwood Rd	$26,500	1994		C	276	9	2484

Appendix E: Criteria for Mapping Hotspots

Tier 1- Areas that have great influence on the sustainability of parks.

Tier 2- Areas that have some influence on the sustainability of parks.

Factors:

- Proximity to body of water
    - Tier 1: Areas within 100 feet of body of water, or directly connected
    - Tier 2: Areas 101-300 feet of body of water
- Proximity to roads/highways/parking lots
    - Tier 1: Areas within 60 feet
    - Tier 2: Areas 61-100 feet
        - According to Siegel Report
- Park Use (info hopefully from User Group)
    - Tier 1: Areas high level of active use
    - Tier 2: Areas medium level of active use
- Ponding/saturation (particularly on or near playing fields)
    - Tier 1: Areas commonly inundated/with standing water
    - Tier 2: Areas occasionally inundated/with standing water
- Areas tree species diversity
    - Tier 1: Areas with 1-2 species of trees
    - Tier 2: Areas with 3-4 species of trees
- Areas of invasive species in understory percentages
    - Tier 1: Areas with greater than 25% invasive presence
    - Tier 2: Areas with 10-24% invasive presence
- Areas shade percentages
    - Tier 1: Areas with little or no shading on infrastructure
    - Tier 2: Areas with partial shade cover on infrastructure

Appendix F: Percentages of Green and Gray Cover

Park	Area of asphalt trails (Square feet)	Percent Gray Cover (includes trails, parking lots, building, basketball courts etc.)
Rice Creek Fields	43,552	50
McCullough	39,288	5
Bucher	33,800	10
Wilson	22,408	15
Shamrock	19,000	10
Lake Judy	14,072	5
Commons	10,280	40
Sitzer	7,696	25
Ponds	5,256	5
Bobby Theisen	13,584	15

Bobby Theisen Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	1681.52822	7274.88	30496	34413	
	962.93608	168.8			
		6115.44			
Total	**2644.4643**	**13559.12**	**30496**	**34413**	
Entire Park	**828990.36**		**Percentages**	**Gray**	**9.78450272**
Total Gray	**81112.5843**			**Green**	**90.2154973**

Bucher Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	1777.28831	24513.44		21398	
	410.69358	281.76			
		250.4			
		299.68			
		471.52			
		321.84			
		600.32			
		6898.32			
Total	**2187.98189**	**33637.28**	**0**	**21398**	
Entire Park	**986416.2**		**Percentages**	**Gray**	**5.80112755**
Total Gray	**57223.26189**			**Green**	**94.1988725**

Lake Judy Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	469.71862	6886.712			
		6416.08			
Total	**469.71862**	**13302.79**	**0**	**0**	
Entire Park	**318554.28**		**Percentages**	**Gray**	**4.32344234**
Total Gray	**13772.51062**			**Green**	**95.6765577**

McCollough Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	1453.54526	10595.76	59112	38882	
	368.06852	11197.68			
		1751.28			
		3372.32			
		5699.44			
		2600.4			
		598.64			
		8457.52			
Total	**1821.61378**	**44273.04**	**59112**	**38882**	
Entire Park	**3422422.08**		**Percentages**	**Gray**	**4.21013687**
Total Gray	**144088.6538**			**Green**	**95.7898631**

Ponds Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
		3666.88			
		454.64			
Total	**0**	**4121.52**	**0**	**0**	
Entire Park	**77841.72**		**Percentages**	**Gray**	**5.29474426**
Total Gray	**4121.52**			**Green**	**94.7052557**

Rice Creek Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	5.229.808	13724.24	42485		
	1305.80613	1832.64			
	124.39051	10499.84			
	32.71816	6887.76			
		328			
		328			
		4665.76			
		6240.16			
		1630.32			
		1490.64			
		800			
		800			
Total	**1462.9148**	**49227.36**	**42485**	**0**	
Entire Park	**503379.36**		**Percentages**	**Gray**	**18.5099514**
Total Gray	**93175.2748**			**Green**	**81.4900486**

Shamrock Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	1481.90307	11198.24	33843	21923	
	1178.1204	4154			
		160			
		3596.08			
Total	**2660.02347**	**19108.32**	**33843**	**21923**	
Entire Park	**1058725.8**		**Percentages**	**Gray**	**7.32336394**
Total Gray	**77534.34347**			**Green**	**92.6766361**

Shoreview Commons Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	454.96846	7398.64	153931	21264	
	533.85161	521.12	78178		
	69142.82207	1763.28	55222		
	6193.78491				
	14.358.90976				
	137.59711				
	774.06108				
	436.17473				
	2450.17796				
	2519.69724				
	429.6366				
Total	**83072.77177**	**9683.04**	**287331**	**21264**	
Entire Park	**1926310.32**		**Percentages**	**Gray**	**20.8352106**
Total Gray	**401350.8118**			**Green**	**79.1647894**

