Appendix D TECHNICAL MEMORANDUM: ANALYSIS AND EVALUATION FOR SHARED, STACKED-FUNCTION, GREEN INFRASTRUCTURE

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SRF No. 7687-0280

MEMORANDUM

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City of Saint Paul, MN

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DATE: December 23, 2013

SUBJECT: ANALYSIS AND EVALUATION FOR SHARED, STACKED-FUNCTION, GREEN INFRASTRUCTURE

Purpose

This memorandum summarizes the input gathered from stakeholders, and precedent investigations that set the foundation for technical evaluation of shared, stacked-function green infrastructure (SSGI). This memorandum also documents the process used to solicit and screen potential redevelopment sites along the corridor that resulted in a list of high priority sites. Finally, this memorandum summarizes the investigation of four potential SSGI approaches on two of the high priority sites, including conceptual designs developed and cost-benefit analyses performed.

Referenced Memorandums

- White Paper: Shared, Stacked-function, Green Infrastructure Policy Investigation

SSGI Opportunities and Barriers

Developers Focus Group

Over the course of the project, the project team met with select developers with project experience in the Cities of Saint Paul and/or Minneapolis. The group discussed existing approaches and methods to stormwater management and identified opportunities and implementation barriers of SSGI.

Existing stormwater management considerations include:

- Location is the primary determinant in deciding whether to redevelop a site. Developers will make stormwater management work for site selected.
- Stormwater approach used is based on estimated construction and long-term maintenance costs. Underground treatment is expensive to construct.

- Some developers believe that cities typically require developers to over-engineer their systems as a safeguard since existing utility mapping may not be accurate.
- Incentives do motivate developers in deciding to what extent they will implement stormwater treatment elements, but may not necessarily be a driver of the approach taken. Potential/existing incentives mentioned include:
  - Minneapolis stormwater quantity and quality credits
  - Expedited permitting process
  - Density bonuses
- Developers typically are not pioneers regarding new technologies, unless it is on a very small scale. They want to see in-place examples first. It was expressed that cities and large corporations provide a benefit when they implement new technologies from which others can learn.
- Most treatment is being placed underground.
- Most developers see stormwater management features as an initial installation cost, not as an on-going utility.
- LEED certification – Developers are doing buildings that meet LEED certification levels, but are not going through the certification process due to costs. When LEED certification is done, main reason is to use it as a marketing tool.
- Development processes work better when they are streamlined.

Opportunities for SSGI from a developer's perspective included the following:

Sharing

- Private-private sharing not desirable (last resort)
  - Financiers (private and public) want to understand and control risk (e.g., default, long-term management/maintenance, environmental liability)
    - Developers typically don't rely upon their neighbors – too much risk if the relationship goes bad, if maintenance is not being performed, or other creates an environmental liability.
    - Legal agreements between private property owners are difficult to create.
- Private-public sharing is more desirable
  - Less perceived risk by financiers
  - Opens up opportunity to increase density
- Connecting to existing stormwater facilities may pose problems for affordable housing projects due to current affordable housing financing regulations.

Stacked Function – Developers are already doing stacked function developments – it is a matter of business due to high cost of land.

Shared, stacked-function green infrastructure

- Developers are supportive of this concept. They felt the topic was a worthwhile exploration.

- Regional stormwater facilities are desirable to developers as it reduces risk, is a known component when developing the site and is perceived to be a better approach than handling stormwater on a site-by-site basis.
- Developer contributions should be considered to cover:
  - Initial construction
  - Long-term maintenance
  - Easements
- Developers liked the concept of integrating art.

In summary, the developer focus group indicated that sharing stormwater facilities between private developments and public agencies is the preferred approach versus sharing occurring solely between private developments. This is primarily due to perceived risk by developers and their financiers. The group also stated adjacencies to open space provide value to residential and retail developments through increased rents or unit sale prices. Finally, they indicated that predictable development processes are valuable. These insights help inform the development of potential SSGI approaches.

Stakeholder Advisory Committee

A Stakeholder Advisory Committee (SAC) was established for the project. Committee members represented various departments in the Cities of Saint Paul and Minneapolis, the Capitol Region Watershed District (CRWD), the Mississippi Watershed Management Organization (MWMO), the University of Minnesota, and the Saint Paul Riverfront Corporation. The SAC provided corridor and community insight and advised the project team.

Project opportunities identified by the SAC were as follows:

- Shift the paradigm about how stormwater is managed.
- Make the development process easier by addressing stormwater earlier in the approval process.
- Maximize all types of environmental benefits.
- Create win-win scenarios.

The investigation quickly raised a number of logistic issues that a successful SSGI implementation approach must address. Below is a summary of the implementation challenges that were identified:

Shared **Green Infrastructure**	**Developer Concern**	**Agency Concern**
How can initial implementation costs be covered for phased implementation?	X	
How to encourage/incentivize/regulate the use of ***shared*** green infrastructure between private property owners?		X
How can newer green infrastructure technologies be encouraged, or and be tested?		X

Shared **Green Infrastructure (Cont.)**	**Developer Concern**	**Agency Concern**
How can long-term functionality risk be minimized for new technologies?	X	X
How to educate/communicate with and incorporate businesses that may own property but not expected to redevelop, to be part of a "shared" agreement?		X
How can stormwater treatment requirements be effectively communicated to property owners who plan to or are in the process of redevelopment?	X	X
Should private property runoff treatment be allowed in public right-of-way or on public property? How would equitable use of the site be determined?		X
Can shared green infrastructure be implemented and maintained for less than green infrastructure implemented on individual parcels?	X	
Can shared green infrastructure be implemented in a manner that still maintains long term opportunities for a site?	X	

Stacked-function **Green Infrastructure**	**Developer Concern**	**Agency Concern**
How can public art be incentivized on private property?		X
Should public art be incentivized on private property?		X
How can shared green infrastructure contribute to the creation of open spaces along the corridor?		X
Are there particular stacked functions that should be incentivized?		X
How can numerous related initiatives along the corridor be coordinated?		X
How can stormwater runoff be recycled for aesthetic uses?	X	X
In what ways can runoff be reused/recycled?	X	X
To what extent should visible green infrastructure along the corridor be encouraged/incentivized?		X
Can intangible benefits associated with shared, stacked-function green infrastructure be quantified?	X	X
How is long-term maintenance of private shared BMP managed?	X	X
How are long-term maintenance costs for shared facilities allocated and collected?	X	
When a BMP fails, how can agencies determine which owner is at fault and force the property owner(s) to bring it back into compliance?		X

In summary, many of the potential SSGI implementation barriers identified by the SAC and developers focus group revolved around long-term risk management and associated cost implications.

