

# Crystal Shopping Center Stormwater Management Plan



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Responsive partner.  
Exceptional outcomes.

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# Credits

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## List of Acronyms

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BMP	Best Management Practice
EPA	Environmental Protection Agency
GIS	Geographic Information System
LID	Low Impact Development
MIDS	Minimum Impact Design Standards
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NURP	Nationwide Urban Runoff Program
ROW	Right of Way
SCM	Stormwater Control Measure
SCS	Soil Conservation Service
SCWMC	Shingle Creek Watershed Management Commission
SSGI	Shared, Stacked-function Green Infrastructure
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids

# 1.0 Summary

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The Shingle Creek Watershed Management Commission (SCWMC) Third Generation Watershed Management Plan Implementation Plan calls for systematically completing subwatershed assessments in high-priority areas to reduce pollutant loads and runoff volumes throughout the watershed.

The Crystal Shopping Center Area in the City of Crystal is a highly impervious area that developed largely without stormwater controls and which discharges to the impaired Middle Twin Lake. The purpose of this study is to help the City of Crystal reduce pollutant loads and runoff volumes discharging to Middle Twin Lake through implementation of stormwater of Best Management Practices (BMPs).

The study focuses on providing the City of Crystal with a variety of stormwater management options that can be used in the Crystal Shopping Center Area to reduce flooding and improve water quality. The study is meant to illustrate Shared, Stacked-Function Green Infrastructure (SSGI) in a highly impervious watershed. "Shared, stacked-function" refers to situations where the green infrastructure is intended to provide service for more than one parcel (public or private). The entire facility also functions to provide additional amenities beyond solely managing stormwater.

The proposed green infrastructure is designed to meet MPCA Minimum Impact Design Standards (MIDS). The first 1.1 inches of runoff will be retained on-site and infiltrated where practical. If all of the proposed practices were implemented, TSS loading to Middle Twin Lake would be reduced by about 39,000 pounds annually and TP loading by 122 pounds annually. In addition, the SSGI would infiltrate 194 acre-feet of runoff per year. In effect, rainfall events in this area would be reduced by 1.1 inches and the City storm sewer would be capable of managing larger rainfall events.

Section 3.0 of this report provides descriptions of specific types of green infrastructure, and Section 4.0 provides sample green infrastructure layouts to consider. Each page of Section 4.0 shows an approach to stormwater management in public and/or private settings. The green infrastructure identified in this report could be implemented as shown and also viewed as an assortment of stormwater management methods to be incorporated in reconstruction projects throughout the City.

## 2.0 Background

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### 2.1 PURPOSE

The purpose of this study is to provide the City of Crystal with a variety of stormwater Best Management Practice (BMP) options that can be used throughout the City and to illustrate Shared, Stacked-Function Green Infrastructure (SSGI) in a highly impervious watershed. "Shared, stacked-function" refers to situations where the green infrastructure is intended to provide service for more than one parcel (public or private). The entire facility also functions to provide additional amenities beyond solely managing stormwater.

The goals of this study are to help the City of Crystal reduce flooding concerns within the area and reduce pollutant loads discharging to downstream Twin Lake through implementation of Best Management Practices (BMPs). Twin Lake is currently classified as 'Impaired' for excess nutrients by the Minnesota Pollution Control Agency (MPCA). Approximately 5,550 acres drains to the Twin Lake system and the Twin and Ryan Lakes TMDL estimates nutrients loads in the watershed need to be reduced by up to 76%.

The Crystal Shopping Center Area is largely impervious and has been developed without BMPs so it presents exceptional opportunities for implementing green infrastructure. Section 3.0 of this report provides descriptions of specific types of green infrastructure, and Section 4.0 provides sample green infrastructure layouts to consider. Each page of Section 4.0 plans an approach to stormwater management in both public and private settings. The green infrastructure identified in this report could be implemented as shown and also viewed as an assortment of stormwater management methods that can be incorporated in reconstruction projects throughout the City.

### 2.2 STUDY AREA

The area identified for potential improvement is shown in Figure 1 of the attached figures. It is roughly 97 acres of commercial real estate bisected at the midpoint by County Roads 8 and 10. The entire area is tributary to Upper Twin Lake to the east.

Approximately 5.5 acres of the study area already incorporates some form of stormwater management. These stormwater practices are split between a few private and public properties and include stormwater ponds, an infiltration trench, and several rain gardens.

As part of ongoing street maintenance, the City of Crystal reconstructed the City streets in the area in 2013 and 2015. The County Road intersection was also recently reconstructed. Additional stormwater management within the street right-of-way will most likely be delayed until future repairs are needed.

### 2.3 FRAMEWORK

Stormwater management in urban areas has evolved substantially over the past 20 years. Historically, the goal was to move water off the landscape quickly to reduce or eliminate flooding. Now, stormwater professionals focus on keeping a raindrop where it falls to mimic natural hydrology, recharge groundwater and minimize the amount of pollution reaching our lakes, rivers, and streams.

In 2009, the Minnesota Legislature allocated funds to “develop performance standards, design standards or other tools to enable and promote the implementation of low impact development and other stormwater management techniques.” Minimum Impact Design Standards (MIDS) represent the next generation of stormwater management and is based on low impact development (LID). LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product.

Many practices have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements. By implementing LID principles and practices, water can be managed to reduce the impact of built areas and promote the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed’s hydrologic and ecological functions. LID has been characterized as a sustainable stormwater practice by the Water Environment Research Foundation and others.

Using the LID approach, the MIDS study determined this region should seek to retain 1.1 inches of runoff on-site from all impervious surfaces. The increase from the current SCWMC rule of retaining 1.0 inches of runoff will further reduce runoff rates, runoff volumes, and pollutant loads to pre-settlement conditions.

The City of Crystal is also bound to the Municipal Separate Storm Sewer System Permit (MS4) which was originally issued in 2006 to address the federal Phase II National Pollution Discharge Elimination System (NPDES) stormwater regulations for small MS4s. The MS4 permit has since been updated to further comply with and exceed the standards set forth in the NPDES. The municipal MS4 permit now requires no increase in runoff volume, total suspended solids (TSS), and total phosphorus (TP) for new development, and redevelopment must reduce runoff volume, TSS, and TP discharged from the site.

MIDS is more stringent than the NPDES requirements because it attempts to return stormwater hydrology to pre-settlement conditions rather than existing conditions under the NPDES permit.

## **2.4 METHODOLOGY**

Wenck evaluated stormwater runoff in the study area by reviewing existing conditions using Geographic Information Systems (GIS) and data provided by the City. Wenck modeled the existing area hydrology and water quality using the computer program P8. Green infrastructure hydrology was modeled in HydroCAD. HydroCAD is capable of developing the hydraulic inputs (rating curves) to the P8 model with confidence and efficiency. It is also a sufficient model to evaluate baseline flooding concerns for design storm events. The rating curve hydraulics from the HydroCAD models were input to the P8 model devices to predict the potential for runoff volume and pollutant loading reductions in this part of the Crystal Shopping Center Area.

P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) is a computer model used for predicting the generation and transport of stormwater runoff pollutants in urban watersheds. P8 is a useful diagnostic tool for evaluating and designing watershed improvements like green infrastructure. The model requires a user to input watershed characteristics, green infrastructure dimensions, local precipitation and

temperature, and water quality parameters.

P8 calculates runoff separately from pervious and impervious areas. Calculations for pervious areas use the Soil Conservation Service (SCS) Curve Number (CN) method. Runoff from impervious areas begins once the cumulative storm rainfall exceeds the specified depression storage, with the runoff rate equal to the rainfall intensity.

The P8 model uses an hourly precipitation record (rain and snowfall) and daily temperature record. Precipitation and temperature data were obtained from the Minneapolis-St. Paul International Airport. Records from 2001 to 2010 were used for this study.

Wenck selected the NURP50 particle file for this study. The component concentrations in the NURP50 file represent the 50th percentile (median) values compiled in the EPA's Nationwide Urban Runoff Program (NURP).

## **2.5 LIMITATIONS AND ASSUMPTIONS**

Due to limited information, potential SSGI locations shown in the following section require further investigation before they can be implemented. Topography, soil types, utilities, and future land use is needed to proceed with final design. The recommended SSGI designs were placed with the intention to fit the landscape and meet MIDS. The results of a final design may vary slightly from what is proposed in this report.

Based on NRCS Web Soil Survey Wenck determined that soil types were mostly "urban fill" which suggests the surface elevation was raised using outside fill material (Figure 2 of the attachments). The native soils in the area are loamy sands. Consequently, Wenck assumed infiltration practices would extend below the fill material and an infiltration rate of 0.8 inches per hour was appropriate. This infiltration rates was used area-wide unless more detailed data was available that suggested otherwise. A detailed soil investigation to determine soil type and groundwater elevations is needed before design of any of the proposed practices.

## 3.0 Shared, Stacked-Function, Green Infrastructure

***Infiltration Trench***

***Pervious Pavers***

***Stormwater Reuse***

***Stormwater Planter***

***Tree Trench***

***Infiltration Basin***

***Infiltration Catchbasin***

Communities can choose to maintain healthy waters, provide multiple environmental benefits and support sustainability using green infrastructure. Typically stormwater infrastructure serves only a single purpose: to dispose of runoff. Green infrastructure uses vegetation and soil to manage rainwater where it falls. Modern engineering practices can entwine natural processes with fabricated environments to provide stormwater management, flood mitigation, improved air quality, groundwater recharge, and improved downstream conditions.

A wide scale of options is available within the realm of green infrastructure. The Low Impact Development (LID) approach to stormwater management incorporates green infrastructure as well as traditional best management practices (BMPs). “Shared, stacked-function” refers to designs that intend to provide service to more than one parcel (public or private) and the entire facility may function to provide additional amenities including artwork, public interaction, and green space. Examples of green infrastructure are presented below. Specific uses for these technologies are summarized in Section 4.0.

### 3.1 INFILTRATION TRENCH

Infiltration trenches are an adaptable stormwater management technique where space is limited, and is most suitable for highly urban areas or areas with large parking lots. Underground infiltration consists of perforated pipes or cisterns placed beneath a parking lot or open area. An example is shown below.

Stormwater runoff is directed to this area via storm sewer for storage and infiltration. A manhole, filter, or hydrodynamic device provides pretreatment for runoff entering the storage area. In large storm events, the storage volume above the outlet reduces flow rates and discharge is directed into the storm sewer. Large angular rock (1-3 inches) surrounds the perforated pipes and provides additional storage capacity and structural stability for soils above. The design can be modified to include a filtration layer when infiltration is not practical.

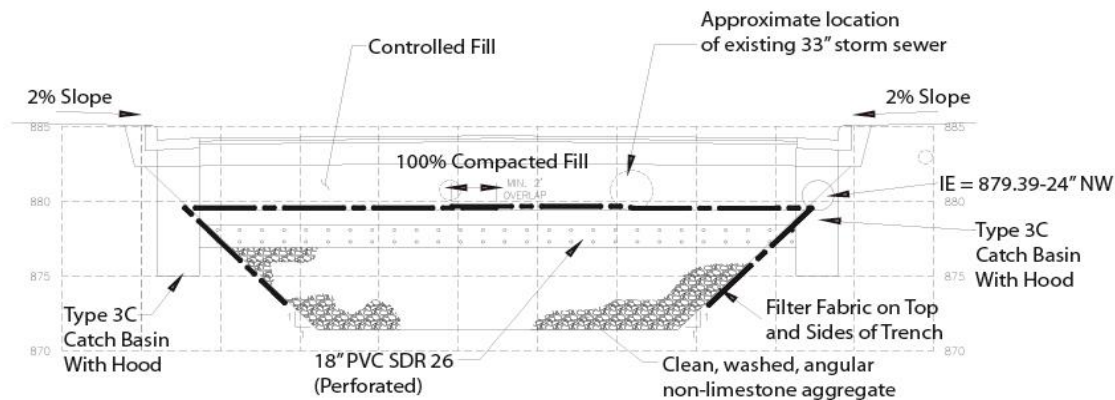
Street replacement also provides an opportunity for this type of shared,



A cut view of an underground infiltration system. This system may be placed under a parking lot, park or other area to accommodate storage and infiltration of runoff.



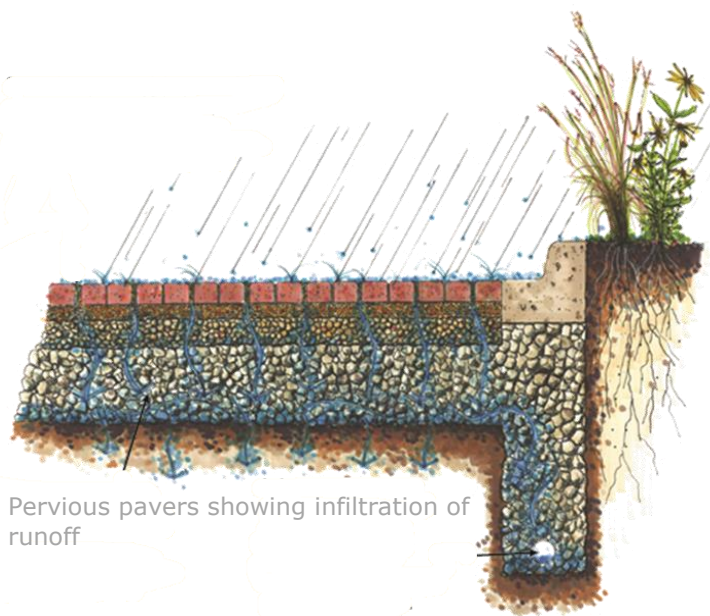
stacked-function green infrastructure. Infiltration trenches can be placed beneath roads where no utilities are present. During road reconstruction the infiltration trench can be added to the project to reduce downstream pollutant loads. Maintenance includes periodic removal of sediment accumulated in the pretreatment devices. To maintain system functionality, sediment deposition should not exceed 1 foot in depth.



Cross section of an infiltration trench beneath the road.

### 3.2 PERVIOUS PAVERS

Pervious pavers have several different designs that follow the same general structure and result in reduced runoff volumes. Impervious pavement (concrete or asphalt) is replaced with pavers what allow water to pass through to the sub-base via gaps between the blocks. The subbase consists of an angular rock with large void spaces to temporarily store and infiltrate water that passes through the pervious pavement above. This method of pavement construction provides a means of infiltrating runoff from paved surfaces as well as any other contributing surface areas. The figure to the right is an illustration of pervious pavers and how water flows through.



While pervious pavers remain unproven for heavy traffic, trucks, and high speeds, it is well-suited to handle light traffic and occasional heavy vehicles. Potential areas for implementation are parking lots, residential roads, driveways, sidewalks, walkways; curb islands and other similar surfaces as shown in the photos below.

To ensure long performance of pervious pavers, it is important to maintain the pavement. Periodic vacuuming is the key maintenance needed for pervious pavers and using little or no salt in the winter is recommended. Studies have shown that de-icing chemicals can be reduced or eliminated because snow-melt and ice infiltrates rather than refreezing.



Images of pervious pavement in a parking lot (A) and low traffic areas (B).

Maintenance of the surrounding landscaped areas will also ensure that the pavement does not become clogged with eroded sediment.

Pervious pavement has recently been shown to reduce the need for de-icing on roadways. In the images below, a section of porous asphalt is outlined in black. The image shows snow accumulating on the traditional pavement but not on the porous section. Snow and ice build-up is reduced substantially by pervious pavement, which allows municipalities to avoid applying salt as frequently. With recent increases in salt prices, pervious pavement in low traffic areas may be a valuable and a long-lasting alternative to salt application.

### 3.3 STORMWATER REUSE

Stormwater reuse is the practice of collecting rain water from impermeable surfaces and storing it for future use. There are a number of systems used for the collection, storage and distribution of rain water including rain barrels, cisterns, evaporative control systems, and irrigation.

Stormwater reuse facilities fit the shared, stacked-function mold by conserving groundwater, saving money through reduced groundwater pumping and treatment, and reducing pollutant loads to local lakes and rivers. Most commonly, these systems capture “free water” from a local pond and irrigate (after filtering) green space.



How snow accumulates on porous and traditional pavement in Robbinsdale, MN.





Cistern and artwork  
at the Maplewood  
Mall, MN



Recently implemented at the Maplewood Mall in Maplewood, MN (below), a large above-ground cistern was installed at the mall entrance to capture roof runoff. The Maplewood Mall cistern has a pump handle that, when pumped, cascades water down over a series of spinning gears and chimes and into an infiltration area. The system also serves to educate shoppers on stormwater management techniques and conservation. A tiled collage on the mall's wall provides an artistic background that illustrates an urban water cycle.

Cisterns are not always the most cost effective means of managing stormwater. However, many cities encourage residents to reuse water by providing rain barrels at reduced or no cost to the users. This can be especially effective at providing opportunities for public involvement and art.

### 3.4 STORMWATER PLANTER

Stormwater planters are a familiar practice in urban areas to collect and infiltrate rainwater runoff. They are typically shallow depressions surrounded by poured concrete or landscaping block walls with soil engineered to quickly infiltrate water (within 48 hours).

Effective stormwater planters have vegetation that is accustomed to changes in moisture availability and known to remove pollutants (see Section 3.8 for more information about vegetation). Stormwater planters are placed along roads and with an opening in the curb, allowing runoff from parking lots, sidewalks, and roads to enter the planter to be treated and infiltrated. The sidebar photo and the photo below show stormwater planters from West Union, IA. Stormwater planters vary in size and shape but operate similarly. Runoff enters through the curb cut. When filled, runoff will bypass the planter and continue to the next downstream catch basin, pipe, or pond.