Sitzer Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	1925.93299	2300.64	13511	18882	
	1821.79958	1233.6	14869		
		521.44			
		2006.16			
		4830.32			
Total	**3747.73257**	**10892.16**	**28380**	**18882**	
Entire Park	**410727.24**		**Percentages**	**Gray**	**15.0712898**
Total Gray	**61901.89257**			**Green**	**84.9287102**

Wilson Park Gray Areas (sq ft)					
	Structures	**Trails**	**Parking Lot**	**Tennis/Bball**	
	24.42254	1992.48	36410	19818	
	1400.34204	8424.72			
	110.55597	3727.52			
		3044			
		568.56			
Total	**1535.32055**	**17757.28**	**36410**	**19818**	
Entire Park	**545066.28**		**Percentages**	**Gray**	**13.8553059**
Total Gray	**75520.60055**			**Green**	**86.1446941**

Total Percentages

Park	Green	Gray
Bobby Theisen Park	90.22%	9.78%
Bucher Park	94.20%	5.80%
Lake Judy Park	95.68%	4.32%
McCollough Park	95.79%	4.21%
Ponds Park	94.71%	5.29%
Rice Creek Park	81.49%	18.51%
Shamrock Park	92.68%	7.32%
Shoreview Commons	79.16%	20.84%
Sitzer Park	84.93%	15.07%
Wilson Park	86.14%	13.86%

Appendix G: Pervious Surface Cost Comparison

Low Impact Development Techniques

Bonestroo Century College West Campus

Permeable Pavements

Permeable Pavement Type	*Description*	*Maintenance*	*Durability*	*Reuse*	*Costs*
Interlocking Concrete Pavements 	Comprised of a layer of durable concrete pavers separated by joints filled with small stones.	Vacuum sweep and inspect every spring. If clogs, may need to remove fill between pavers and replace.	Sanding is not permitted; limit salt application. Plow might chip paver edges. Minimal heaving.	Units can use cement substitues (flyash, slag, silica fume, etc.) and crushed recycled aggregate. Pavers can be reused.	SF Costs Including Subbase: $12.00 - $21.00
Porous Concrete 	Mixture contains little or no sand allowing for substantial void content between 15% to 25%.	Low pressure wash and/or vacuum. Sweeping is ok if combined with vacuuming.	Sanding is not permitted. Avoid using deiicing chemicals. Plastic or rubber tipped snow plow blade is recommended.	Fly ash, a byproduct, can be used in the concrete; 25% max. for exterior concrete.	SF Costs Including Subbase: $11.00 - $16.00
Porous Hot Mixed Asphalt 	Contains no fine aggregate particles thereby creating void spaces in the pavement.	Inspect several times in first few months after constructed; annually thereafter. Vacuum sweep.	Use liquid de-icer in place of sand or course salt; fine salt is ok	Pavement can be recycled. Questionable if material can be manufactured from recycled asphalt.	SF Costs Including Subbase: $7.50 -$8.00
Concrete Cellular Paving Systems 	A cast on site 5 1/2 to 6" depth cellular reinforced concrete system with voids created by plastic void formers.		No salt or sand. Snow plows ok.	Plastic formers are made from recycled material. Fly ash can be used in the concrete up to 40%.	SF Costs Including Subbase:

Initial costs of permeable paving may be competitive or more with conventional materials. These costs are often offset when the need for other types of stormwater drainage is eliminated.

Appendix H: Questions for Park Maintenance

Are all parks maintained under the same protocol (mowed at same intervals, given same amount of weed control treatment, fertilizer, etc)? Or do you have specific maintenance protocols for specific parks?

How often are different areas mowed (playing fields/open space)? Are there exceptions?

How many people are employed in the maintenance department?

Are trails swept in autumn? If so, how often?

Do crews perform all scheduled maintenance needs for each park on one trip, or are there job-specific crews (mowing crew, landscaping crew, trails crew) that come at different times?