Literature Review

A review of national studies related to SSGI was performed over the course of the project. Several concurrent studies of particular interest titled, *River North: Area Wide Green* Infrastructure Study (Wenk Associates, 2013), *Creating Clean Water Cash Flows* (Natural Resources Defense Council, EKO Asset Management Partners, the Nature Conservancy, 2013) and *Banking on Green* (American Rivers, the Water Environment Federation, the American Society of Landscape Architects, ECONorthwest, 2012) were all investigating variations of SSGI, which affirmed this is an issue of interest across the country. These national studies consistently indicated that green infrastructure was less expensive to construct than traditional gray infrastructure, regardless of scale. Note that the studies do not necessarily compare gray to green costs where existing stormwater systems are in place or where contamination or utility conflicts are present. The studies also illustrated new models for stormwater management must be initiated through leadership within municipal government. The following two precedents projects provided insight on how new SSGI policies could be developed and integrated with existing governmental rules and processes:

Fee-in-Lieu Program, Charlotte, NC – This community provides flexibility in their stormwater regulations in order to better facilitate desired redevelopment along a transit corridor. The City of Charlotte instituted an off-site mitigation program to provide flexibility and reduce cost barriers for site-constrained redevelopment properties that supported growth and economic development along Charlotte's light rail system. An ordinance allows property developers to pay a one-time fee if cost or site constraints prevent them from meeting their stormwater retention mandates. The City charges developers a fee per impervious acre and constructs off-site facilities in a cost-efficient manner on city-controlled lands. [1]

Stormwater Management Enhancement Districts, Philadelphia, PA – The City of Philadelphia facilitates the aggregation of properties into Stormwater Management Enhancement Districts (SMEDs), which are areas identified as having potential for large, coordinated green infrastructure projects. The City takes leadership in identifying SMEDs and contracts with an engineering specialist to evaluate potential green infrastructure retrofits that are technically, economically, and practically attractive and prepare a Stormwater Improvement Plan. These proactive steps taken by the City encourage the use of stormwater facilities that take advantage of economies of scale and also lower retrofit project assessment and analysis costs, thus incenting desired development.[2]

[1] Valderrama, Alisa. et. al. *Creating Clean Water Cash Flows: Developing Private Markets for Green Stormwater Infrastructure in Philadelphia*, Natural Resources Defense Council, January 2013, pg. 40.
[2] Valderrama, Alisa. et. al. *Creating Clean Water Cash Flows: Developing Private Markets for Green Stormwater Infrastructure in Philadelphia*, Natural Resources Defense Council, January 2013, pg. 30.

SSGI Precedents

Conceptually, shared, stacked-function stormwater management is not a new approach. Historically, for new developments in growing municipalities, the term "regional pond" was often used to describe a similar situation where one stormwater facility was built by a city for the benefit of many parcels, and by virtue of size may also provide passive recreational amenities and/or wildlife habitat. In other instances, smaller developments built common (shared) ponds in outlots, owned by homeowner associations. (However, often the outlot would go into tax-forfeiture and become owned by a city.)

SSGI builds on this general concept but seeks to employ it on a much smaller scale in a fully developed environment. Examples of SSGI can be found both locally and nationally. The following precedent projects were examined in more detail to better understand how SSGI is being applied and designed, along with associated opportunities and constraints.

National Precedents

Normal IL Roundabout – This project harvests, cleanses, and reuses co-mingled (public and non-public) stormwater runoff to create a water-based amenity in a new community open space.

Canal Park, Washington DC – Stormwater runoff captured from the site and adjacent private buildings will be harvested, cleansed and reused to create water-based amenities and for toilet flushing in a new urban park.

Local Precedents

Tartan Crossings, Oakdale, MN – As part of the redevelopment of an underperforming strip mall into new commercial sites, the City's Public Works Department constructed an artistically designed shared stormwater feature that functions as a new recreational, aesthetic and educational amenity in public right-of-way.

Trout Brook Nature Sanctuary, Saint Paul, MN – Stormwater runoff from an existing residential neighborhood will be daylighted from storm sewers to help enhance a new park. Cleansed through a series of ponds, the treated runoff will provide a significant water source for a newly re-established historic waterway that will run through the new park sanctuary.

Central Corridor, Saint Paul, MN – Boulevards cross streets to the Green Line were retrofitted by the CRWD to incorporate stormwater planters and rain gardens at a dozen locations. Localized runoff from the streetscape and, in some instances, private parking lots, are treated by these features.

Victoria Park, Saint Paul, MN – Stormwater runoff from an adjacent street was directed into a stormwater swale within the newly created Victoria Park and will function as an aesthetic park feature.

Heritage Park, Minneapolis, MN – Stormwater runoff from residential redevelopment sites and adjacent neighborhoods is daylighted from storm sewers and cleansed through a series of filtration basins that are incorporated into a neighborhood street designed to emulate a parkway. The harvested stormwater provides water for new parkland amenity ponds.

Hamline Library Green Alley, Saint Paul, MN – The City constructed a porous bituminous pavement alley that collects and infiltrates stormwater runoff from the alley itself and adjacent private and public parcels.

Potential Redevelopment Sites Identification

The project team desired to develop a pool of up to ten potential redevelopment sites along the corridor that would be strong candidates for conceptual SSGI design and evaluation. Project stakeholders were solicited and previous station area plans and sub area studies were reviewed to identify potential future redevelopment sites along the corridor. This effort resulted in a significant quantity of potential sites. To better facilitate a process of screening the list down to ten sites, clusters of potential development projects were consolidated into groups. These groups were comprised of adjacent sites that could potentially share stormwater facilities. As desired future park/open space locations were identified in Saint Paul's station area plans, each Saint Paul grouping also included a park/open space candidate site. If a potential site could not be logically grouped with other potential redevelopment sites, it was eliminated from the screening process. A total of 37 groups of potential redevelopment sites were developed (see attached Figures 1-8) comprised of 13 groups in Minneapolis and 24 groups in Saint Paul.

The 37 groups were screened using site suitability factors, such as topography and depth to bedrock and project parameters, such as distance from University Avenue and site size. In addition to the site suitability and project parameter screening criteria, the following overarching selection criteria were used to make the final selection:

- A geographical distribution of sites based on the approximate project percentage in each city (30 percent of project area located in Minneapolis and 70 percent of project area located in Saint Paul).
- A range of large and small sites.
- Several potentially contaminated sites.
- A range of potential development scenarios with near to mid-term development potential based on input received from Saint Paul and Minneapolis Planning staff.

The selection process resulted in three site groups located in Minneapolis and seven site groups located in Saint Paul. A brief summary of the 10 site groups follows:

Site M2 – West Bank Cedar Avenue

- The City is already planning to make streetscape improvements along this corridor and is working with owners of private plazas adjoining the right-of-way to concurrently update those spaces. This is a high visibility, diverse, and unique commercial area with a lot of pedestrian and auto traffic.

Site M4 – University of Minnesota Potential Bio-Med Expansion

- This group would entail working with University staff to develop a concept that may also include retrofit sites identified in the MWMO Bridal Veil Creek Study.

Site M7 – Development at 4th St SE & 29th Ave SE (Prospect Park Station)

- The City is working with two different developers on new residential development (2901 4th Street southeast & 2635 4th Street southeast) in a current industrial area. The existing street has no sidewalks/curb/boulevard and is scheduled by the City for reconstruction.
- The group overlaps with a Bridal Veil Study catchment area and a recommended retrofit location.

Site SP3 – Westgate

- This group contains a larger site that is seeing developer interest. The Saint Paul Parks Department has developed several park configurations concepts for this area. The Saint Paul Riverfront Corporation previously developed a concept plan for the area.

Site SP5/SP6 - Wabash Commons/Raymond/Myrtle

- Several existing planning studies address sites in this medium sized group.

Site SP9 – Charles Common

- This group would highlight the development of a centralized treatment system for parcels that abut University Avenue.

Site SP14 – Bus Barn Site

- A portion of this large group is currently receiving redevelopment attention. The site provides the opportunity to investigate the integration of stormwater within a larger open space amenity feature.

Site SP17 – Lexington Village Commons

- This medium to large sized group is located adjacent to the typical SAC meeting location (Wilder Foundation), which may allow for SAC field visits.

Site SP19 – New Rondo Park, Dale and University

- This medium sized group includes a number of parcels along University Avenue.

Site SP20 – Western and University/Old Home Site

- A number of small sites along University Avenue comprise this group.

The project team received SAC member feedback on the recommended sites at the July 17, 2012 SAC meeting before making the final selection of the 10 potential advance design site groups.

Investigations of Potential SSGI Approaches

In August 2012, six SSGI approaches were presented to the SAC for consideration. Based on feedback received, the following four were selected for additional feasibility analysis:

- New Public Parks/Open Spaces
- Street Right-of-Way
- Green Alleys
- Shared Parking Facilities

Detailed descriptions of the six SSGI approaches presented and SAC feedback can be found in the White Paper, *Shared, Stacked-Function, Green Infrastructure Policy Investigation*.