Pretreatment for stormwater planters is required by the Minnesota Pollution Control Agency (MPCA) to filter large



Stormwater planters in  
West Union, IA

debris and particles from runoff prior to entering the planter. Pretreatment options for stormwater planters include sumped catchbasins, forebays, or proprietary devices (i.e. Rain Guardian or Stauner sediment trap).

The design and maintenance of stormwater planters is similar to curb cut rain gardens. Stormwater planters can be located on or near storm sewer catch basins. Placing the curb cut upstream of the catch basin allows runoff to first enter and fill the stormwater planter before overflowing into the storm sewer. Maintenance includes mulch, trash removal, seasonal plant trimming, and plant replacement.

Stormwater planters have also been recently implemented on the Green Line between Minneapolis and St. Paul. The planters add needed green infrastructure into the 100% impervious corridor of University Avenue in St. Paul.

### 3.5 TREE TRENCH

Tree trenches provide underground storage for runoff while increasing green space on the surface. These practices are aesthetically pleasing and great for largely paved areas like roads, parking lots, and sidewalks. Below is an example of a fully functioning tree trench system in the Maplewood Mall parking lot. The trees spring up from the pavement while stormwater is directed underground.

The Ramsey Washington Metro Watershed District (RWMWD) installed this tree trench system in the Maplewood Mall parking lot as part of a redevelopment effort. In this application, the tree trench extends between parking lot islands and below drive lanes and parking stalls. Trench drains connect parking lot islands and collect runoff from the parking lot to be stored and infiltrated in the engineered media below the parking lot surface.

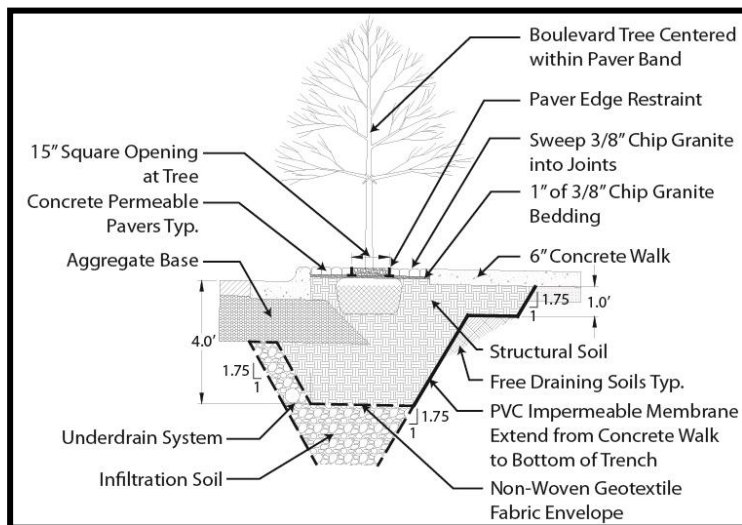
A common design in Europe is known as the Stockholm Tree Trench Method and was developed to provide suitable growing conditions for trees in highly urbanized environments. This method includes media with 2-4 inch angular rock layers that can support tree roots and provide storage for runoff.



Tree trenches installed in the Maplewood Mall parking lot in Maplewood, MN.

To help sustain the growth of the trees in an urban environment, special measures are needed. The tree trenches installed by RWMWD used a patented structural soil developed by Cornell University. CU-Structural Soil™ (also known as CU-Soil™) was developed as a way to safely bear pavement loads after compaction and yet still allow root penetration and vigorous tree growth. The figures show healthy young trees in an entirely impervious landscape.





Example tree trench cross section used in St. Paul, MN.

The Capitol Region Watershed District (CRWD), City of St. Paul and Metropolitan Council recently installed tree trenches on the Green Line in St. Paul. These trees are buried in a soil engineered to support the tree root system and collect runoff from the surrounding area. A cross-section of the design is shown below.

Maintenance of tree trenches is similar to other vegetated stormwater management. Newly planted trees need to be watered regularly. According to Johnson et al. 2008, trees need 1.5 gallons of water per inch of trunk diameter when soil is dry. This watering should be sustained for the

first three years after planting. Young trees should also be protected from rodents by installing plastic tubing or mesh that extends 1 to 2 feet above the snow line. Trees should be pruned once (1) in each year 2 and 3, every three (3) years up to 10 years, and every five (5) years after that. Periodic removal of sediment from pretreatment sumps and removal of trash and debris will improve the longevity of the trenches.

### 3.6 INFILTRATION BASIN

Infiltration basins combine surface storage, infiltration, biological treatment, plant uptake, and evapotranspiration into a single green infrastructure. Stormwater is collected into the treatment area which consists of a grass buffer strip, sand bed, ponding area, organic or mulch layer, planting soil, and plants. The infiltration system incorporates the more natural means of managing stormwater than any other treatment type.

The picture below shows an infiltration basin along the perimeter of a parking lot in downtown St. Paul. Note the ribbon curb that defines the edge of the pavement but also allows runoff to flow over the curb, through the vegetated buffer and into the bioretention basin.



Opportunities to include infiltration systems in the landscape include landscaping islands, cul-de-sacs, parking lot margins, commercial setbacks, open space, rooftop drainage and streetscapes (i.e., between the curb and sidewalk). Infiltration basins are extremely versatile

Infiltration basin along a parking lot in St. Paul, MN.



because of their ability to be incorporated into landscaped areas. Maintenance activities typically include sediment removal and maintenance of the vegetation. Invasive species need to be managed, dead vegetation must be removed, and dead plants must be replaced.

Similar to other green infrastructure, public art can be incorporated into infiltration basins. The picture below demonstrates how a basin in Oakdale, MN incorporated public art into the retaining walls and flow path. The decorative retaining walls create a “stepped” system that allows water to infiltrate or overflow to the next downstream step. The picture at the bottom of the page shows the circular pretreatment sump at the upstream end of the steps and the decorative concrete spheres in the concrete flume that carries concentrated flow from the overflow of each step.

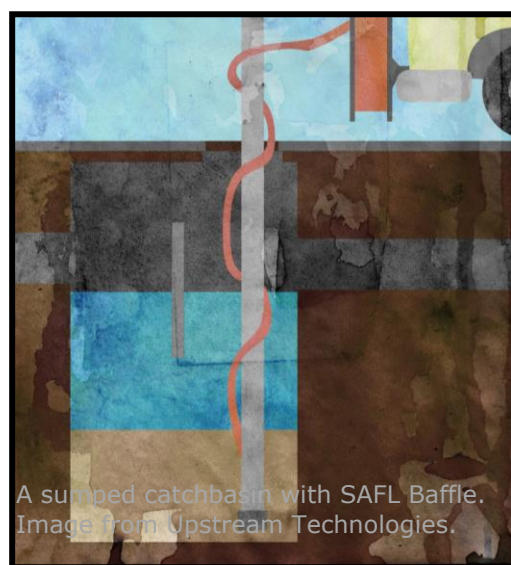


“Stepped” infiltration basin in Oakdale, MN.

### 3.7 INFILTRATION CATCHBASIN

An infiltration catchbasin is constructed in place of a standard catch basin and serves to trap sediment, infiltrate runoff, and convey overflow to the storm sewer. A standard catchbasin can be retrofitted by installing a sump in the catchbasin and creating a porous bottom to allow runoff to infiltrate. Typically, the infiltration catchbasin will be constructed over a bed of porous rock media to increase the retention volume and disperse runoff. Sediment accumulates in the sump which requires periodic removal using a vacuum truck as shown in the figure to the right.

Infiltration catchbasins can be constructed in-line or in branches of the storm sewer. When designed in-line, a device should be installed to dampen flow, promote sediment deposition, and prevent sediment resuspension. There are a few proprietors that offer such devices. The SAFL Baffle, produced by



A sumped catchbasin with SAFL Baffle. Image from Upstream Technologies.

Upstream Technologies, and The Preserver, produced by Momentum Environmental are two examples. These products slow down flow and increase the time that water has to settle out particulates and can further increase the sediment removal efficiency.

Storm sewer sumps need regular maintenance in order to be effective. Vacuum trucks are needed to remove accumulated sediment and other debris. It is good practice to clean sumps during the spring thaw and throughout the summer season. Sumps that are not maintained properly may cause previously trapped sediment to re-suspend which acts to oppose the goal of this technology.

### 3.8 SSGI IN COLD CLIMATES

In Minnesota, stormwater management is defined by managing rainfall runoff as well as snowmelt, whose characteristics are different. Design criteria focusing on rainfall runoff alone may not work well during cold periods resulting in increased maintenance costs. In years when snowfall is high, this becomes a major concern because a substantial percentage of annual runoff volume and loading can result from snowmelt.

A thorough description of the science of snowmelt and recommended management approaches can be found in the Minnesota Stormwater Manual. This description includes and reports the trend toward LID and SSGI show a great deal of promise for snowmelt management. LID is effective because it relies on the natural interaction between runoff and soil biology. The manual discloses SSGI, such as permeable pavers, infiltration, and road drainage infiltration systems, are effective under cold climate conditions with proper maintenance.

Road salt application is an ever-increasing challenge for stormwater managers. Shingle Creek has an approved TMDL for chloride primarily due to winter road salt use. High chloride concentrations damage and kill vegetation planted in infiltration basins, stormwater planters, and tree trench systems. Vegetation is a key ingredient to the performance of these systems and replacement can be costly. The following table from the Minnesota Stormwater Manual lists cold climate vegetation of the upper Midwest with known salt tolerance (sorted by growth form). These species should be considered for stormwater planters and tree trenches exposed to high chloride concentrations.

**Table 1: Salt tolerant vegetation native to Minnesota.**

Species	Soil Moisture	Salt Tolerance in Soil	Growth Form	Notes on Use
American Elm	Always Wet/Frequently Saturated	Medium/Low <sup>1</sup>	Tree	
Green Ash	Always Wet	Medium <sup>1</sup>	Tree	
Hackberry	Frequently Saturated/Mostly Drained	Medium	Tree	
Jack Pine	Mostly Drained	High <sup>1</sup>	Tree	

Species	Soil Moisture	Salt Tolerance in Soil	Growth Form	Notes on Use
Poplars	Frequently Saturated/Mostly Drained	Medium1	Tree	Including aspen, cottonwood, black and silver-leaved poplar; fast growing; also provide good streambank stabilization; highly tolerant to salt spray
White Ash	Frequently Saturated/Mostly Drained	High1	Tree	
Cutleaf Sumac	Mostly Drained	High	Shrub	
Smooth Sumac	Mostly Drained	Medium	Shrub	Colonizes and spreads in high sun
Staghorn Sumac	Mostly Drained	High	Shrub	
Canada Wild Rye	Frequently Saturated	Medium	Herbaceous Grass	
Karl Foerster Reed Grass	Frequently Saturated/Mostly Drained	High	Herbaceous Grass	This is a cultivar for landscaping
Alkali Grass	Mostly Drained	High	Herbaceous Grass	
Blue Gramma Grass	Mostly Drained	High	Herbaceous Grass	Selections being made for strongly salt-tolerant varieties; see University of Minnesota for latest
Little Bluestem	Mostly Drained	High	Herbaceous Grass	
Perennial Ryegrass	Mostly Drained	Medium	Herbaceous Grass	
Seed Mix: MN DOT Urban Prairie	Mostly Drained	High	Herbaceous Grass	
Seed Mix: MN DOT Western Tall Grass Prairie	Mostly Drained	Medium	Herbaceous Grass	
Tall Wheatgrass	Mostly Drained	High	Herbaceous Grass	
Western Wheat Grass	Mostly Drained	High	Herbaceous Grass	



## 4.0 Assessment

Wenck reviewed existing conditions using Geographic Information Systems (GIS) and data provided by the City, and then modeled the area hydrology and water quality using the computer program P8. Wenck selected BMPs for the study that would achieve the goals of reducing flooding risks, managing runoff rates, and reducing pollutant loads. These BMPs were tailored to fit each site and maximize the effects. A proposed model was constructed by incorporating the proposed BMPs into the existing conditions model.

### 4.1 EXISTING CONDITIONS

Wenck created the existing conditions model to mimic the watershed as it is today by routing runoff through the storm sewer, stormwater ponds, rain gardens, and infiltration basins. The majority of the watershed is collected in storm sewer and discharged to Upper Twin Lake untreated. The site is primarily commercial property with intermittent City property including two parking lots and Becker Park (Table 2). County Roads 8 and 10 bisect the area. Figure 3 gives a breakdown of the property ownership.

**Table 2: Breakdown of property ownership.**

Property Owner	Area (acres)	Percent Impervious
City of Crystal	13.1	30%
Hennepin Tax Forfeit	0.3	82%
Private	67.5	89%
City Roads	4.2	82%
County Roads	11.7	85%
<b>Total</b>	<b>96.9</b>	<b>81%</b>

The area is broken into 48 sub-watersheds of which 7 are public streets or roads. A map of the sub-watershed delineations is shown in Figure 4 (attached).

The study area existing condition generates approximately 42,000 pounds of TSS and 143 pounds of TP annually. This estimate includes the expected removals due to existing green infrastructure in the study area: two stormwater ponds, three rain gardens, and one infiltration trench. The ponds are located in sub-watersheds 028 and 029. There are rain gardens in 016, 021, and 022. Sub-watershed 016 also includes an infiltration trench.

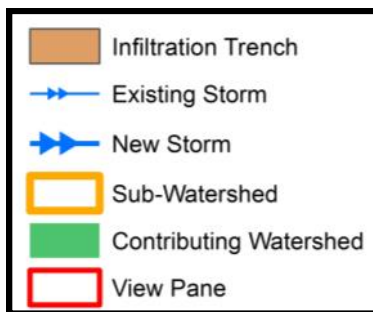
Figures 5 and 6 (attached) give breakdowns of existing pollutant loads by area. It is clear from Figures 5 and 6 that the sub-watersheds with the highest annual pollutant loads tend to be those that do not have existing green infrastructure in place and are highly impervious. Becker Park, for instance, has lower than average pollutant loads because it has the most unpaved area. The untreated sub-watersheds with high impervious areas offer the greatest margin for improvement.

## **4.2 PROPOSED PRACTICES**

The future possibilities model incorporates new green infrastructure into the existing conditions model to demonstrate what can be achieved in different applications. The new green infrastructure was designed to meet MIDS where practical. The new stormwater management practices are placed strategically within the sub-watersheds to capture the most runoff. These potential SSGI locations are described below. If all of the proposed practices were developed, the City of Crystal would reduce TSS loads by 39,000 pounds per year and TP loads by 122 pounds per year. Sub-watersheds where MIDS was met achieved greater than 90% TSS load reduction and greater than 85% TP load reduction annually.

The following pages are dedicated to the proposed BMPs. Each page gives a breakdown of what the BMP achieves, how much it will cost, and what percentage of the property is publicly owned including streets. Figures 7 and 8 (attached) show the net TSS and TP loads by sub-watershed as a result of the proposed BMPs.





**Underground  
Garage with a  
History of Flooding**

**TSS reduction:**

1,374 lbs/yr

**TP Reduction :**

4.3 lbs/yr

**Volume Reduction:**

209,000 cf/yr

**Drainage Area:**

2.61 acres

**Percent Public:**

28%

**Construction Cost:**

\$92,000

**Life Cycle Cost:**

\$142,000

**Life Cycle / Pound TP:**

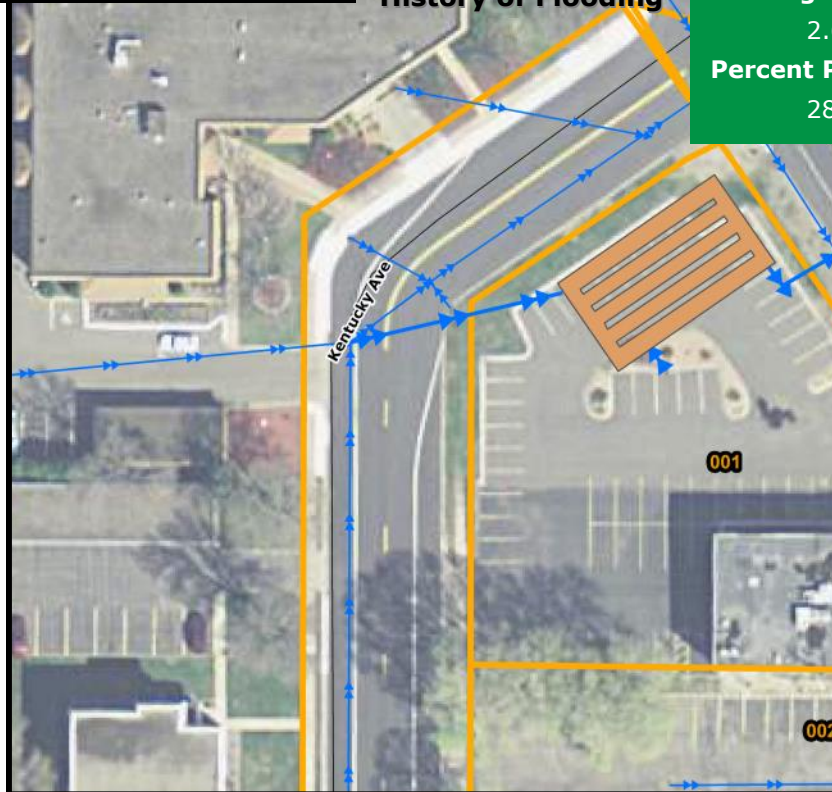
\$1,650/lb

**Percent Impervious:**

88%

**Percent Private:**

72%



**Sub-Watershed 001** - is partially tax forfeit land, giving ownership of the property to Hennepin County. This provides a unique opportunity for a public project that demonstrates Shared Stacked-Function Green Infrastructure in a highly urban area. The City of Crystal could construct an infiltration trench in the parking lot so the site's functionality is maintained while managing stormwater and reducing flooding concerns.