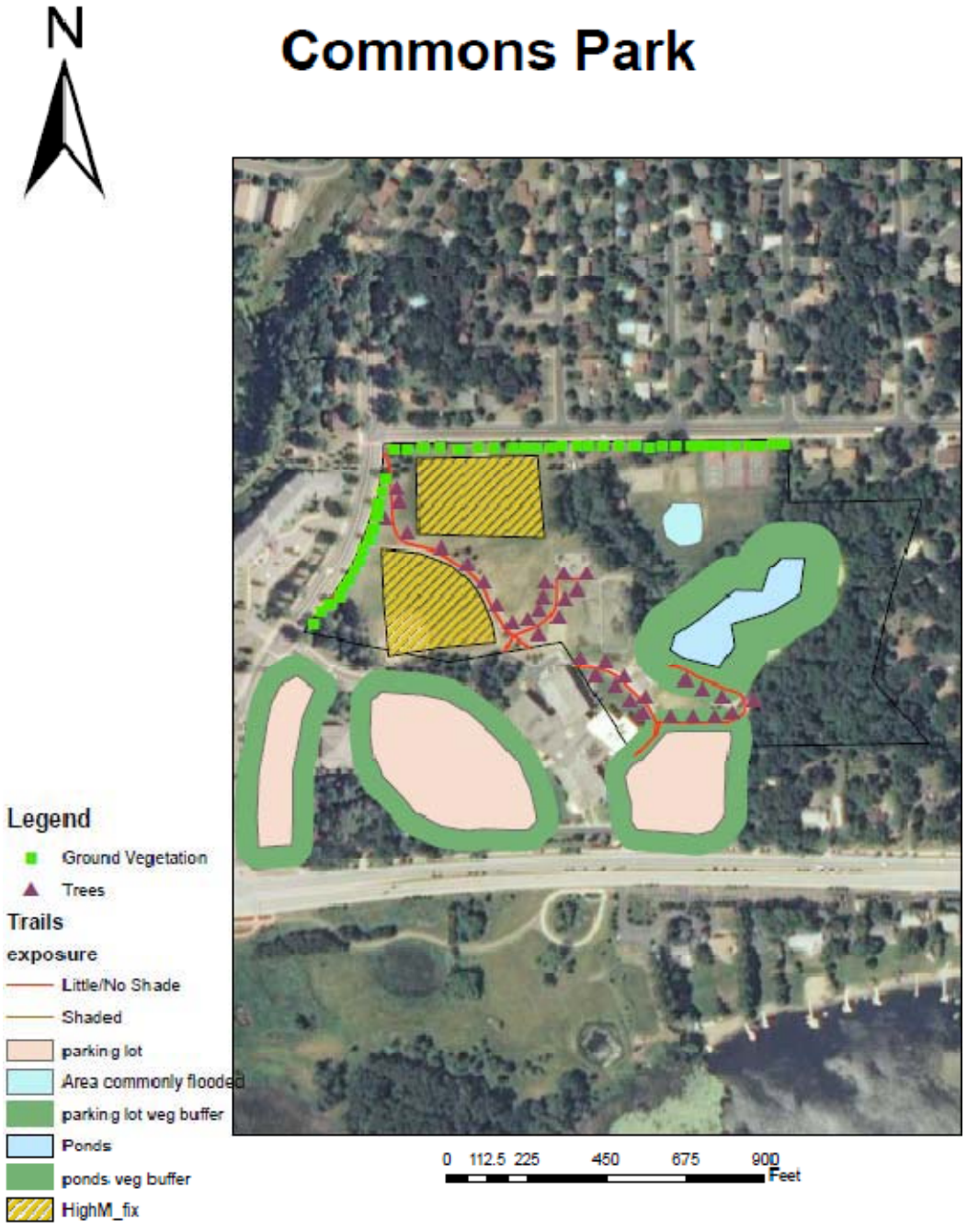
How often are landscaped areas cared for? Is it different for different parks?

How do you deal with areas that are commonly flooded or saturated? Are they maintained in the same way as areas that are not commonly flooded or saturated?

Is fertilizer used? If so, do you apply uniform amount for all areas, or specific amounts for specific areas?

Do bodies of water in parks have buffer strips?

Appendix I: Hotspot Maps



McCullough

N

0 130 260 520 780 1,040
Feet

Legend

- Trees

Trails

exposure

- Little/No Shade
- Shaded

- roads_Clip
- parking lot
- parking lot veg buffer
- roads_Clip_Buffer
- Ponds
- ponds veg buffer
- one_two_tree_species
- Greater than 20% Invasives
- Areas of High Active Use

Shamrock

Legend

- Ground Vegetation
- Trees

Trails

exposure

- Little/No Shade
- Shaded
- parking lot
- Basketbal Court
- Basketbal Court Buffer
- parking lot veg buffer
- Ponds
- ponds veg buffer
- one_two_tree_species
- Areas of High Active Use
- park boundaries

0 75 150 300 450 600 Feet

Wilson

Legend

- Trees

Trails

exposure

- Little/No Shade
- Shaded
- parking lot
- parking lot veg buffer
- Ponds
- ponds veg buffer
- Areas of High Active Use