SSGI Illustrative Exercise

Concurrent with the selection of the four potential SSGI approaches, the project team prepared illustrative concepts to assist project stakeholders with visualizing how SSGI could be manifested in a redevelopment project. For the purpose of the exercise, Wacouta Commons, located in downtown Saint Paul was selected to illustrate how the new public parks/open space SSGI approach could take form. This exercise asked the question, "If SSGI had been implemented when Wacouta Commons park was initially developed, how could have it looked and functioned?" This exercise assumed that rate control was incorporated into the new multi-family structures that bound the south and west sides of the park. Existing site conditions are depicted in attached Figures 9-10. The project site is approximately 5 acres as shown in Table 1 below. The current drainage patterns would allow for the harvesting of runoff from an additional 11.5 acres.

Table 1: Wacouta Commons Project Area Acreages

Total Project Site	**5.0 Acres**
Development	3.0 Acres
Open Space/Park	0.9 Acres
Streets r/w	1.1 Acres
Available Offsite Drainage area	**11.48 Acres**

The following hydrologic data was calculated for the site.

Table 2: Wacouta Commons Site Hydrologic Data

Hydrologic Data	1.3" Volume Control Cubic Feet (CF)	1.64 cfs/ac Rate Control Cubic Feet (CF)	Percent (%) of volume for project
Total Project Site	**16,364**	**23,290**	
Development	11,169	15,058	68
Open Space/Park	1,159	2,126	7
Street Right-of-way	4,035	6,106	25
Available Offsite	**44,815**	**82,721**	

Concept A

Informed by the Normal, IL roundabout precedent, this concept illustrated a highly engineered system featuring two cisterns, vegetated filters, and UV filters that would allow for the daylighting of treated stormwater in an interactive channel/fountain in the park (see Figure 11). The main cistern provides gross pollutant removal/retention for site use. A vegetative filter channel is used for secondary treatment. The secondary cistern provides clean water for the water channel for park vegetation irrigation. The cisterns shown were

sized to meet the water quality and volume control requirements, but could be sized for rate control. In addition, the cisterns could be sized to harvest runoff from the off-site drainage area, as this water may be needed to supply all the needed irrigation water needs for the park.

Concept B

In this concept, a series of cascading bioretention basins comprise the majority of the park. Pathways, boardwalks and plazas that surround and pass between the basins provide park visitors visual access to diverse basin habitats (see Figure 12). The basins shown were sized to meet the water quality and volume control requirements, but could be sized for rate control. The system could be designed as a gravity system with shallow storm sewer connections to the basins. Each basin would likely have a different vegetative appearance due to varying volumes of runoff draining to each basin. This concept was inspired by Tanner Springs Park in Portland, Oregon.

Concept C

This concept illustrated a terraced central lawn framed by tree allees and small gathering spaces. An underground passive irrigation system and permeable pavement parking bays would be used in this concept to meet stormwater requirements (see Figure 13). The stormwater facilities were sized to meet the water quality and volume control requirements, but could be sized for rate control. The system could be designed as a gravity system with shallow storm sewer connections to the irrigation system. Rooftop runoff that would enter the system would not require pretreatment. The irrigation could be supplemented with offsite runoff via a cistern/pump system.

The exercise highlighted that the physical form of SSGI could vary widely in terms of the amount of park space dedicated to stormwater facilities and the desired level of park user interaction with the harvested and treated stormwater.

SSGI Conceptual Designs

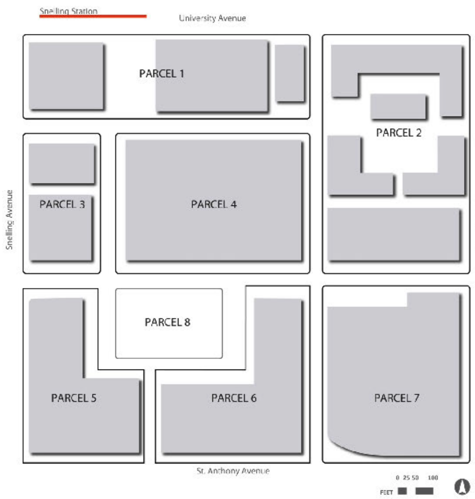
Two potential redevelopment sites along the corridor, the Bus Barn and Brownstone sites, were selected to further investigate the feasibility of implementing the four SSGI approaches (see Figure 14). Design goals for concept development included:

- Meeting regulatory requirements for stormwater with SSGI
- Harvesting offsite water if possible to support the stormwater facility, as needed
- Integrating public art into the design process

Concept designs and estimated life cycle costs were developed for each of the four SSGI approaches on both sites for a total of eight SSGI concepts and life cycle cost estimates. In order to determine if cost efficiencies could be achieved using SSGI, stormwater treatment approaches and estimated life cycle costs were developed for the Bus Barn site, assuming that stormwater treatment was performed on an individual site basis.

General block and building configurations used for the Bus Barn Site were based on previously developed station area plans or current proposed redevelopment plans, as shown in the illustration below. The illustration also lists the BMPs used in the individual parcel concepts.

Bus Barn- Conceptual Parcels and BMPs:



Parcel	BMPs Used: Green Roof	Underground Infiltration/ Filtration (Site Open Space)	Pervious Pavers with Underground Infiltration/ Filtration (Parking Lot)	Bioretention and Pond
1	√	√		
2			√	
3	√	√		
4	√	√		
5	√	√		
6	√	√		
7	√	√		
8				√

Bus Barn Site

The Bus Barn site is representative of a large-scale, urban village redevelopment area. With a size of 34-acres, the Bus Barn site is envisioned as a long-term, phased, development area. It was assumed that select streets and blocks would be reconfigured and that significant demolition and reconstruction of buildings would occur as part of the redevelopment process. General block and building configurations were based on the Snelling Station Area Plan. Figure 15 depicts the existing drainage patterns on the site. Figures 16-19 illustrate Bus Barn site design concepts, key design elements, and design assumptions for each SSGI approach. Public art concepts developed for the Bus Barn site are depicted in Figures 20 – 21.

Brownstone Site

The Brownstone site is representative of a small parcel redevelopment project. The Brownstown site was selected as it is small in scale, yet exceeded one acre where water quality and volume control standards are required. Existing drainage patterns on the site are shown in Figure 22. Small projects typically consist of existing building expansions, or the complete demolition of several structures, parcel assembly and development of a larger building. Figures 23-26 illustrate Brownstone site design concepts, key design elements, and design assumptions for each SSGI approach. Public art concepts developed for the Brownstone site are depicted in Figure 27.

Costing Approach and Summary

The preparation of estimated life cycle costs was based on a combination of national studies and local construction experience. Sources of costing data included:

- Best Management Practices Construction Costs, Maintenance Costs, and Land Requirements, Prepared for Minnesota Pollution Control Agency, June 2011
- Water Environment Research Foundation (WERF), BMP and LID Whole Life Cost Model: Version 2.0
- Green Values National Stormwater Management Calculator, Center for Neighborhood Technology
- Recent construction bids

Figure 28 lists assumptions that were used in the development of the estimated life cycle costs. Tables 3 – 5 summarize the outcomes of the life cycle costing exercise.