The proposed design demonstrates Shared Stacked-Function Green Infrastructure by diverting runoff from Kentucky Avenue into the infiltration trench. Runoff from the street, neighboring properties, and the site's parking lot collects in a combined stormwater management system to improve water quality from a larger area. The infiltration trench has a footprint of approximately 2,800 square feet.

The building identified above has an underground garage which experienced flooding in the past. Diverting runoff into the infiltration trench will reduce the risk of future flooding by retarding peak flows and retaining 1.1 inches of runoff. The design could also be expanded to receive runoff from the North Broadway storm sewer.

# 002 & 003

<b>TSS reduction:</b>	<b>Drainage Area:</b>
1,628 lbs/yr	2.84 acres
<b>TP Reduction :</b>	<b>Percent Impervious:</b>
5.0 lbs/yr	96%
<b>Volume Reduction:</b>	<b>Percent Private:</b>
245,000 cf/yr	100%

**Sub-Watersheds 002 & 003** - encompass property that is currently vacant. The property is in a prime location for commercial business and is expected to redevelop in the near future. When this area redevelops, it will be required to meet the current watershed rules and treat 1 inch of runoff from impervious surfaces. This amounts to a stormwater system capable of infiltrating 2,500 cubic feet of runoff.

There are several options for stormwater management on this site. One example: A cistern that catches roof runoff could slowly release water to a series of tree trenches. The passive watering system would keep the trees well watered through periods of dry weather and give the location more scenic appeal.

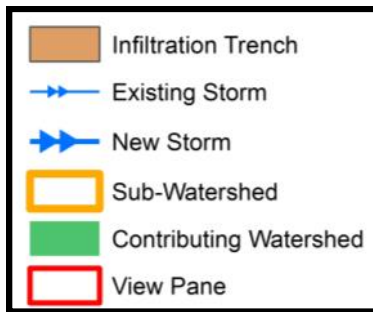


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# 004



## TSS reduction:

1,167 lbs/yr

## TP Reduction :

3.6 lbs/yr

## Volume Reduction:

178,596 cf/yr

## Drainage Area:

2.29 acres

## Percent Public:

34%

## Construction Cost:

\$78,000

## Life Cycle Cost:

\$128,000

## Life Cycle / Pound TP:

\$1,776/lb

## Percent Impervious:

85%

## Percent Private:

66%



**Sub-Watershed 004** - is uniquely situated along Kentucky Avenue to allow for a storm sewer diversion. The site currently functions as an office building. The proposed infiltration trench collects runoff from the site and street storm sewer by diverting runoff from a nearby manhole. In effect, the stormwater control

measure is able to accommodate runoff from multiple land uses and preserves the property's main function.

The figure to the left is a street view of the location for the proposed infiltration trench. The existing parking lot is nearing the need for replacement. The ideal time to install the infiltration trench is when the pavement is replaced. This would prevent replacing pavement multiple times and coincide with meeting the Watershed rules for pavement replacement.

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# 005, 006, & 007

<b>TSS reduction:</b>	<b>Construction Cost:</b>
1,462 lbs/yr	\$235,000
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
4.7 lbs/yr	\$335,000
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
242,629 cf/yr	\$3,564/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
2.82 acres	83%
<b>Percent Public:</b>	<b>Percent Private:</b>
13%	87%

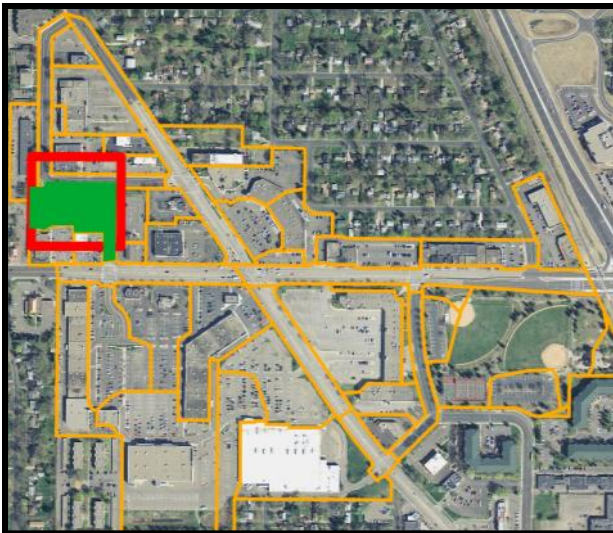


**Sub-Watersheds 005, 006, & 007** - do not have trees where the property borders the street. Tree trenches offer several benefits suited to locations that are highly impervious with limited space. The benefits of installing tree trenches are evidenced by their growing popularity in urban environments. The proposed tree trenches are complimented by rain gardens specially located to receive roof and parking lot runoff.

The planted trees improve the street-scape by adding vegetation but requiring a minimum footprint. The underground rock media provides a stable subsoil for the tree's roots that may be lacking to other urban trees. The extra stability has been shown to lengthen the lifespan of urban trees. The tree canopy promotes evapotranspiration which reduces annual runoff volumes. In addition, runoff storage is provided in the underground rock media and promotes infiltration and groundwater recharge. Both the tree trenches and the rain gardens increase the area's green space. The Rain Guardian is a common pretreatment device used for both tree trenches and rain gardens.



## 008 & 010



### TSS reduction:

1,396 lbs/yr

### TP Reduction :

4.4 lbs/yr

### Volume Reduction:

215,622 cf/yr

### Construction Cost:

\$48,600

### Life Cycle Cost:

\$98,600

### Life Cycle / Pound TP:

\$1,597/lb

### Drainage Area:

0.54 acres

### Percent Impervious:

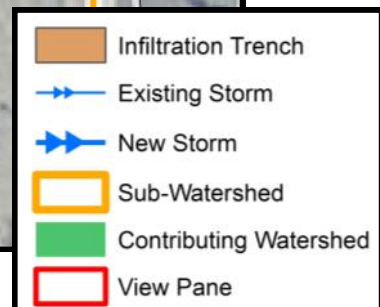
100%

### Percent Public:

29%

### Percent Private:

71%



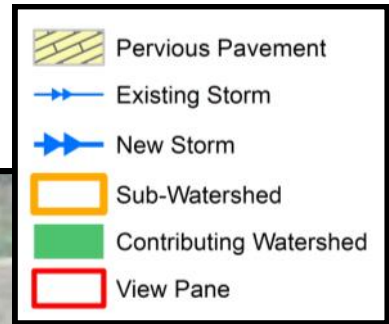
**Sub-Watersheds 008 & 010** - have a parking area that is under-utilized. There is a paved area in the northeast corner of Sub-Watershed 008 that is rarely used. The pavement could be removed and replaced with green space which reduced runoff volumes and increases the appeal of the area. As an added benefit, the green space would offer an outdoor location for employees to take a break or eat lunch.

Shared, stacked function green infrastructure could be promoted by installing an infiltration trench below the green space. The added stormwater management gives the property multiple uses: it meets watershed goals, infiltrates and treats runoff from multiple properties and land uses, and reduces flood concerns downstream by retaining runoff.

Because the facility benefits multiple properties, a clear designation of maintenance responsibilities is recommended. The green space would require regular landscaping maintenance. The infiltration trench would require annual inspections and period removal of sediment using a vacuum truck.

# 009

<b>TSS reduction:</b>	<b>Construction Cost:</b>
532 lbs/yr	\$34,800
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
1.7 lbs/yr	\$54,800
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
84,942 cf/yr	\$1,612/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
0.97 acres	90%
<b>Percent Public:</b>	
100%	



**Sub-Watershed 009** - drains to the center of the parking lot rather than the curb. The catch basins are located in the driving lanes which limits the ability to capture runoff before it enters the storm sewer. Pervious pavers offer a

means of collecting runoff that neither changes the site's topography, nor alters the site's functionality.

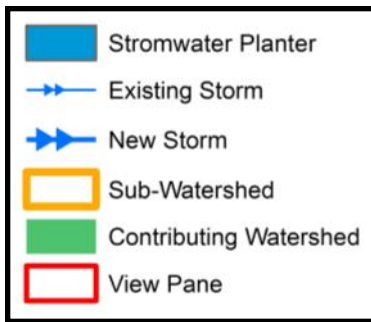
Runoff flows over the parking lot and between the pervious pavers to the porous rock storage below. When the storage is occupied, runoff overflows into the existing catch basins. Pavers should be periodically inspected and vacuumed to remove accumulated particulates. This maintains the functionality and longevity of the pervious pavers.

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# 011



## TSS reduction:

328 lbs/yr

## TP Reduction :

1.1 lbs/yr

## Volume Reduction:

51,836 cf/yr

## Drainage Area:

0.54 acres

## Percent Private:

100%

## Construction Cost:

\$48,600

## Life Cycle Cost:

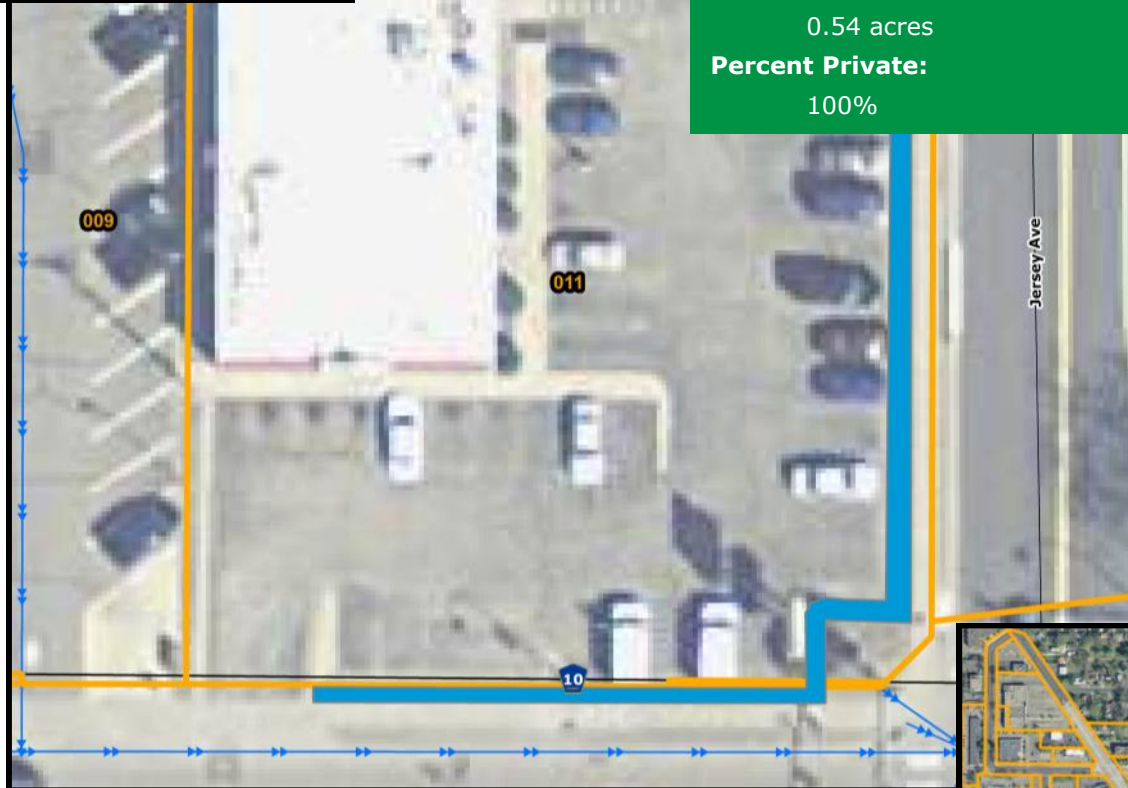
\$98,600

## Life Cycle / Pound TP:

\$4,482/lb

## Percent Impervious:

100%

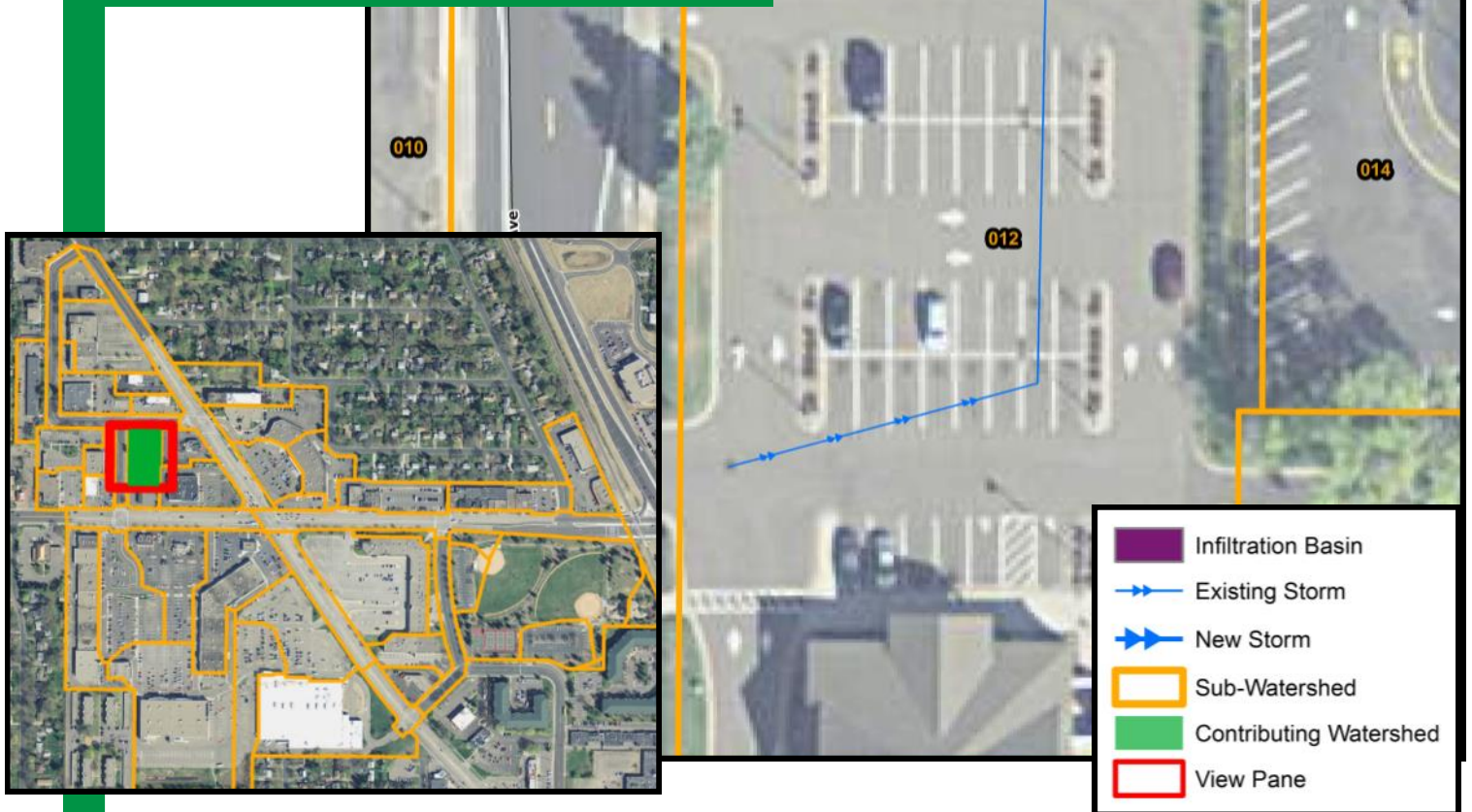


**Sub-Watershed 011** - is a half acre site that is almost entirely impervious with very little room to accommodate stormwater management. Stormwater planters are perfectly suited to the limitations of this property. The proposed stormwater planters stretch the length of the property line, improve the aesthetics of the site, and capture runoff along the curb. No parking spaces are lost to stormwater management.

Lack of space will often drive up the cost of green infrastructure, as is the case for this property. While stormwater planters are ideal where space is limited, they tend to be expensive to construct and maintain.

# 012

<b>TSS reduction:</b>	<b>Construction Cost:</b>
423 lbs/yr	\$9,000
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
1.3 lbs/yr	\$59,100
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
66,647 cf/yr	\$2,272/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
0.97 acres	72%
<b>Percent Private:</b>	
100%	



**Sub-Watershed 012** - Has an existing storm sewer system that runs through a green space at the north end of the property creating an ideal scenario for stormwater management. The proposed plan re-purposes this green space with an infiltration basin. The infiltration basin is situated between two large trees at the east and west ends of the green space, respectively. The project breaks the existing storm sewer to discharge directly into the proposed infiltration basin. Overflow from the basin is discharged into the other end of the existing storm sewer and ultimately downstream.

It is possible that the infiltration basin could receive street runoff in addition to the private property. Installing curb cuts along the road allows runoff from the street the enter the basin. Overflow is discharged back to the street storm sewer.

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**Sub-Watershed 013** - is a highly trafficked area with minimal available space. Any stormwater management must collect runoff without impeding the site's function. A simple retrofit option is proposed to treat runoff without interfering with continued business.