Table 3: Life Cycle Cost Summary

	Bus Barn Site Life Cycle Costs		Brownstone Site Life Cycle Costs	
	Cost per Cubic Foot of Volume Achieved	Cost per Square Foot of Impervious Surface	Cost per Cubic Foot of Volume Achieved	Cost per Square Foot of Impervious Surface
Individual Parcel Basis	$17.60 P $362.80 GR	$11.00 P $35.40 GR		
Open Space Concept	$18.80	$2.50	$36.70	$4.90
Street R/W Concept	$19.40	$2.60	$24.90	$3.40
Alley Concept	$19.20	$2.60	$21.90	$3.10
Structured Parking Concept	$8.50	$1.20	$32.80	$4.70

P = Pervious Pavers, GR = Green Roof

Table 4: Bus Barn Site - Detailed Summary of Estimated Life Cycle Costs

	Construction Costs					Life Cycle Costs	
	Capital Cost	Cost/ CF of Volume Achieved	Cost/ SF of Impervious Surface	Annual O & M Cost	Life Span Years	Cost/ CF of Volume Achieved	Cost/ SF of Impervious Surface
Individual Parcel Basis	$1,025,658 P $ 744,447 GR	$10.50 P $164.10 GR	$6.60 P $16.00 GR	$3,832 P $21,231 GR	25: Green Roof and Pavers 30: Pipe Gallery	$17.60P $362.80 GR	$11.00 P $35.40 GR
Open Space Concept	$1,040,900	$6.00	$0.80	$13,632	10: Bioretention 25: Pond	$18.80	$2.50
Street R/W Concept	$2,161,389	$12.40	$1.60	$40,420	25: Pavers 40: Tree Trenches	$19.40	$2.60
Alley Concept	$2,157,881	$12.20	$1.60	$45,060	30: Pavers 60: Pipes	$19.20	$2.60
Structured Parking Concept	$ 933,759	$5.20	$0.70	$18,675	50	$8.50	$1.20

P = Pervious Pavers, GR = Green Roof

Table 5: Brownstone Site - Detailed Summary of Estimated Life Cycle Costs

	Construction Costs					Life Cycle Costs	
	Capital Cost	Cost/ CF of Volume Achieved	Cost/ SF of Impervious Surface	Annual O & M Cost	Life Span Years	Cost/ CF of Volume Achieved	Cost/ SF of Impervious Surface
Individual Parcel Basis	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Open Space Concept	$264,683	$28.40	$3.80	$2,350	60	$36.70	$4.90
Street R/W Concept	$110,626	$11.80	$1.40	$384	25:Pavers 10: Bump-outs	$24.90	$3.40
Alley Concept	$138,027	$13.90	$2.00	$2,610	30:Pavers 60: Pipes	$21.90	$3.10
Structured Parking Concept	$200,867	$19.90	$2.90	$4,017	50	$32.80	$4.70

Findings

This investigation indicated that the four SSGI approaches identified (Parks, Parking, Alleys, and Street Right-of-way) were feasible at both the urban village and small site scale. In addition, the study indicated that several of these approaches lend themselves more strongly to a particular scale of development. For example, while green alleys can be incorporated into all scales of development, this approach is a more viable option for use with small scale development projects than the parks approach. Likewise, a structured parking approach is better aligned with an urban village development scale. The figure below highlights the applicability of the four SSGI approaches to different development scales.

A comparison of the individual basis estimated costs to conceptual SSGI estimated costs indicated that cost efficiencies can be achieved through the sharing of stormwater facilities. Also, the incremental cost increase to provide water quality and volume control measures in addition to rate control (e.g., filtration or infiltration features) for a shared facility are not significant.

Another finding indicated that while it is more difficult to implement a SSGI facility that serves numerous small redevelopment parcels, these small parcels appear to receive higher benefit from SSGI than larger development sites, as it is easier for larger developments to allocate space to green infrastructure.

Attachments

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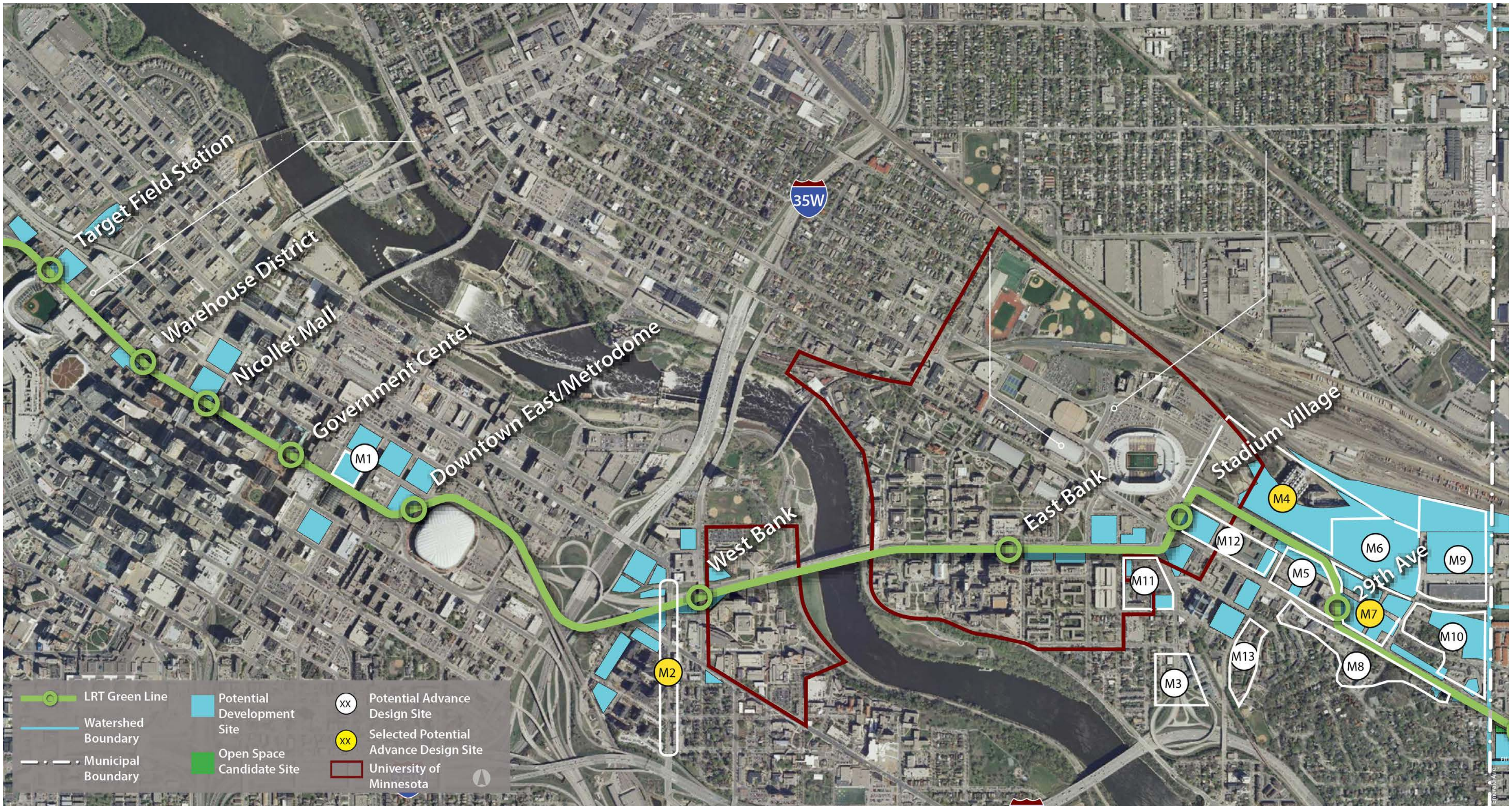