An infiltration catch-basin (image below) has a porous media for a base and a sump. The catch-basin operates like a sumped catch basin during a rainfall event with the added benefit of infiltration. Runoff is slowed enough to settle out some of the particulate matter and retained in the sump. Pooled water in the sump and porous rock media infiltrates through the open bottom.

The infiltration catch-basin is a proven technology for parking lots and streets. Periodic maintenance is required to remove accumulated sediment and maintain infiltration potential.

## TSS reduction:

44 lbs/yr

## TP Reduction :

0.04 lbs/yr

## Volume Reduction:

1,307 cf/yr

## Construction Cost:

\$8,000

## Life Cycle Cost:

\$10,000

## Life Cycle / Pound TP:

\$12,500/lb

## Drainage Area:

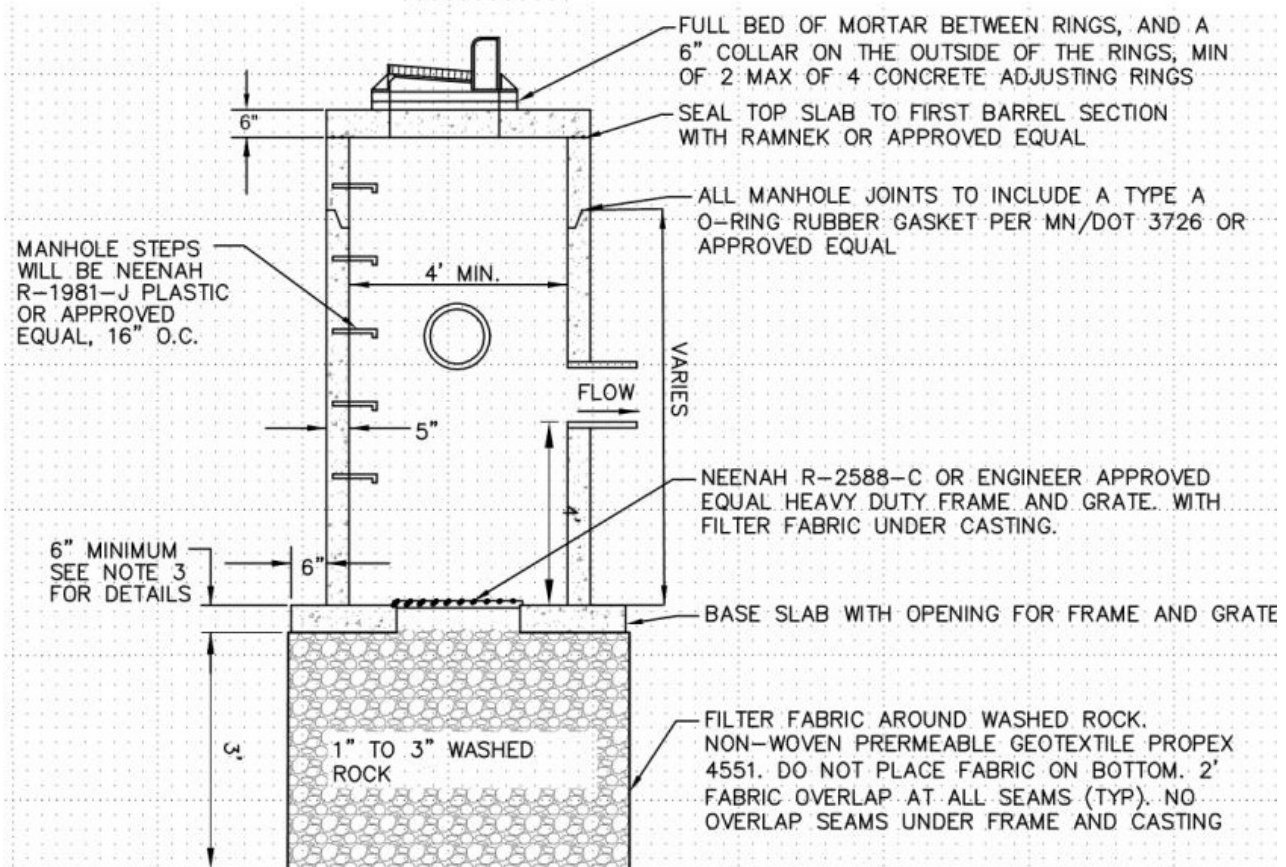
0.37 acres

## Percent Impervious:

80%

## Percent Private:

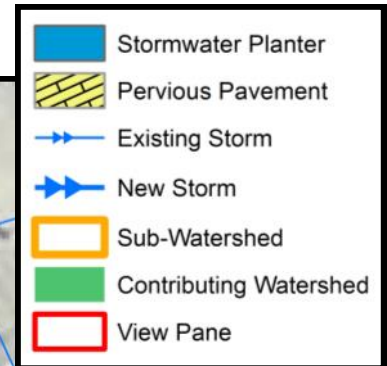
100%



**Infiltration Catch-basin Detail from Capital Region Watershed District.**

# 014

<b>TSS reduction:</b>	<b>Construction Cost:</b>
463 lbs/yr	\$49,200
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
1.5 lbs/yr	\$99,200
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
73,181 cf/yr	\$3,307/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
0.82 acres	93%
<b>Percent Private:</b>	
100%	



**Sub-Watershed 014** - drains runoff to the center of the parking areas which receive regular traffic. The site has some parking that is under-utilized, but is located at the highest elevations on the site making it unsuitable for stormwater

management. To maintain the site's function and promote infiltration, pervious pavers and stormwater planters are proposed in the low-lying areas.

The pervious pavers replace existing pavement around a catch basin to capture runoff before it enters the storm sewer. Runoff will first enter the pavers and spill over into the catch basin when the underlying voids are saturated. The stormwater planters are proposed as a barrier between a drive through lane and a traffic lane. As a result, the stormwater planters offer both stormwater function and traffic separation.





## TSS reduction:

858 lbs/yr

## TP Reduction :

2.7 lbs/yr

## Volume Reduction:

131,116 cf/yr

## Construction Cost:

\$19,100

## Life Cycle Cost:

\$69,100

## Life Cycle / Pound TP:

\$1,279/lb

## Drainage Area:

1.78 acres

## Percent Impervious:

83%

## Percent Private:

100%

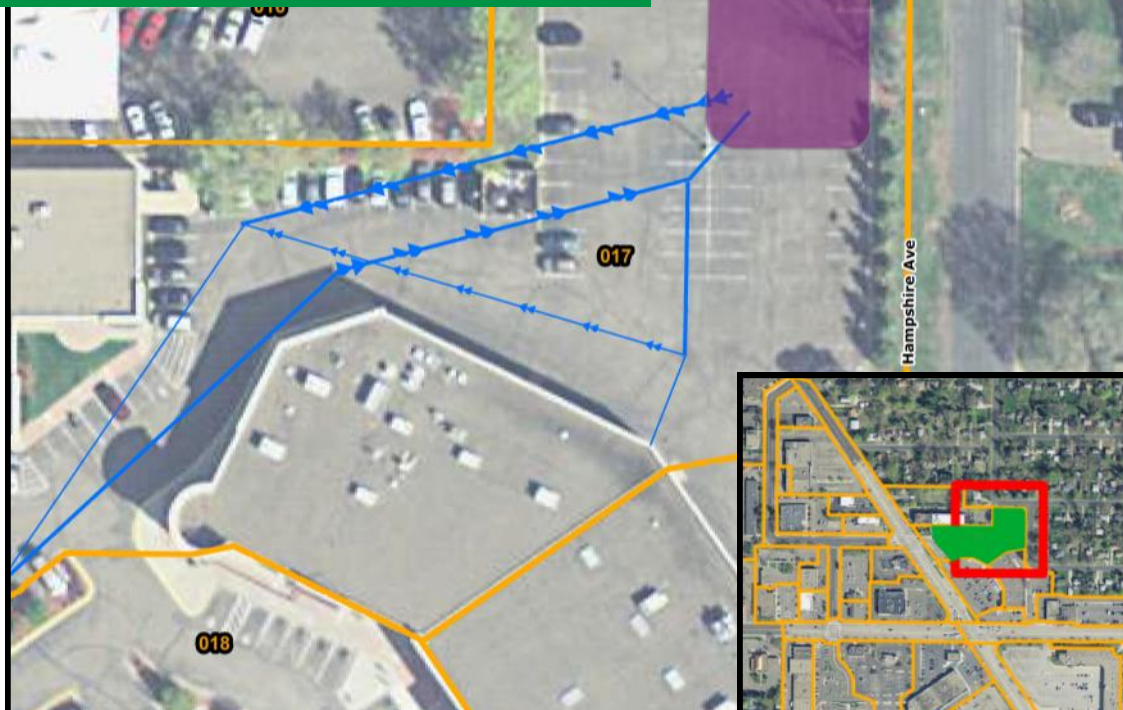


**Sub-Watershed 015** - has some under-utilized parking on the corner of West Broadway and Bass Lake Road. The location is ideal for public interaction with stormwater management. This location may conflict with city zoning regulations which require a certain number of parking spaces. If parking regulations become an issue, the practice could be constructed as an infiltration trench to maintain the available parking.

The proposed infiltration basin should be lined with native butterfly habitat. Educational signage along the road invites passers-by to engage the environment and learn about shared, stacked-function, green infrastructure. The infiltration basin requires some storm sewer replacement to route runoff to the desired location. The storm sewer work increases the cost of this infiltration basin which tends to be one of the more inexpensive stormwater control measures.

# 017

<b>TSS reduction:</b>	<b>Construction Cost:</b>
1,152 lbs/yr	\$45,800
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
3.6 lbs/yr	\$94,800
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
177,725 cf/yr	\$1,039/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
2.28 acres	84%
<b>Percent Private:</b>	
100%	



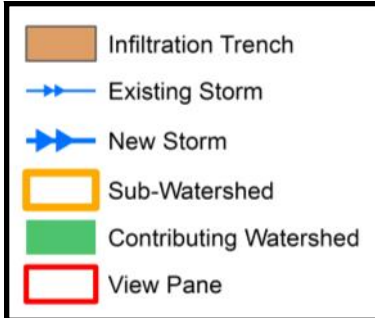
**Sub-Watershed 017** - has underutilized parking that is ideal for green space conversion. The northern most parking lot on the property is not regularly used. The area is, here, converted to green space with an infiltration basin. The green space surrounding the basin could include trails and playground equipment to be used by those in the adjacent neighborhood. The draw of a park and green space would bring people to the area on a regular basis, and higher traffic to the area could boost revenue to the neighboring businesses.

The infiltration basin will require some replacement of the storm sewer network which brings up the cost of construction. Even with the additional storm sewer costs, the practice is still a relatively affordable means of managing stormwater. The added benefits of an area attraction, public interaction, reduced impervious area, and reduced flood risk outweigh the associated costs.

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**TSS reduction:**  
705 lbs/yr

**TP Reduction :**  
1.8 lbs/yr

**Volume Reduction:**  
34,200 cf/yr

**Drainage Area:**  
1.40 acres

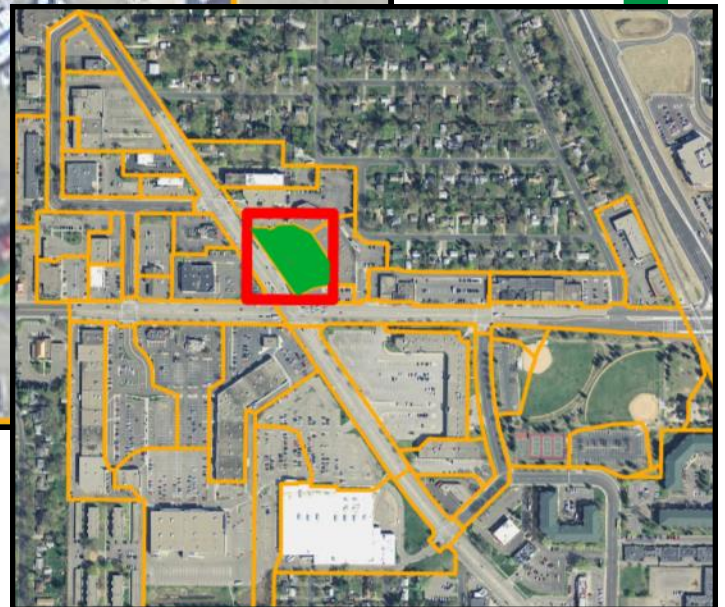
**Percent Private:**  
100%

**Construction Cost:**  
\$51,000

**Life Cycle Cost:**  
\$101,000

**Life Cycle / Pound TP:**  
\$2,800/lb

**Percent Impervious:**  
91%

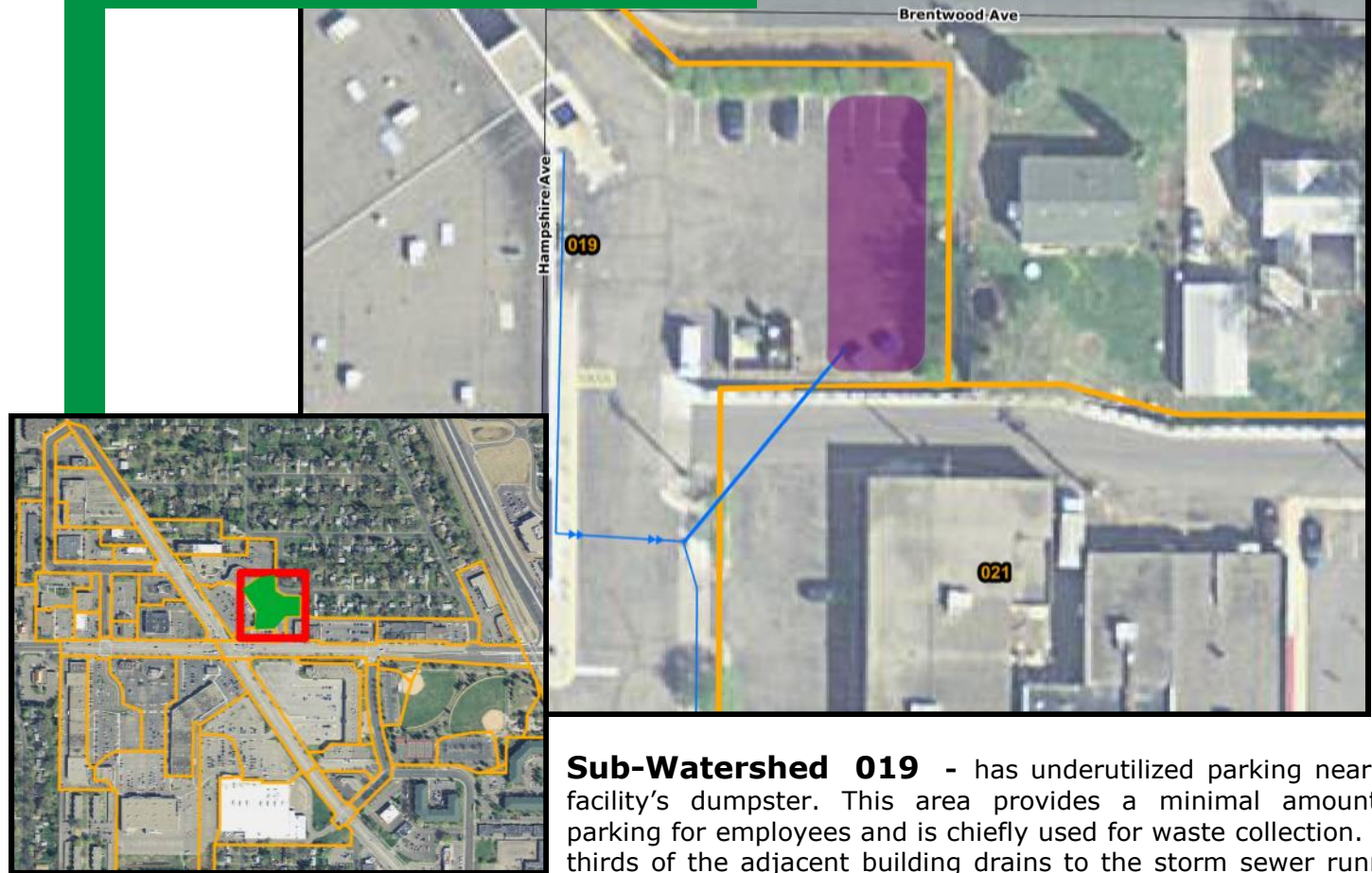
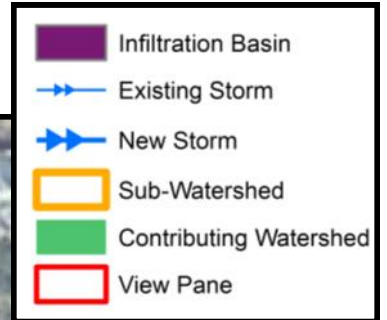


**Sub-Watershed 018** - has a well used parking lot that needs to be maintained. The parking lot generates a large volume of runoff and linked sediment load.

The proposed infiltration trench is ideal for maintaining the function of the site and as shown in the image above, requires minimal adjustment to the storm sewer. Currently, runoff from the parking lot is collected in the existing catch basins and routed to a single junction before discharging to the city storm sewer. The proposed infiltration trench is placed at this junction to minimize construction costs and maximize volume retention. In effect, runoff from the parking lot and parts of the connected commercial building is retained without affecting the site's functionality.

# 019

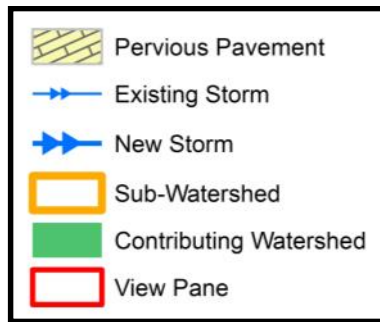
<b>TSS reduction:</b>	<b>Construction Cost:</b>
854 lbs/yr	\$18,500
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
2.7 lbs/yr	\$68,500
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
131,987 cf/yr	\$1,268/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
1.51 acres	94%
<b>Percent Private:</b>	
100%	



**Sub-Watershed 019** - has underutilized parking near the facility's dumpster. This area provides a minimal amount of parking for employees and is chiefly used for waste collection. Two thirds of the adjacent building drains to the storm sewer running along the alley.

An infiltration basin in this location treats runoff from the drainage area and potentially trap debris intended for the dumpsters. The roof runoff and parking lot runoff can be collecting in the infiltration basin through a low-flow bypass pipe. The pipe would function as the primary discharge point for the area storm sewer until the basin water elevation exceeds the pipe crown. Then runoff discharges downstream as before.



**TSS reduction:**

204 lbs/yr

**TP Reduction :**

0.5 lbs/yr

**Volume Reduction:**

9,900 cf/yr

**Drainage Area:**

0.38 acres

**Percent Private:**

100%

**Construction Cost:**

\$14,600

**Life Cycle Cost:**

\$34,600

**Life Cycle / Pound TP:**

\$3,400/lb

**Percent Impervious:**

97%

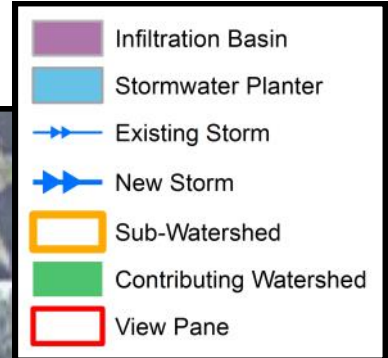


**Sub-Watershed 020** - is a small parking lot that drains to two curb-line catch basins. The parking lot receives a regular inflow and outflow of commercial patrons, so the lot's functionality needs to be maintained. Because it is almost entirely impervious, this sub-watershed also generates a significant amount of runoff and particulate matter.

The proposed pervious pavers will collect both runoff and the linked sediment load before reaching the curb and ultimately discharging downstream. In large rainfall events, the porous media below the pavers will become saturated and runoff will spill over into the existing catch basins. The volume retained will help reduce flooding concerns downstream.

# 021

<b>TSS reduction:</b>	<b>Construction Cost:</b>
1,046 lbs/yr	\$110,200
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
3.3 lbs/yr	\$160,200
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
119,154 cf/yr	\$2,428/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
1.73 acres	100%
<b>Percent Public:</b>	<b>Percent Private:</b>
71%	29%

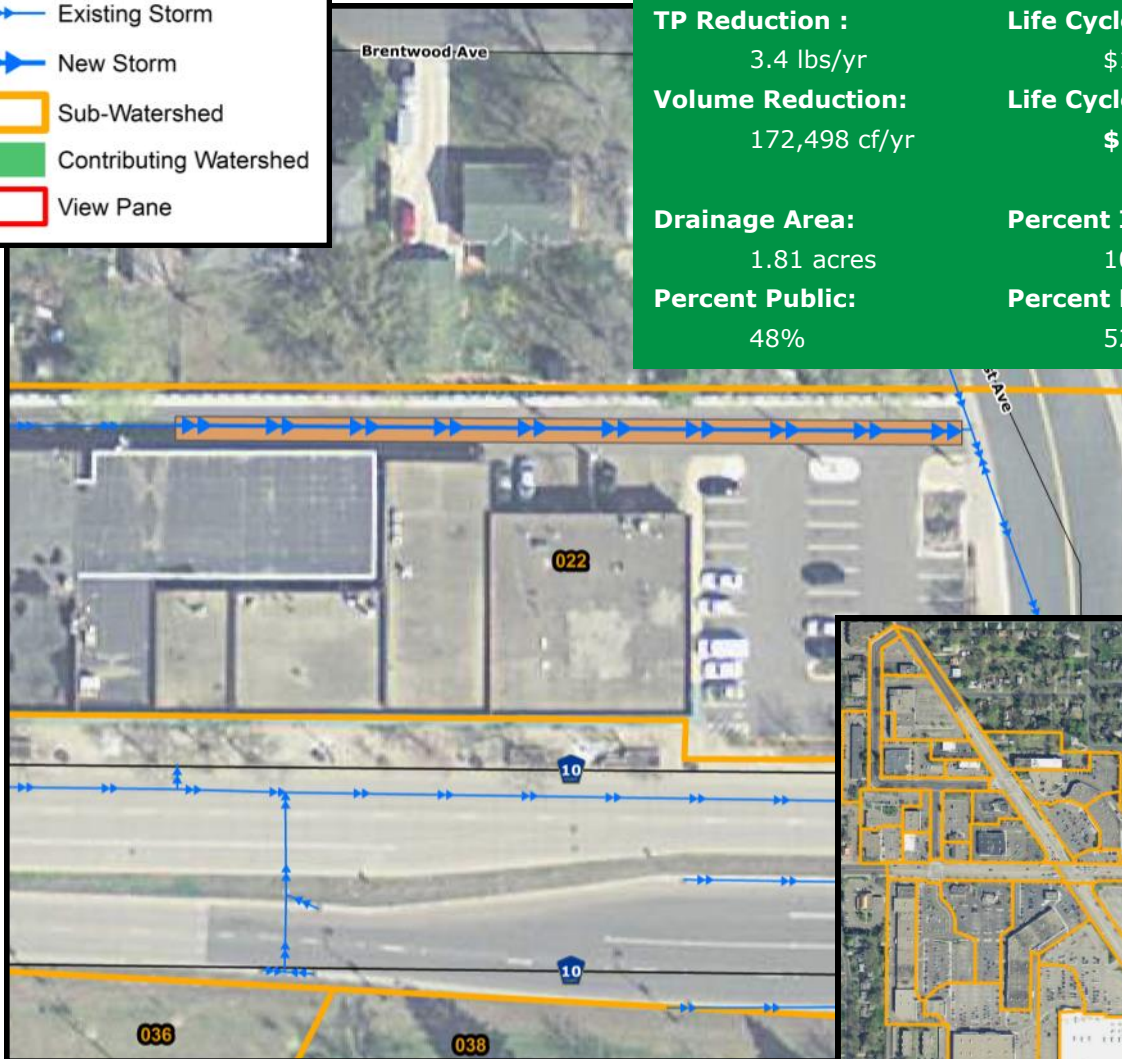
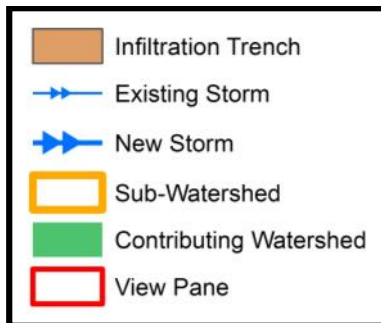


**Sub-Watershed 021** - has a parking lot owned by the City of Crystal. The site has an existing rain garden installed in place of a few parking spaces. This rain garden receives runoff from the entire parking lot.

The proposed plan improves the existing rain garden by expanding the footprint, deepening the storage, and planting native vegetation to promote pollutant removal. The addition of plants will increase pollutant removal and water retention. To supplement the rain garden, stormwater planters are proposed along the perimeter of the parking lot. Runoff from the parking lot, adjacent buildings, and alley will be collected in the stormwater planters and infiltrated or conveyed to the rain garden.

Vegetation has a positive impact on stormwater management but also increases the maintenance requirements. Annual inspections, pruning, and replacement of mulch and dead plants is needed.



**TSS reduction:**

1,092 lbs/yr

**TP Reduction :**

3.4 lbs/yr

**Volume Reduction:**

172,498 cf/yr

**Drainage Area:**

1.81 acres

**Percent Public:**

48%

**Construction Cost:**

\$72,500

**Life Cycle Cost:**

\$122,500

**Life Cycle / Pound TP:**

\$1,801/lb

**Percent Impervious:**

100%

**Percent Private:**

52%

**Sub-Watershed 022** - also has a parking lot owned by the City of Crystal. This parking lot has a small rain garden installed in the place of a few parking spaces. The alley to the north has a storm sewer that collects runoff from the buildings along the north side of Bass Lake Road.

To add stormwater capacity to the existing rain garden, an infiltration trench is proposed in place of the storm sewer. The infiltration trench will replace the existing storm sewer pipe with an in-line perforated pipe and porous rock media. Runoff from small rainfall events is retained in the porous media and perforated pipe while high flows pass through uninhibited and continue down stream as before. In both high- and low-flow scenarios, retained runoff is infiltrated removing debris, particulates, and reducing peak runoff rates.

# 023

## TSS reduction:

954 lbs/yr

## TP Reduction :

3.1 lbs/yr

## Volume Reduction:

155,509 cf/yr

## Construction Cost:

\$34,300

## Life Cycle Cost:

\$84,300

## Life Cycle / Pound TP:

\$1,360/lb

## Drainage Area:

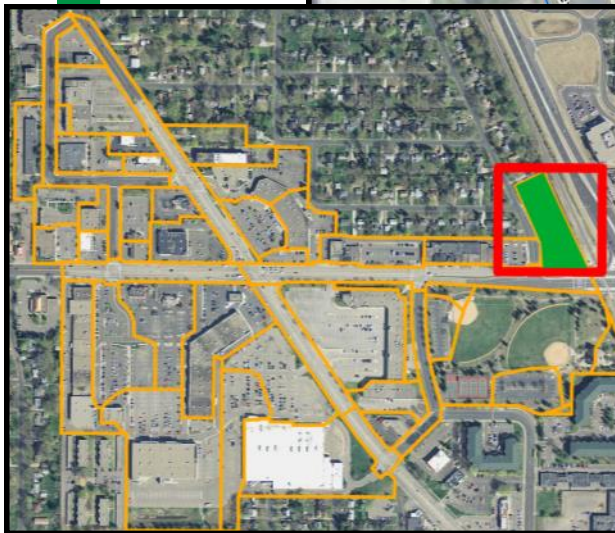
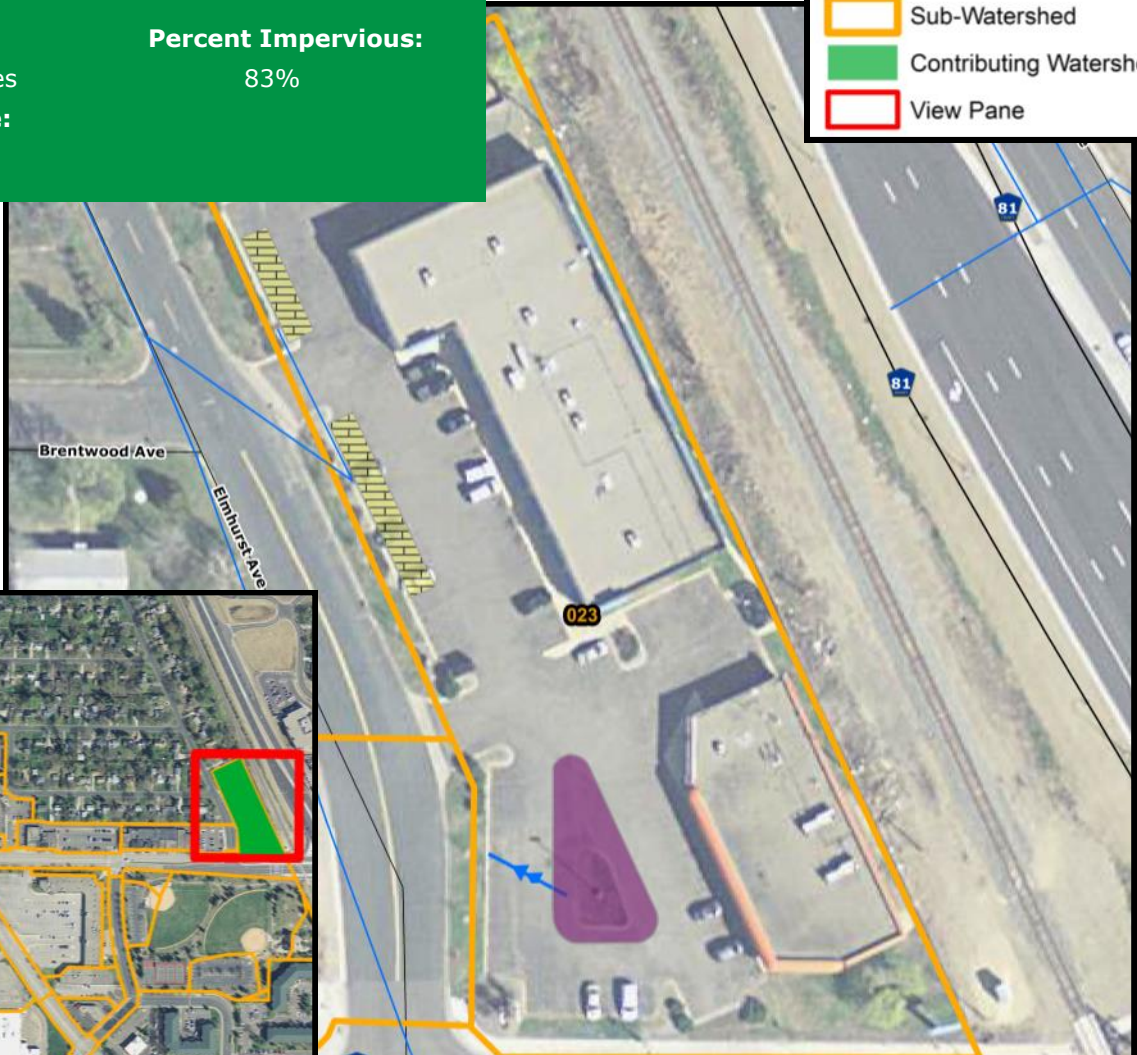
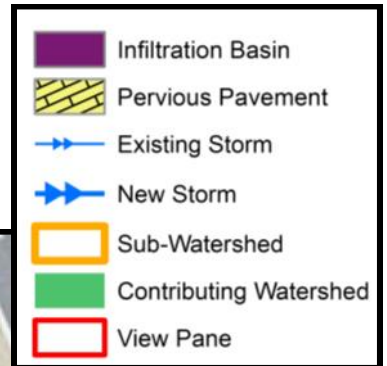
1.88 acres

## Percent Impervious:

83%

## Percent Private:

1100%



**Sub-Watershed 023** - is the combination of several small shops and their parking which is almost entirely impervious. The property is sloped to the west directing runoff toward Elmhurst Avenue.

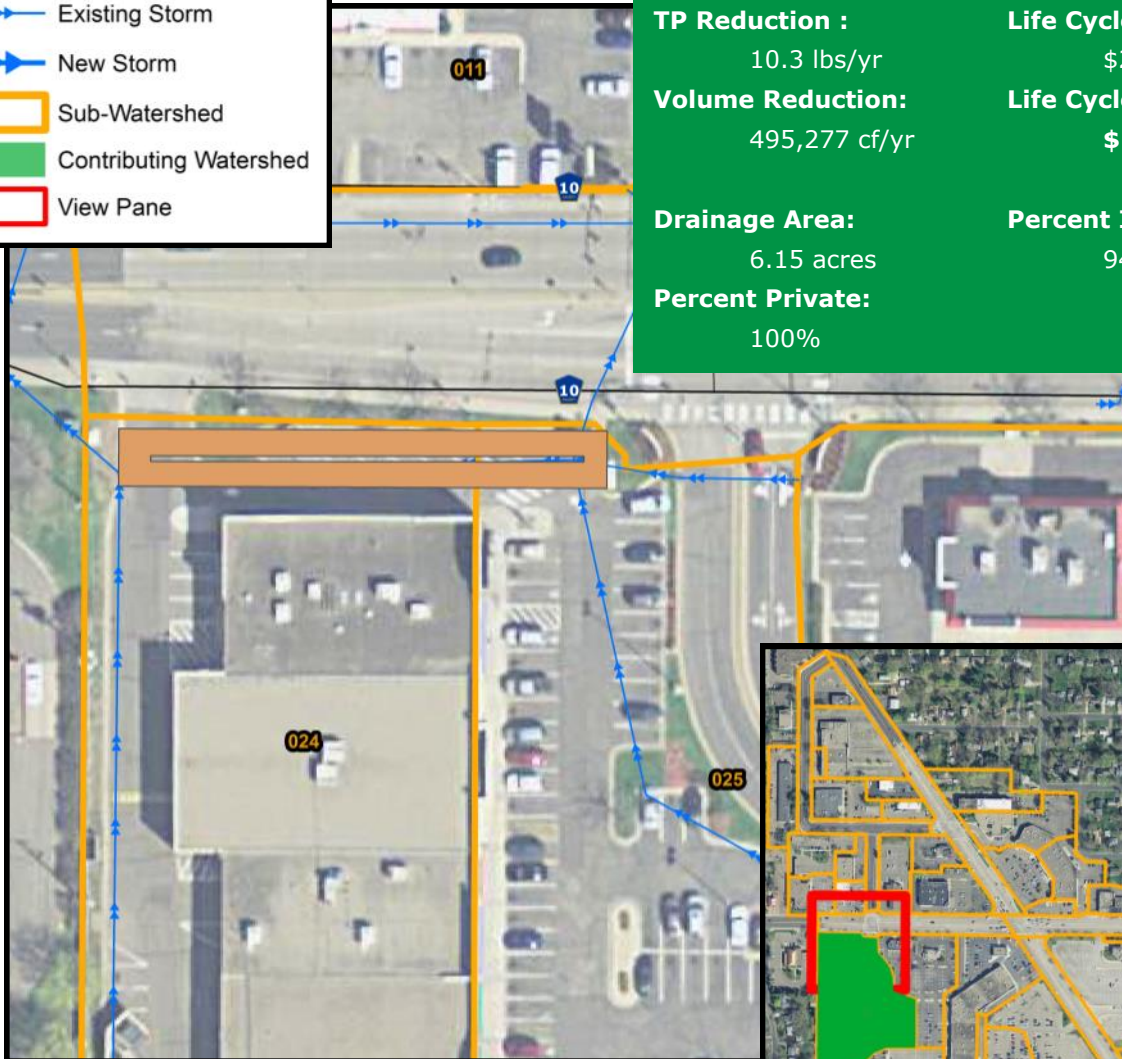
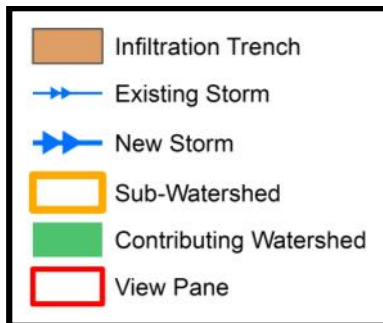
The proposed plan uses multiple practice types in the available space to manage runoff. The proposed pervious pavement is placed on the west property line to collect runoff before it enters the storm sewer. When the porous media is saturated, runoff will continue into the catch basins as before. The proposed infiltration basin is also located in a low lying area replacing some impervious area and a parking lot island.