FIGURE 1 Corridor Analysis West Segment

FIGURE 2 Corridor Analysis Central Segment

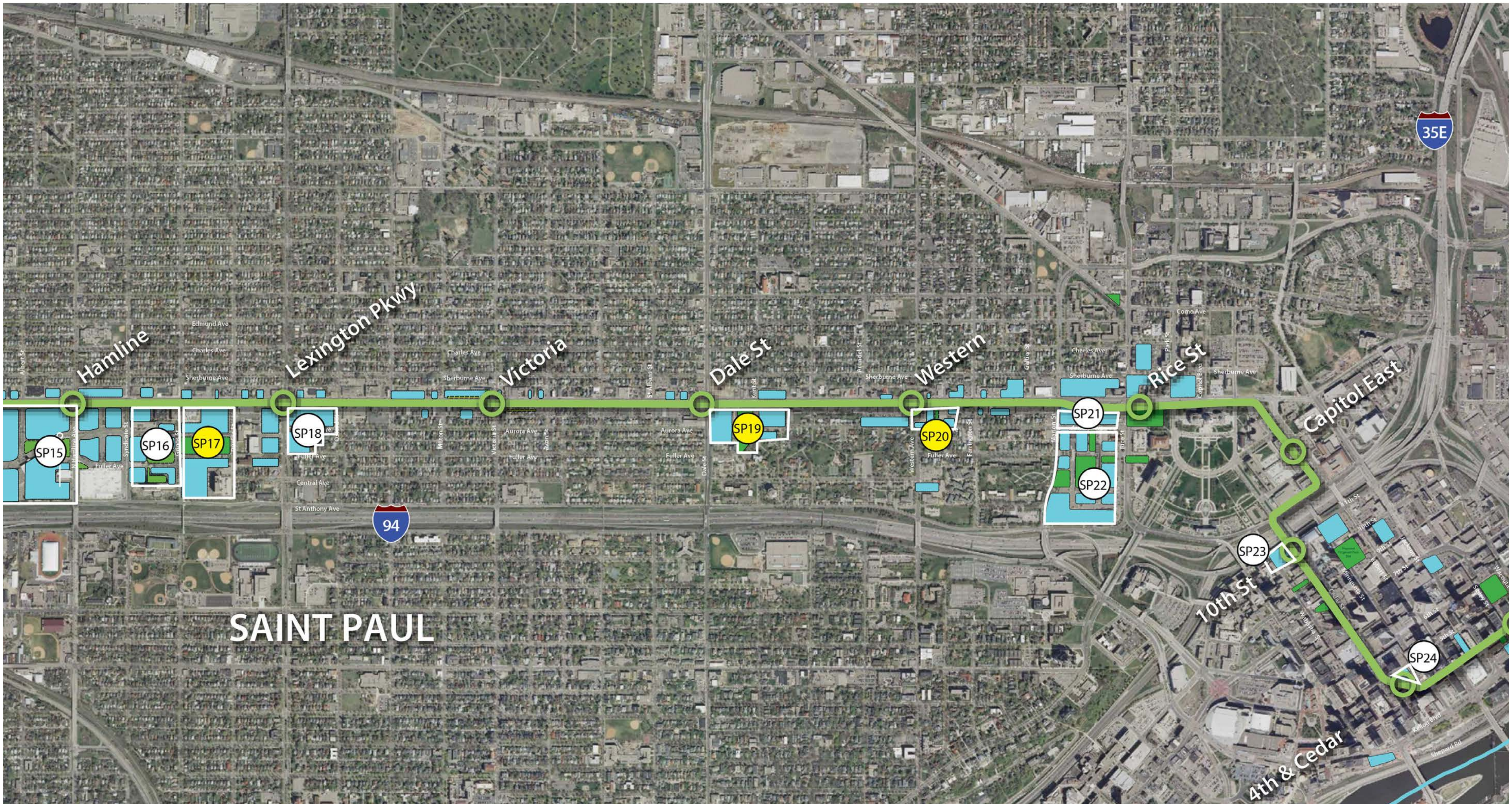


FIGURE 3 Corridor Analysis East Segment

Overarching Selection Criteria (any one of these criteria could override matrix results)

- Geographical distribution
- Range of development scenarios

SELECTION TIER	SITE SELECTION PARAMETERS																	POTENTIAL TRIPLE BOTTOM LINE OPPORTUNITIES								
Criteria Category	Project Parameters								Site Suitability									Environmental Function				Social Function			Economic Function
Criteria	Can be shared among multiple parcels	Identified as potential redevelop-ment site in previous study?	Established development program for site	Proximity to the corridor	Probable SSGI construction cost	Potential for redevelopment/ project timeline	Site size (1 ac to 10 ac)	Opportunity for linkage of features to create enlarged green space	Contaminated soils	Utility conflicts	Bedrock	Groundwater	Contributing drainage area	Appropriate subgrade soils (A or B)	Available storm sewer system	Topography	Under public control	Volume control	Rate control	Water quality	Additional Ecological benefits	Integration of public art	Green reference	Provide community open space	Promotes Redevelopment
POTENTIAL SITES – MPLS																									
5th and Portland (M1)	◐	●	○	●	○	○	●	○	○	○	●	●	◐	◐		◐	○								
Cedar Avenue (M2)	●	●	◐	◐	●	◐	●	◐	●	○	●	●	●	◐		◐	◐								
Huron Boulevard Area (M3)	◐	○	○	○	◐	○	●	◐	◐	◐	●	●	◐	◐		◐	◐								
University of Minnesota Potential Bio-Med Expansion (M4)	●	●	○	●	○	○	◐	●	○	○	●	●	●	◐		◐	◐								
Prospect Park Station West (M5)	●	●	○	●	○	○	◐	◐	○	○	◐	◐	◐	◐		●	○								
Crushers Site (M6)	●	●	○	●	○	○	◐	●	○	◐	●	●	◐	◐		◐	○								
Prospect Park Station East (M7)	●	●	●	●	○	●	◐	●	○	○	◐	◐	◐	◐		●	○								
Prospect Park/University Ave (M8)	●	●	○	●	○	○	◐	◐	○	○	◐	◐	●	◐		○	◐								
Industrial (M9)	●	●	◐	◐	○	◐	◐	◐	○	○	●	●	◐	◐		◐	○								
Residential/Light Industrial (M10)	●	●	○	●	○	○	◐	◐	○	◐	◐	◐	●	◐		●	○								
Washington/Huron (M11)	●	●	○	●	○	○	◐	○	○	○	●	●	●	◐		◐	○								
Stadium Village Station (M12)	●	●	○	●	○	○	◐	○	○	○	◐	◐	●	◐		◐	○								
Glendale Townhomes (M13)	◐	○	○	◐	○	○	●	◐	○	○	◐	◐	◐	◐		●	●								

■ Potential Advanced Design Site ● Most desirable ◐ Moderately desirable ○ Least desirable

FIGURE 4 Site Selection Matrix- Potential Minneapolis Sites

Overarching Selection Criteria (any one of these criteria could override matrix results)