July 2015

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## 024 & 025



### TSS reduction:

3,371 lbs/yr

### TP Reduction :

10.3 lbs/yr

### Volume Reduction:

495,277 cf/yr

### Drainage Area:

6.15 acres

### Percent Private:

100%

### Construction Cost:

\$230,700

### Life Cycle Cost:

\$280,700

### Life Cycle / Pound TP:

\$1,363/lb

### Percent Impervious:

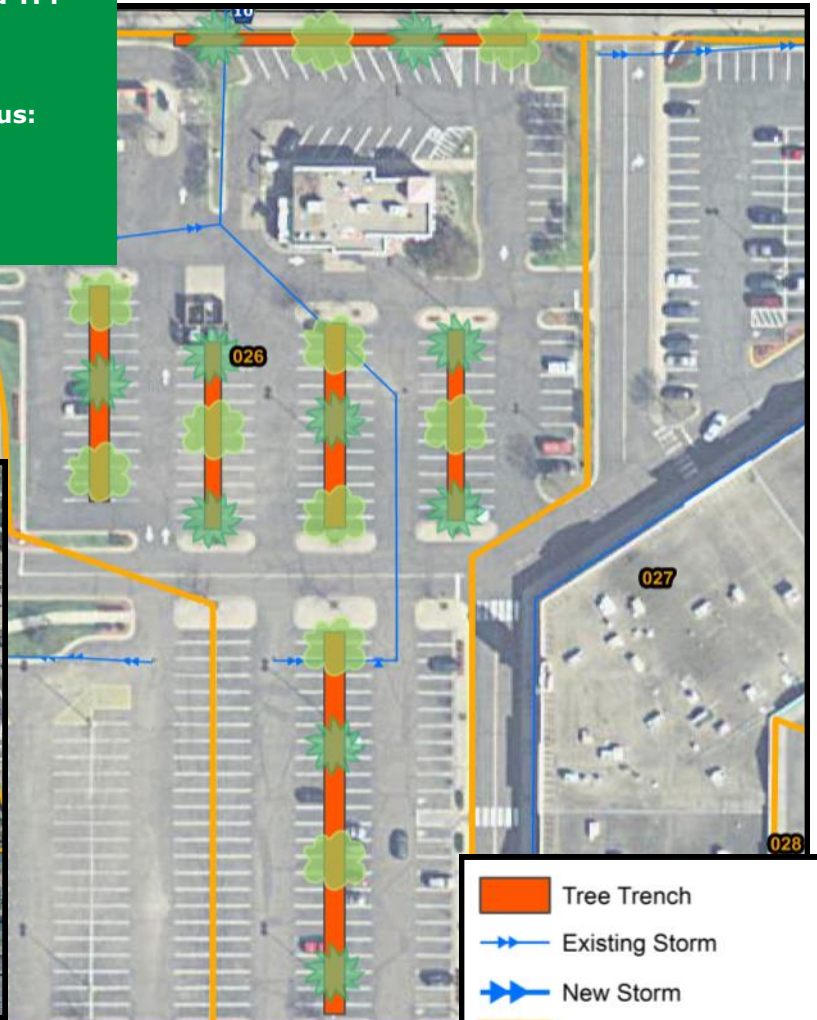
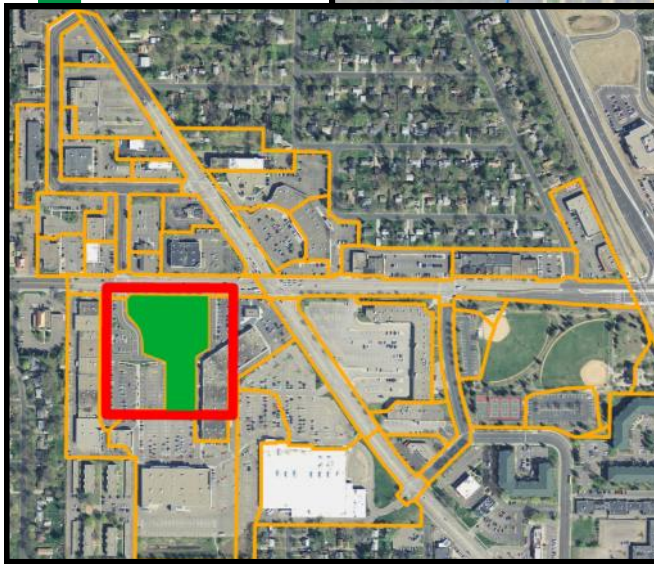
94%

**Sub-Watersheds 024 & 025**– are the first in a series of five sub-watershed plans that illustrate options for managing runoff from large parking lots and highly impervious areas. This location illustrates the economy of scale for shared, stacked-function green infrastructure. Both sub-watersheds are highly impervious but have storm sewer that converges at the northern boundary of the property.

An infiltration trench is proposed in place of existing storm sewer where the storm sewer converges and does not change the surface functionality. Because of its size and contributing watershed, this practice has one of the best pollutant reductions per dollar spent. The practice is able to retain nearly 500,000 cubic feet of runoff annually which will greatly reduce strain to the public storm sewer system in large rainfall events.

# 026

<b>TSS reduction:</b>	<b>Construction Cost:</b>
1,683 lbs/yr	\$275,300
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
5.4 lbs/yr	\$375,300
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
268,765 cf/yr	\$3,475/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
3.04 acres	91%
<b>Percent Private:</b>	
100%	



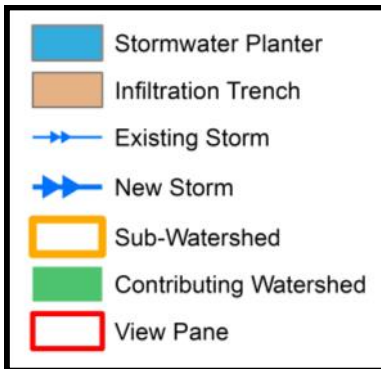
- Tree Trench
- Existing Storm
- New Storm
- Sub-Watershed
- Contributing Watershed
- View Pane

**Sub-Watershed 026** - demonstrates a second method for managing runoff from highly impervious large parking lots. This sub-watershed has rows of parking with very little green space.

The proposed tree trenches provide green space without sacrificing parking spaces. The parking lot's visual appeal is greatly enhanced by the trees and stormwater is treated from a large impervious area. Trees also help reduce the heat-island effect by providing a vegetated canopy over the impervious area.

Tree trenches offer some added benefits but are relatively expensive when compared to infiltration trenches. As a results, the tree trenches are not as cost effective as other means of managing runoff in parking lots.





## TSS reduction:

2,314 lbs/yr

## TP Reduction :

7.2 lbs/yr

## Volume Reduction:

355,885 cf/yr

## Drainage Area:

4.01 acres

## Percent Private:

100%

## Construction Cost:

\$185,200

## Life Cycle Cost:

\$235,200

## Life Cycle / Pound TP:

\$1,633/lb

## Percent Impervious:

96%

**Sub-Watershed 027** – demonstrates the third method of stormwater management for parking lots. The stormwater management is divided between multiple practices. The storm sewer collecting runoff from the buildings is directing into an infiltration trench while runoff from the parking area is collected in the stormwater planters on the curb line. Together this well used parking is preserved and stormwater is effectively managed.



The site has also experienced some regional flooding in the north-east corner of the property. The proposed stormwater planters collect the runoff and discharge overflow to the storm sewer. The ponding area provided in the stormwater planters provides space for flood waters to pool without impacting the parking lot or street. The infiltration trench also retains runoff thereby reducing the peak effluent rates and dampening flood risks.



# 030

## TSS reduction:

1,790lbs/yr

## TP Reduction :

5.5 lbs/yr

## Volume Reduction:

268,765 cf/yr

## Drainage Area:

3.31 acres

## Percent Private:

100%

## Construction Cost:

\$120,100

## Life Cycle Cost:

\$170,100

## Life Cycle / Pound TP:

\$1,546/lb

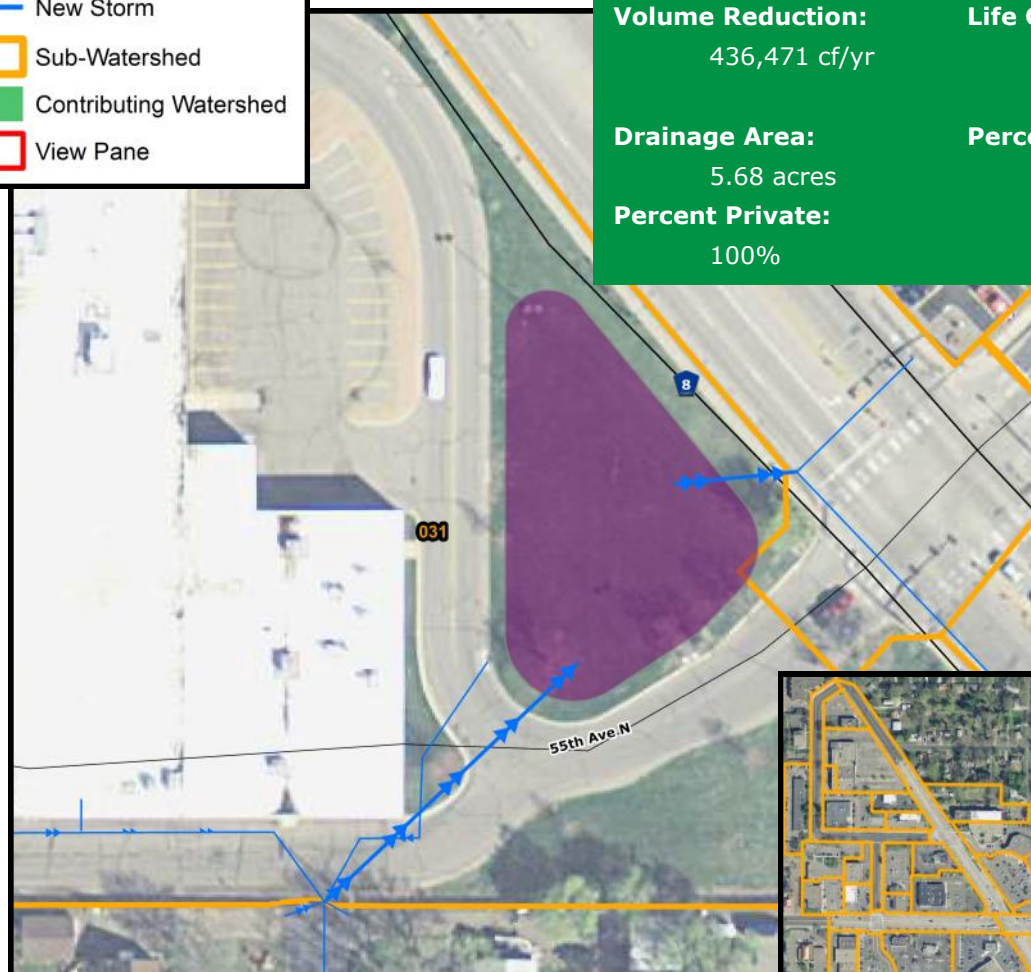
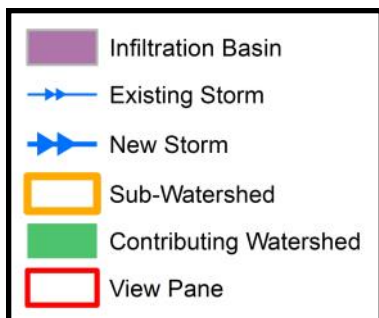
## Percent Impervious:

91%



**Sub-Watershed 030** - is the fourth method (similar to the first method) for managing runoff from large parking lots. This parking lot that drains through on storm sewer flowing to the north.

The proposed infiltration trench is proposed in-line with the existing storm sewer to intercept runoff before it continues downstream. Because the site has central catch basins instead of collection along the curbs, placement of other stormwater control measures is not ideal. Placing the infiltration trench in-line with the existing storm sewer simplifies rate control for the site. The outlet structure for the infiltration trench will manage all the runoff from the site and effectively reduce runoff rates and downstream flooding concerns.

**TSS reduction:**

2,829 lbs/yr

**TP Reduction :**

8.9 lbs/yr

**Volume Reduction:**

436,471 cf/yr

**Drainage Area:**

5.68 acres

**Percent Private:**

100%

**Construction Cost:**

\$61,600

**Life Cycle Cost:**

\$111,600

**Life Cycle / Pound TP:**

\$627/lb

**Percent Impervious:**

83%

**Sub-Watershed 031** – is the building counterpart to sub-watershed 030 and is the fifth variation on managing runoff from large impervious areas. Adjacent to the building is an open green space proposed to be converted to an infiltration basin. Existing green space can often offer some of the most cost effective stormwater management solutions.

The available green space on this site is capable of treating the runoff from the entire sub-watershed in one location including runoff from the building and access roads. The proposed infiltration basin capitalizes on a relatively cheap technology to provide a very effective stormwater treatment for minimal cost. The design requires re-routing some of the existing storm sewer to direct runoff to the basin.





# 034 & 035

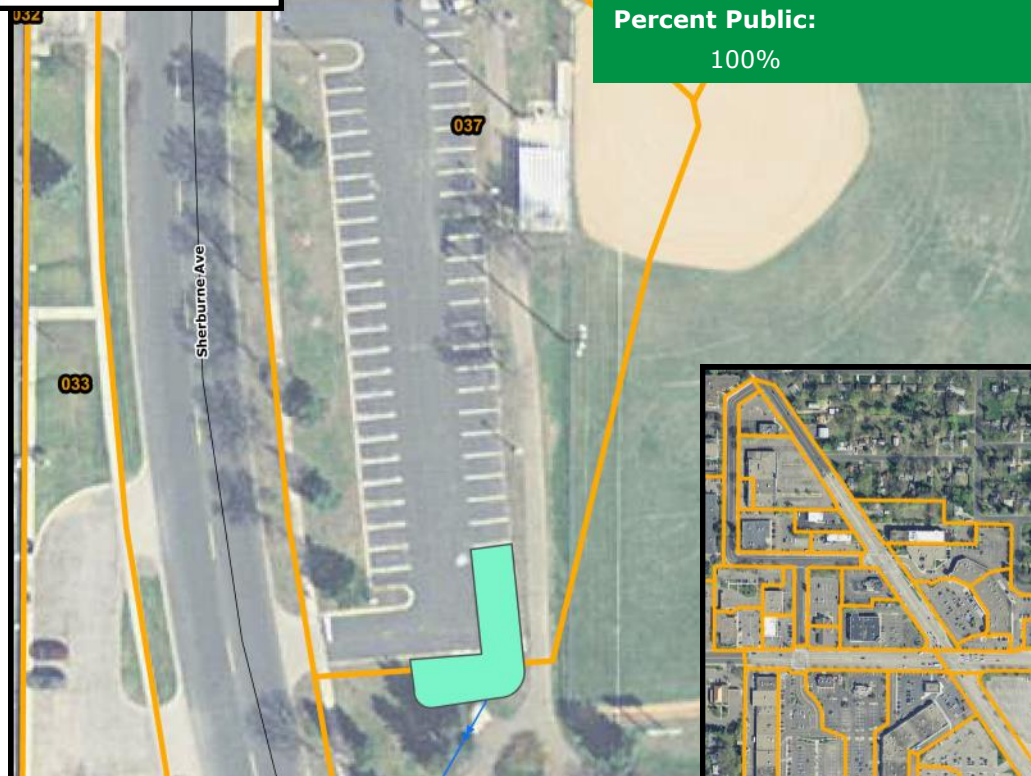
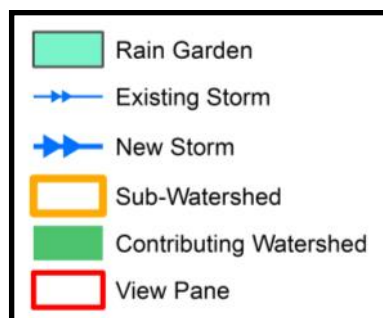
<b>TSS reduction:</b>	<b>Construction Cost:</b>
1,027 lbs/yr	\$95,100
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
3.3 lbs/yr	\$145,100
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
162,914 cf/yr	\$2,198/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
2.02 acres	84%
<b>Percent Private:</b>	
100%	



**Sub-Watersheds 034 & 035** - drain to a central storm sewer in between the properties. The City of Crystal has an easement on the city storm sewer for maintenance purposes. The easement allows the city to replace the

storm sewer with a stormwater control measure to treat runoff from multiple properties. To avoid complication from expanding the easement, the proposed infiltration trench takes the place of the existing storm sewer as an in-line stormwater control measure.

The proposed design replaces the existing storm sewer with a perforated pipe and rock media to retain and infiltrate runoff from the contributing drainage area. While the infiltration trench is designed to retain runoff from the adjacent contributing watershed of 2.02 acres, the existing storm sewer receives runoff from upstream watersheds totaling more than 8 acres. The additional watershed area has stormwater practices that already meet District goals, but the infiltration trench will further slow runoff and decrease flooding concerns in the watershed.

**TSS reduction:**

332 lbs/yr

**TP Reduction :**

1.1 lbs/yr

**Volume Reduction:**

53,143 cf/yr

**Drainage Area:**

1.09 acres

**Percent Public:**

100%

**Construction Cost:**

\$7,100

**Life Cycle Cost:**

\$57,100

**Life Cycle / Pound TP:**

\$2,596/lb

**Percent Impervious:**

50%



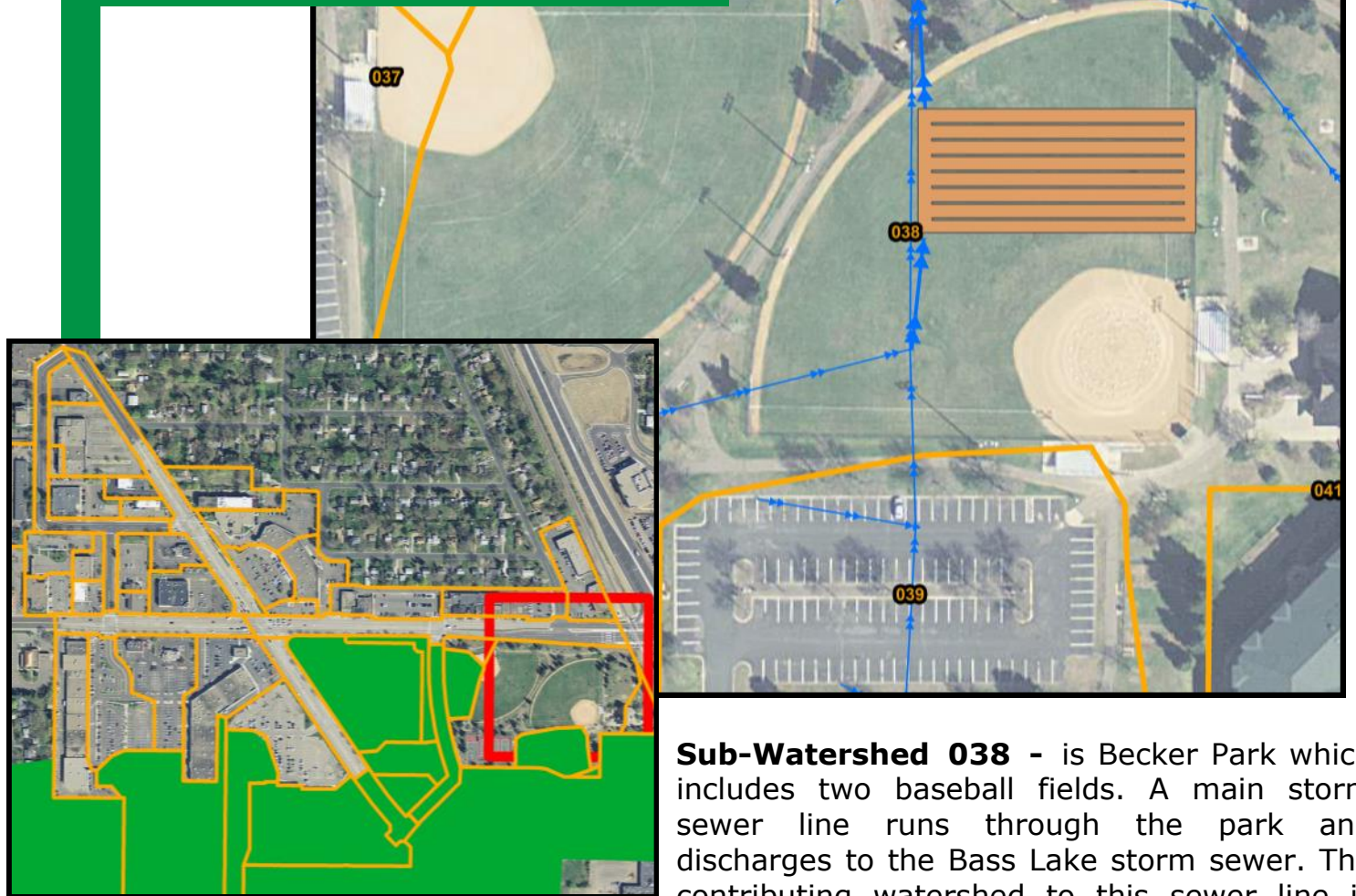
**Sub-Watershed 037** – is the parking lot for Becker Park. The parking lot makes up about half of the watershed and drains to a single catch basin in the south-east corner. The parking lot would be a good opportunity to demonstrate the use of pervious pavers but the pavement is currently in good condition. To avoid replacing pavement unnecessarily, the stormwater management focuses on surface retention.

The proposed design utilizes the rain garden design the City is already familiar with and tweaks it to include vegetation and a bit more storage depth. Runoff from the parking lot will collect in the rain garden and overflow into the existing storm sewer. The rain garden is visible to park patrons and may be a good opportunity to include some educational displays that promote public interaction and awareness.



# 038

<b>TSS reduction:</b>	<b>Construction Cost:</b>
28,505 lbs/yr	\$154,500
<b>TP Reduction :</b>	<b>Life Cycle Cost:</b>
61.1 lbs/yr	\$204,500
<b>Volume Reduction:</b>	<b>Life Cycle / Pound TP:</b>
2.8 million cf/yr	\$167/lb
<b>Drainage Area:</b>	<b>Percent Impervious:</b>
28.7 acres	82%
<b>Percent Private:</b>	<b>Percent Public:</b>
83%	17%



**Sub-Watershed 038** - is Becker Park which includes two baseball fields. A main storm sewer line runs through the park and discharges to the Bass Lake storm sewer. The contributing watershed to this sewer line is 28.7 acres within the study area and over 200

acres total. The numbers reported on this page reflect the effect of the infiltration trench on the study area but the pollutant load reduction would be much greater if the whole contributing watershed were included. This project will have a major impact on downstream water quality and runoff volumes.



## 5.0 Recommendations

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The City of Crystal is teaming with the Shingle Creek Watershed Management Commission to reduce flooding within the watershed and improve water quality discharging to downstream Twin Lake. The City has identified a highly impervious area known as the Crystal Shopping Center where green infrastructure would be most effective at reducing runoff rates, infiltrating runoff, and trapping pollutants. In this report, Shared, Stacked-Function, Green Infrastructure (SSGI) has been tailored to fit the Crystal Shopping Center and evaluated for their potential to achieve the project goals. The report also illustrates uses for various types of SSGI in hopes of providing a guide to implementation elsewhere in the City.

The proposed green infrastructure is designed to meet MPCA Minimum Impact Design Standards (MIDS). The first 1.1 inches of runoff will be retained on-site and infiltrated where practical. If all of the proposed practices were implemented, Twin Lake would receive 39,000 fewer pounds of TSS annually and 122 fewer pounds of TP annually. In addition, the SSGI would infiltrate 194 acre-feet of runoff per year. In effect, rainfall events in this area would be reduced by 1.1 inches and the City storm sewer would be capable of managing larger rainfall events.

The proposed green infrastructure have been prioritized based on the 20 year life cycle cost per pound of TP removed. The most cost effective projects are given first priority and less effective projects have lower priorities. These practices have been partitioned into City (Table 3), county (Table 4), and private (Table 5) projects. The tables should be used to gauge the value of each proposed practice and plan for future projects.

### 5.1 CITY PROJECTS

Due to recent street reconstruction and concentrated utilizes, construction of SSGI within the street right-of-way is not ideal. As a result, where needed, proposed projects were designed within private property and most of the proposed City projects have a joint public-private benefit. These mutually beneficial projects would help the City achieve its stormwater management goals and ensure private property owners meet current and future regulation when they choose to redevelop. A breakdown of the percent of public and private property being treated by an individual practice is listed in Section 4.0.

All of the proposed City projects are ranked in Table 3 based on life cycle cost per pound of TP removed. Wenck recommends the City focus its initial efforts on the large infiltration trench proposed in Becker Park. This practice is not only the most cost effective option, but manages runoff from a comparatively large watershed. The park is owned by the City and soils are ideal for infiltration. Partnerships should be pursued for the remaining projects.

**Table 3: Priority list of City projects by life cycle cost per pound of TP removed.**

Priority	Project	TSS Removed (lbs/yr)	TP Removed (lbs/yr)	Volume Reduction (ac-ft/yr)	Construction Cost	Life Cycle Cost (20 yrs)	Life Cycle per Pound of TP
1	038	28,505	61.1	65.0	\$155,000	\$205,000	\$167
2	008 & 010	1,396	4.4	5.0	\$35,000	\$55,000	\$1,612
3	001	1,374	4.3	4.8	\$92,000	\$142,000	\$1,650
4	004	1,167	3.6	4.1	\$78,000	\$128,000	\$1,776
5	022	1,092	3.4	4.0	\$73,000	\$123,000	\$1,801
6	034 & 035	1,027	3.3	3.7	\$96,000	\$146,000	\$2,198
7	021	1,046	3.3	2.7	\$111,000	\$161,000	\$2,428
8	037	332	1.1	1.2	\$8,000	\$58,000	\$2,596
9	005, 006, & 007	1,462	4.7	5.6	\$235,000	\$335,000	\$3,564

## 5.2 COUNTY PROJECTS

County roads 8 and 10 bisect within the study area and were recently reconstructed. Roads generate higher pollutant loads than most other land use types. Tree trenches could be implemented in the median to retain runoff and increase the tree canopy. The City may be able to team with the county to install tree trenches within the study area. Table 4 gives a breakdown of what will be needed to meet MIDS on the county roads within the study area.

**Table 4: Cost and pollutant removal summary for county project.**

Project	TSS Removed (lbs/yr)	TP Removed (lbs/yr)	Volume Reduction (ac-ft/yr)	Construction Cost	Life Cycle Cost (20 yrs)	Life Cycle per Pound of TP
County Roads	5,865	17.5	18.3	\$513,000	\$913,000	\$2,609

## 5.3 PRIVATE PROJECTS

The green infrastructure proposed on private property is meant to make property owners aware of their environmental impacts and encourage them to improve that impact. The plans will start a conversation about how to reduce stormwater runoff and increase water quality on private property. These options set the stage for a positive impact on the community. The City should endeavor to contact the properties, make them aware of the

stormwater plan, and make the plan accessible for use. Table 5 prioritizes these projects based on life cycle cost per pound of TP removed. The City should emphasize the projects that provide the most impact to the watershed.

**Table 5: Priority list of private projects by life cycle cost per pound of TP removed.**

Priority	Project	TSS Removed (lbs/yr)	TP Removed (lbs/yr)	Volume Reduction (ac-ft/yr)	Construction Cost	Life Cycle Cost (20 yrs)	Life Cycle per Pound of TP
1	031	2,829	8.9	10.0	\$62,000	\$112,000	\$627
2	020	226	1.7	0.9	\$15,000	\$35,000	\$1,018
3	017	1,152	3.6	4.1	\$25,000	\$75,000	\$1,039
4	019	854	2.7	3.0	\$19,000	\$69,000	\$1,268
5	015	858	2.7	3.0	\$20,000	\$70,000	\$1,279
6	023	954	3.1	3.6	\$35,000	\$85,000	\$1,360
7	024 & 025	3,371	10.3	11.4	\$231,000	\$281,000	\$1,363
8	030	1,790	5.5	6.2	\$121,000	\$171,000	\$1,546
9	009	532	1.7	2.0	\$35,000	\$55,000	\$1,612
10	027	2,314	7.2	8.2	\$186,000	\$236,000	\$1,633
11	018	707	2.4	2.8	\$51,000	\$101,000	\$2,104
12	012	423	1.3	1.5	\$10,000	\$60,000	\$2,272
13	014	463	1.5	1.7	\$50,000	\$100,000	\$3,307
14	026	1,683	5.4	6.2	\$276,000	\$376,000	\$3,475
15	011	328	1.1	1.2	\$49,000	\$99,000	\$4,482
16	013	44	0.0	0.0	\$8,000	\$10,000	\$12,500
17	002 & 003	1,628	5.0	5.6	Cost to be reviewed by redeveloper		



## 5.4 NEXT STEPS

In order to being accomplishing improved stormwater management within the study area, the City should take the following steps:

- ▲ **Select** projects that the City would like to construct within the foreseeable future.
- ▲ **Form** relationships with private entities where coordinating may be required.
- ▲ **Apply** for grants. The Minnesota Clean Water Fund is receiving applications for funding on projects that improve water quality throughout the state. The City can receive up to a 75% federal contribution for projects that reduce flooding.
- ▲ **Notify** property owners this report is available and request feedback from interested parties.
- ▲ **Contact** Hennepin County to begin the planning process for the tree trenches in County Roads 8 and 10.
- ▲ **Fully Design and Construct** projects that receive funding.

Wenck can assist the City with securing funding, if needed, and is available for questions from other interested parties.

## 6.0 References

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Chesapeake Stormwater Network. CSN Technical Bulletin No. 5 – Stormwater Design for Redevelopment Projects in Highly Urban Areas of the Chesapeake Bay Watershed, October, 2010.

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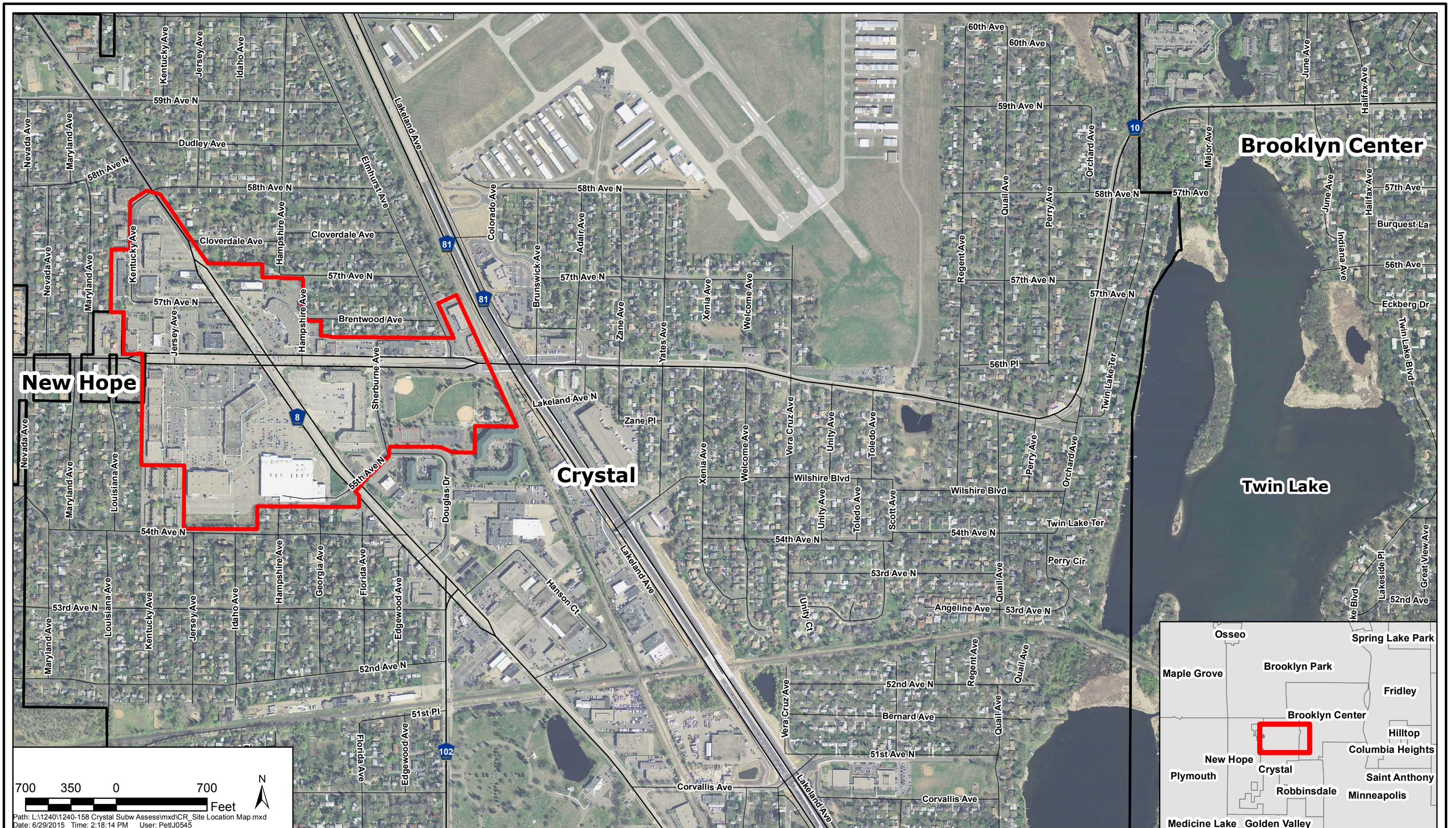
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## Figures