- Geographical distribution
- Range of development scenarios

SELECTION TIER	SITE SELECTION PARAMETERS																	POTENTIAL TRIPLE BOTTOM LINE OPPORTUNITIES								
Criteria Category	Project Parameters								Site Suitability									Environmental Function				Social Function			Economic Function
Criteria	Can be shared among multiple parcels	Identified as potential redevelopment site in previous study?	Established development program for site	Proximity to the corridor	Probable SSGI construction cost	Potential for redevelopment/ project timeline	Site size (1 ac to 10 ac)	Opportunity for linkage of features to create enlarged green space	Contaminated soils	Utility conflicts	Bedrock	Groundwater	Contributing drainage area	Appropriate subgrade soils (A or B)	Available storm sewer system	Topography	Under public control	Volume control	Rate control	Water quality	Additional Ecological benefits	Integration of public art	Green reference	Provide community open space	Promotes Redevelopment
POTENTIAL SITES – ST. PAUL																									
Technology Common (SP1)	◐	●	○	◐	◐	○	●	◐	◐	●	●	●	◐	◐	●	●	○								
University/Curfew (SP2)	◐	●	○	●	●	○	●	◐	●	◐	●	●	●	◐	●	◐	○								
Westgate (SP3)	●	●	◐	◐	○	◐	◐	●	○	●	●	●	●	◐	●	●	○								
Emerald/University (SP4)	◐	●	●	●	●	●	●	◐	●	●	●	●	◐	◐	●	○	○								
Wabash Common (SP5) *Merged with SP6*	●	●	●	◐	○	◐	◐	●	○	○	●	●	●	◐	●	●	◐								
Raymond/Myrtle (SP6) *Merged with SP5*	◐	●	○	●	●	○	●	●	●	●	●	●	◐	◐	●	●	○								
Raymond/Charles (SP7)	●	●	○	●	●	◐	●	◐	●	○	●	●	●	◐	●	●	◐								
Prior and University (SP8)	●	○	◐	●	○	●	●	○	○	●	●	●	◐	◐	●	●	○								
Charles Common (SP9)	●	●	◐	●	●	◐	●	●	●	●	●	●	●	◐	●	●	○								
Episcopal Homes (SP10)	●	○	●	●	●	●	●	○	●	◐	●	●	◐	◐	●	●	○								
Fairview/University (SP11)	●	●	○	●	◐	○	◐	◐	◐	◐	●	●	●	◐	●	●	○								
Dickerman Park Area (SP12)	●	●	○	●	◐	○	◐	●	◐	◐	●	●	●	◐	●	●	○								
Snelling Ave Site (SP13)	◐	●	○	◐	●	○	●	●	●	◐	●	●	◐	●	●	●	○								
Bus Barn Site (SP14)	●	●	○	●	○	◐	◐	●	○	●	●	●	●	◐	●	◐	○								
Midway (SP15)	●	●	○	●	○	○	◐	●	○	●	●	●	●	◐	●	◐	○								

Potential Advanced Design Site (highlighted: SP3, SP5, SP6, SP9, SP14) ● Most desirable ◐ Moderately desirable ○ Least desirable

FIGURE 5 Site Selection Matrix- Potential Saint Paul Sites, cont.

Overarching Selection Criteria (any one of these criteria could override matrix results)

- Geographical distribution
- Range of development scenarios

SELECTION TIER	SITE SELECTION PARAMETERS																	POTENTIAL TRIPLE BOTTOM LINE OPPORTUNITIES							
Criteria Category	Project Parameters								Site Suitability									Environmental Function				Social Function			Economic Function
Criteria	Can be shared among multiple parcels	Identified as potential redevelopment site in previous study?	Established development program for site	Proximity to the corridor	Probable SSGI construction cost	Potential for redevelopment/ project timeline	Site size (1 ac to 10 ac)	Opportunity for linkage of features to create enlarged green space	Contaminated soils	Utility conflicts	Bedrock	Groundwater	Contributing drainage area	Appropriate subgrade soils (A or B)	Available storm sewer system	Topography	Under public control	Volume control	Rate control	Water quality	Additional Ecological benefits	Integration of public art	Green reference	Provide community open space	Promotes Redevelopment
POTENTIAL SITES – ST. PAUL																									
Lexington Urban Village (SP16)	●	●	○	●	◐	○	◐	●	◐	◐	●	●	●	◐	●	◐	○								
Lexington Village Commons (SP17)	●	●	◐	●	◐	◐	◐	●	◐	●	●	●	●	◐	●	●	○								
Aurora Avenue Community Park (SP18)	●	●	○	●	○	◐	●	◐	○	◐	●	●	●	◐	●	●	○								
New Rondo Park, Dale and University (SP19)	●	●	○	●	◐	◐	●	●	◐	●	●	●	●	●	◐	●	○								
Western and University/Old Home Site (SP20)	●	●	○	●	◐	◐	●	◐	◐	○	●	●	●	◐	●	●	◐								
University and Rice (SP21)	◐	●	○	●	◐	○	●	◐	◐	●	●	●	●	◐	●	●	○								
Sears Site (SP22)	●	●	○	◐	○	◐	◐	●	○	●	●	●	●	◐	●	◐	○								
Cedar Ave/ 10th-12th St (SP23)	◐	○	○	●	○	○	●	○	◐	○	○	◐	◐	◐	◐	◐	◐								
4th and Cedar Plaza (SP 24)	◐	●	◐	●	○	●	●	◐	●	●	○	◐	◐	◐	◐	●	●								

Potential Advanced Design Site (yellow rows: SP17, SP19, SP20)   ● Most desirable   ◐ Moderately desirable   ○ Least desirable

FIGURE 6 Site Selection Matrix- Potential Saint Paul Sites, cont.

CRITERION	DESCRIPTION	●	◐	○
Project Parameters				
Can be shared among multiple parcels	Highly valued given study's emphasis on shared function.	Numerous parcels	Limited	None
Identified as potential redevelopment site in previous study?	Emphasis based on SAC comments regarding parcels that have already had public vetting for future redevelopment and is part of an approved plan/ document.	Yes	N/A	No
Established development program for site	The site has a design development program.	Design Development	Conceptual	No
Proximity to the corridor	Greater value is placed on sites that are closer to the Central Corridor.	Within 3 blocks	3-5 blocks	>5 blocks
Probable SSGI construction cost	Subjective value based on site suitability measurements (bedrock, contamination).	Low	Medium	High
Potential for redevelopment/project timeline	Greater value is placed on redevelopment that is planned to occur in a shorter timeframe.	3 years	3-10 years	>10 years
Site size (1 ac to 10 ac)	A 1-10 acre site (1-2 blocks) has enough water to sustain features and has more potential to avoid some of the other site suitability measures (crossing streets, etc).	1-10 acres	>10 acres	<1 acre
Opportunity for linkage of features to create enlarged green space	Ranking based on proximity to other potential redevelopment or future open space.	Potential	Moderate Potential	No Potential
Site Suitability				
Contaminated soils *(source: MPCA "What's in my neighborhood?" data)*	Are there known contamination issues for a site that would impact design or costs of BMPs?	Non existent	Potential/unknown	Known contamination
Utility conflicts	Are there known utilities that need to be relocated in order for BMPs to be constructed that would affect the design or have cost implications? (streets/ overhead utilites crossing site)	None	Potential/unknown	Known multiple relocates required
Bedrock *(source: County Well Index, Depth to Bedrock, and site experience)*	Is bedrock close enough to the surface that it would affect choices of BMPs or have cost implications?	Non existent	Potential/unknown	Known bedrock
Groundwater *(source: County Well Index, Depth to Bedrock and site experience)*	Is bedrock close enough to the surface that it would affect choices of BMPs or have implications on the potential for infiltration BMPs?	Non existent	Potential/unknown	Known high groundwater
Contributing drainage area *(compared topography/slope of the site with site boundary)*	Is the topography or drainage systems such that a BMP can serve more than one property owner, simply serve the site, or potentially not serve the site?	More than individual site	Site only	Less than individual site
Appropriate Subgrade Soils (A or B) *(source: NRCS SSURGO data for Ramsey County and Hennepin County)*	This criterion addresses the sites ability to infiltrate stormwater.	Known A/B soils	Likely C soils/Urban Soils	Known D soils (clay)
Available storm sewer system (gravity) *(source: St. Paul Storm Sewer Data- mapped rim/sump depth, compared to site slope)*	Is the site served by an adequate drainage system at an elevation available for a passive drainage system, or does it require other measures to provide for a positive outlet that affects the short and long term costs?	Available	Available but requires construction to access	Not available without pumping
Topography *(2' contours mapped according to slope criteria)*	Is the site easily adaptable to BMPs with some but not too much slope?	1-4% slopes	0.5-1% or 4-5% slopes	> 5% slopes
Under public control	Greater value is placed on sites where the open space/SSGI is under public control.	Municipal (St Paul/Mpls)	Other Agencies/Public Entities	Private