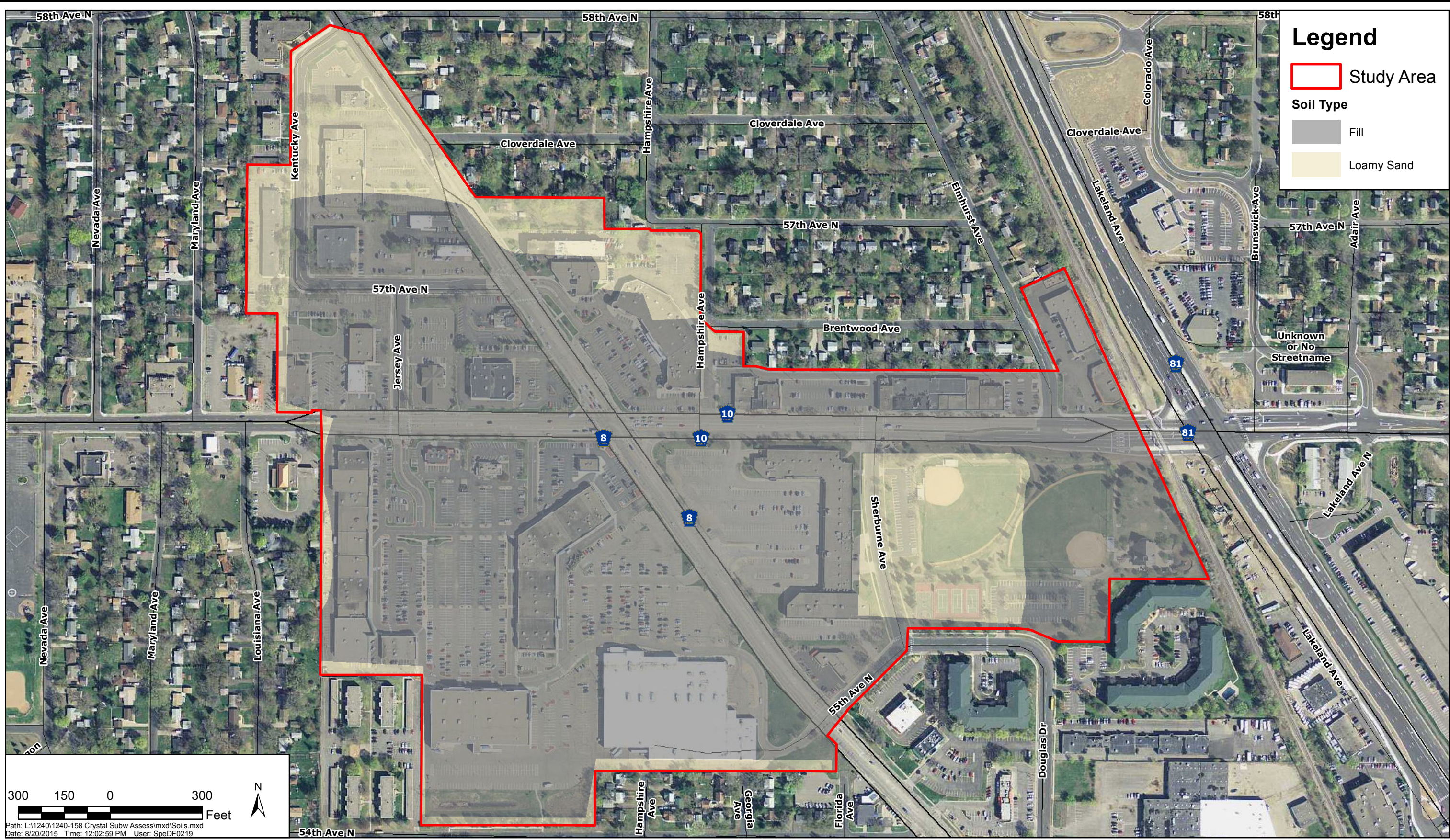
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1. Figure 1 – Site Location Map
2. Figure 2 – Existing Soils
3. Figure 3 – Property Ownership
4. Figure 4 – Watershed Delineation
5. Figure 5 – Existing TSS Loading
6. Figure 6 – Existing TP Loading
7. Figure 7 – Proposed TSS Loading
8. Figure 8 – Proposed TP Loading









**Legend**

Study Area

**Soil Type**

Fill

Loamy Sand

Unknown  
or No  
Streetname

SHINGLE CREEK WMC - CITY OF CRYSTAL

Existing Soils - NRCS Web Soil Survey



Responsive partner. Exceptional outcomes.

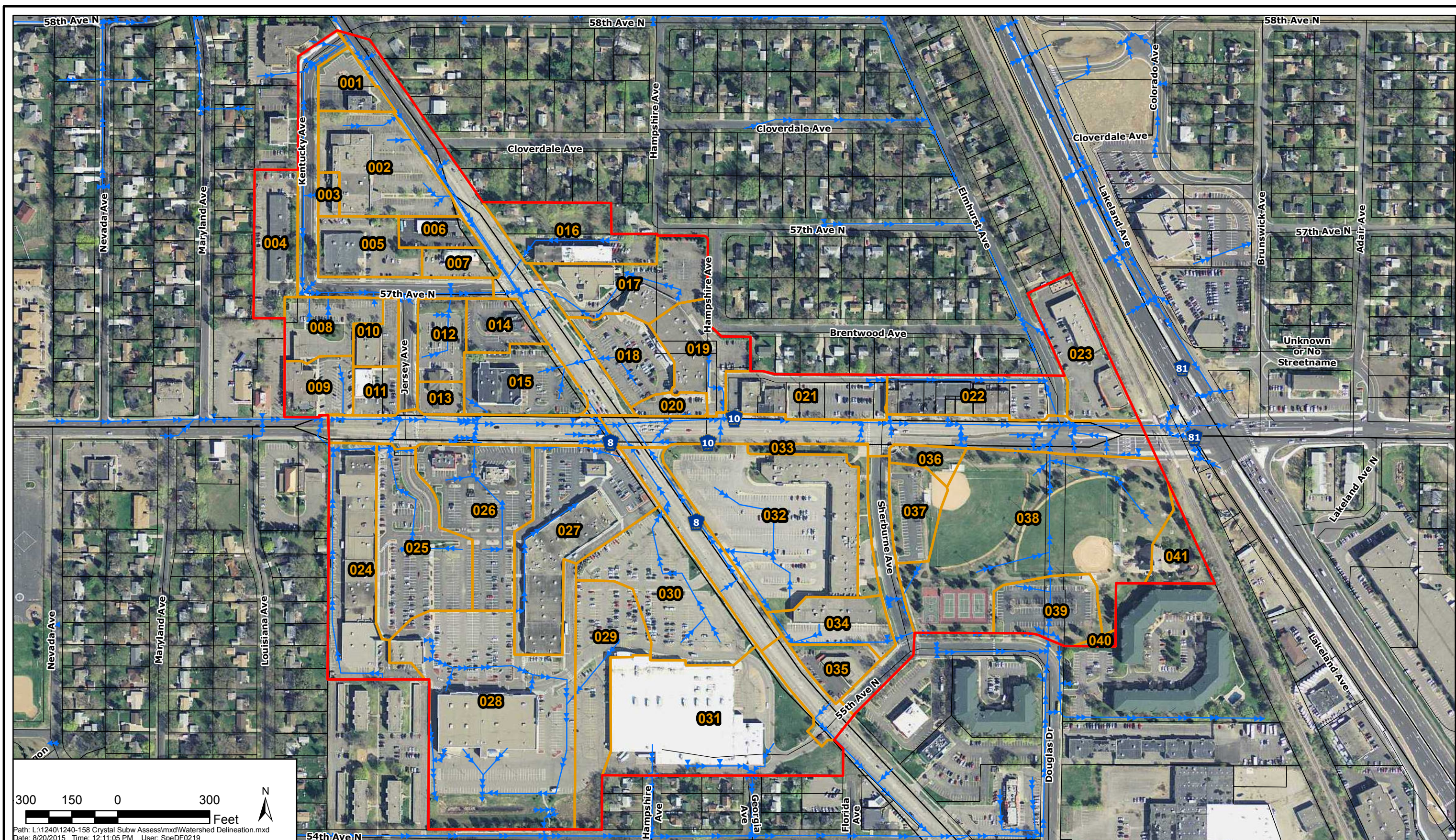
JUNE 2015

Figure 2





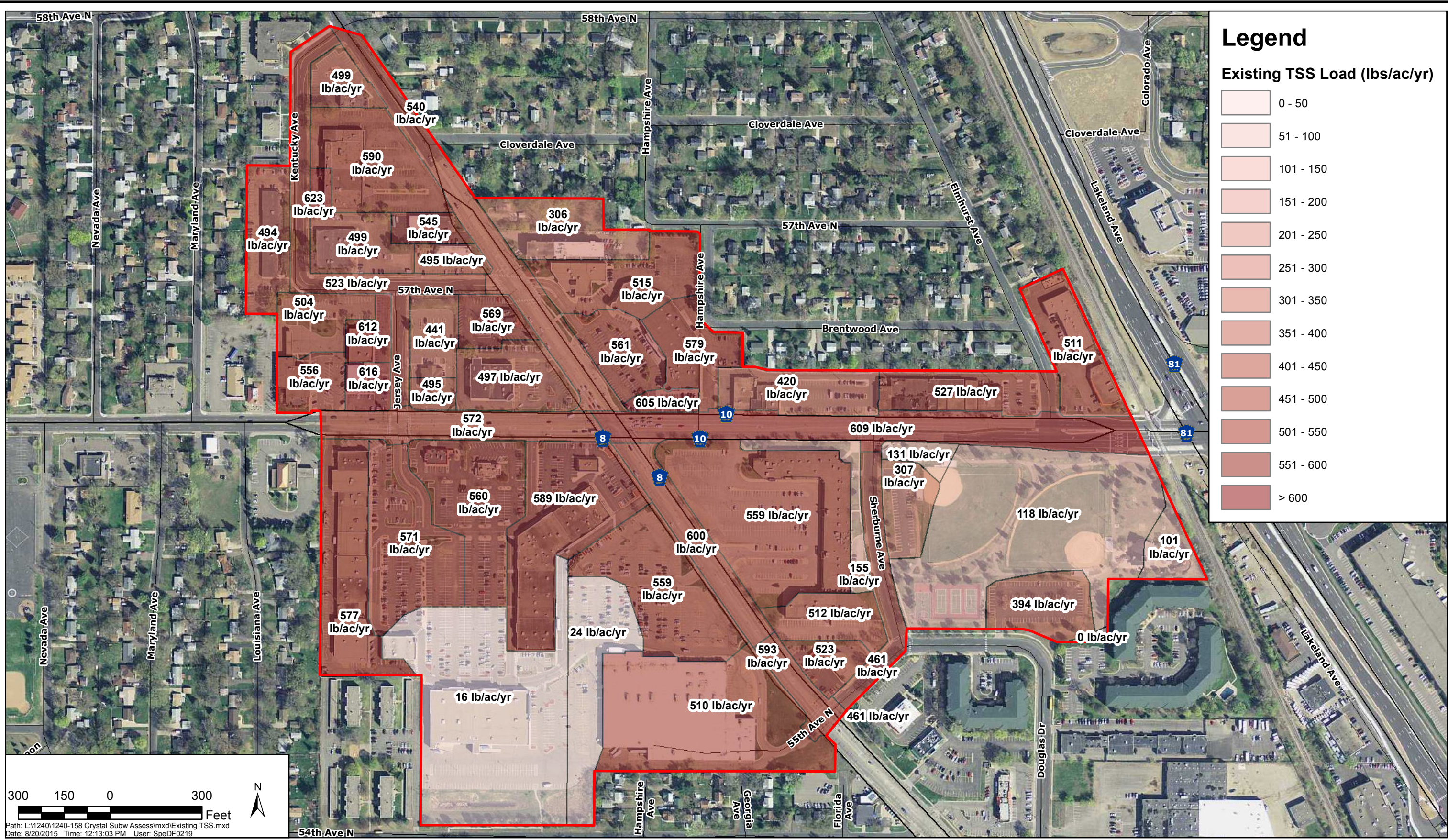




SHINGLE CREEK WMC - CITY OF CRYSTAL

Watershed Delineation





SHINGLE CREEK WMC - CITY OF CRYSTAL

Existing TSS Loading

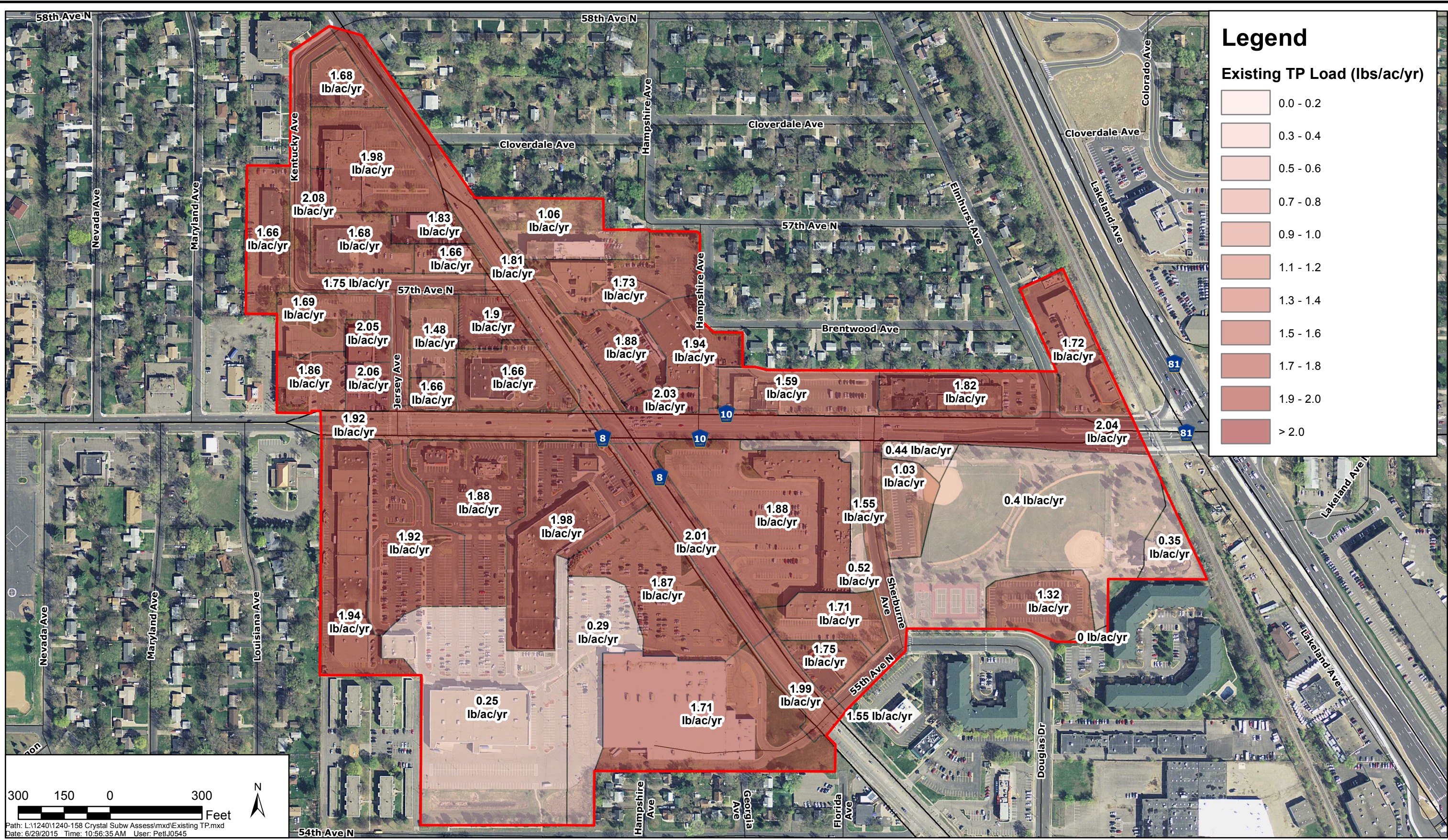


Responsive partner. Exceptional outcomes.

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Figure 5





SHINGLE CREEK WMC - CITY OF CRYSTAL

Existing TP Loading



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Figure 6





Path: L:\1240\1240-158 Crystal Subw Assess\mxs\Proposed TSS.mxd  
Date: 8/20/2015 Time: 12:19:15 PM User: SpeDF0219

SHINGLE CREEK WMC - CITY OF CRYSTAL

Proposed TSS Loading



JULY 2015

Figure 7