FIGURE 7 Site Selection Matrix-Glossary of Site Selection Criterion

CRITERION	DESCRIPTION	●	◐	○
Environmental Function				
Volume control	Can/does the site meet all of its regulatory requirements for volume control?	Meets requirements on site	Partially meets requirements on site	Not able to meet requirements on site
Rate control	Can/does the site meet all of its regulatory requirements for rate control?	Meets requirements on site	Partially meets requirements on site	Not able to meet requirements on site
Water quality	Can/does the site meet all of its regulatory requirements for water quality ?	Meets requirements on site	Partially meets requirements on site	Not able to meet requirements on site
Additional ecological benefits	Provides ecological benefits beyond stormwater management (wildlife/air quality/etc) to mimic natural systems.	Full	Partial	None
Social Function				
Integration of public art	Art is an integral part of the design, with more value placed on publicly accessible locations.	Public	Private	None
Green reference	The project should be identifiable as incorporating sustainable/green infrastructure.	High	Medium	Low
Provides community open space	Higher value was placed on developments that created open space available to the public.	Public	Private	None
Economic Function				
Promotes redevelopment	Perceived attractiveness of site for redevelopment	High	Medium	Low

FIGURE 8 Site Selection Matrix- Glossary of Site Selection Criterion, cont.

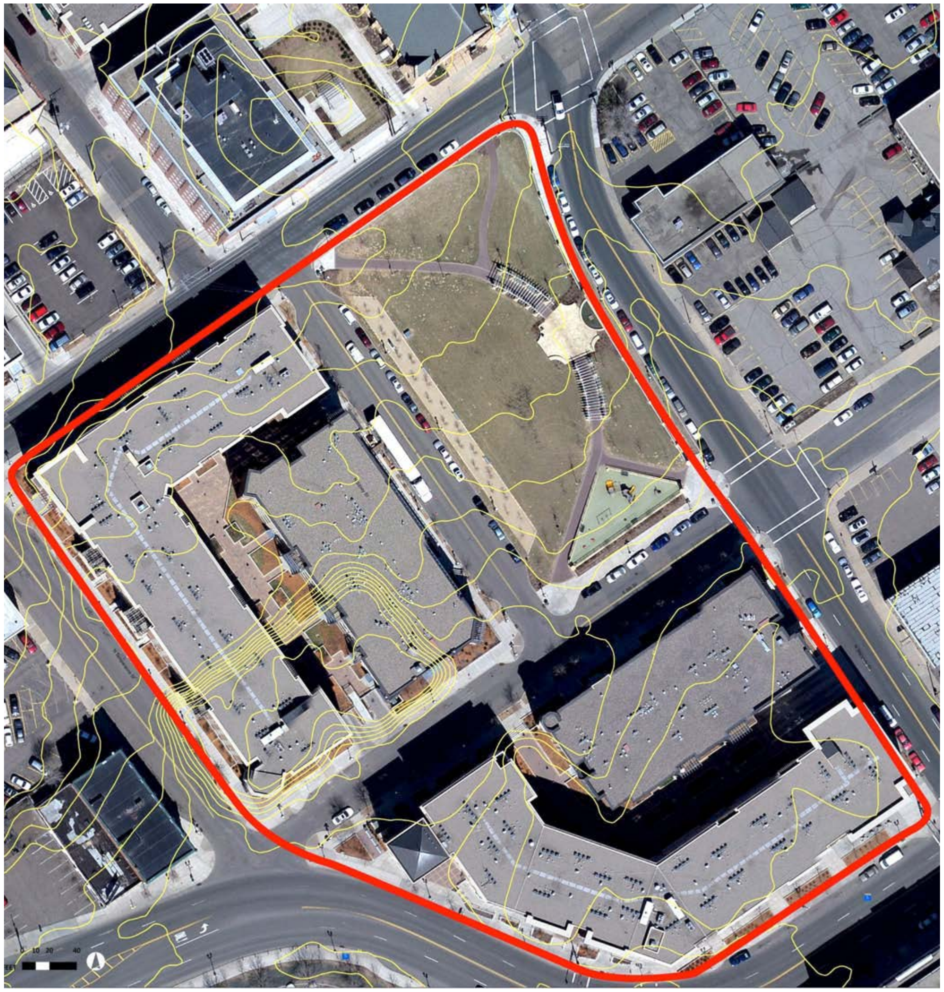


FIGURE 9 Wacouta Commons Existing Topography

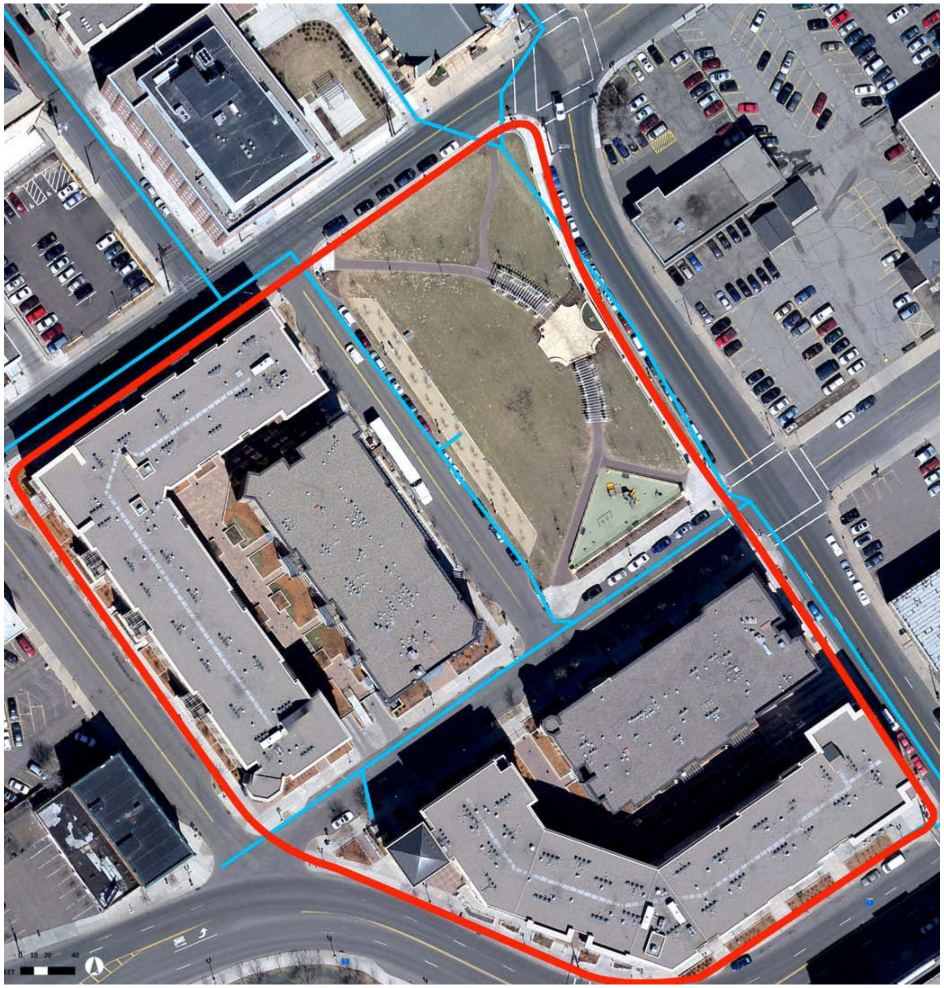


FIGURE 10 Wacouta Commons Existing Drainage Area

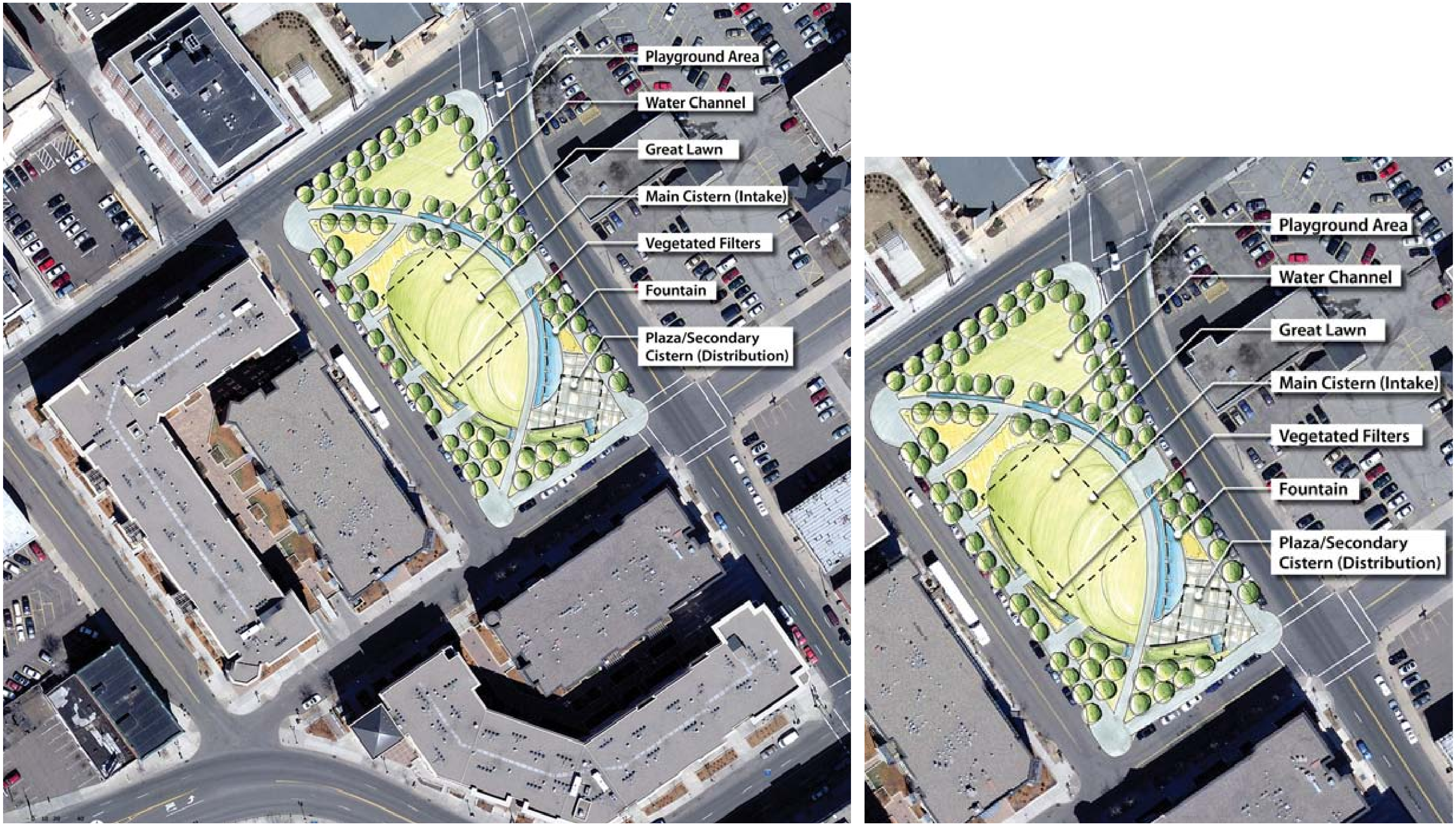
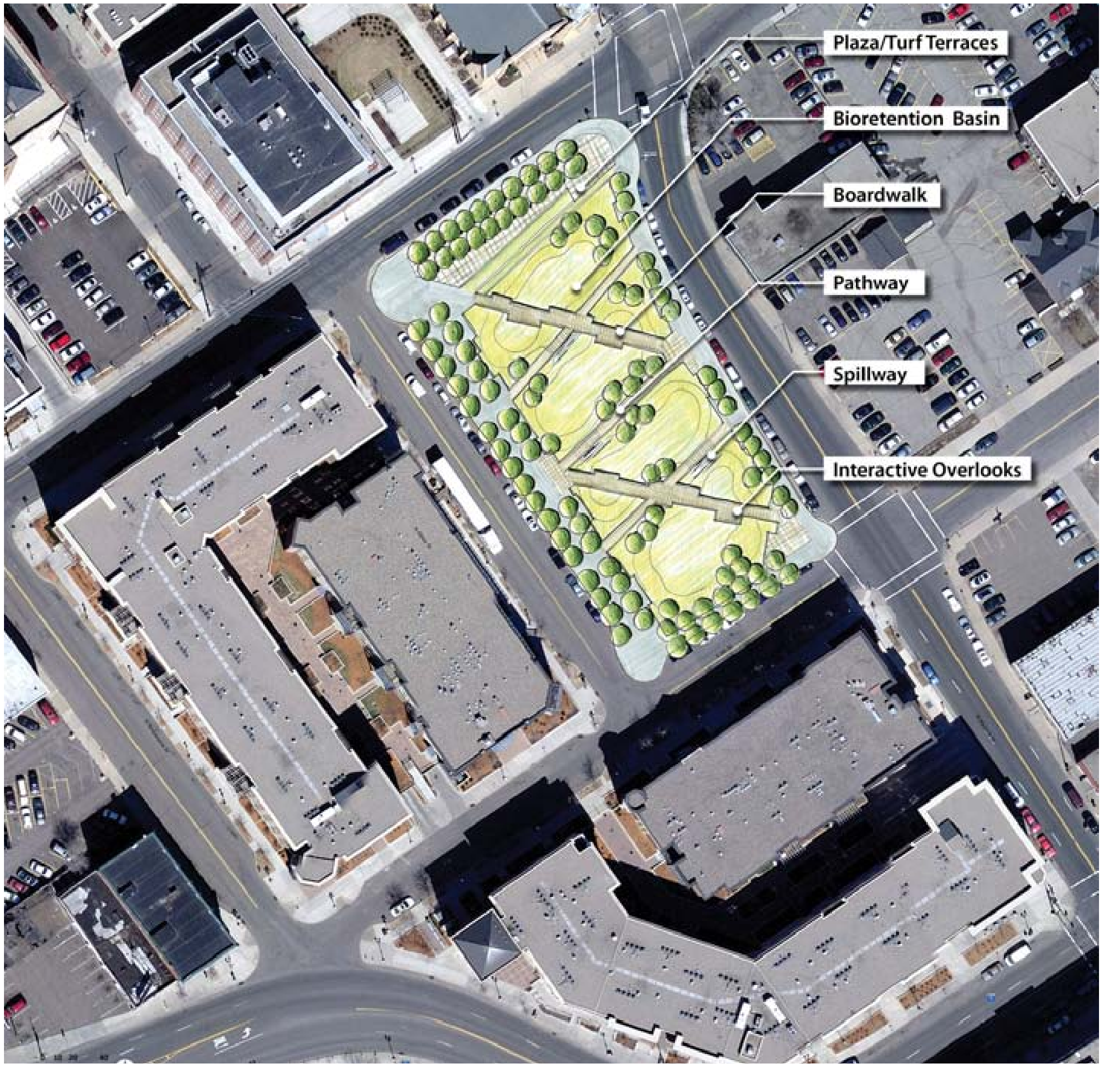


FIGURE11 Wacouta Commons Concept A



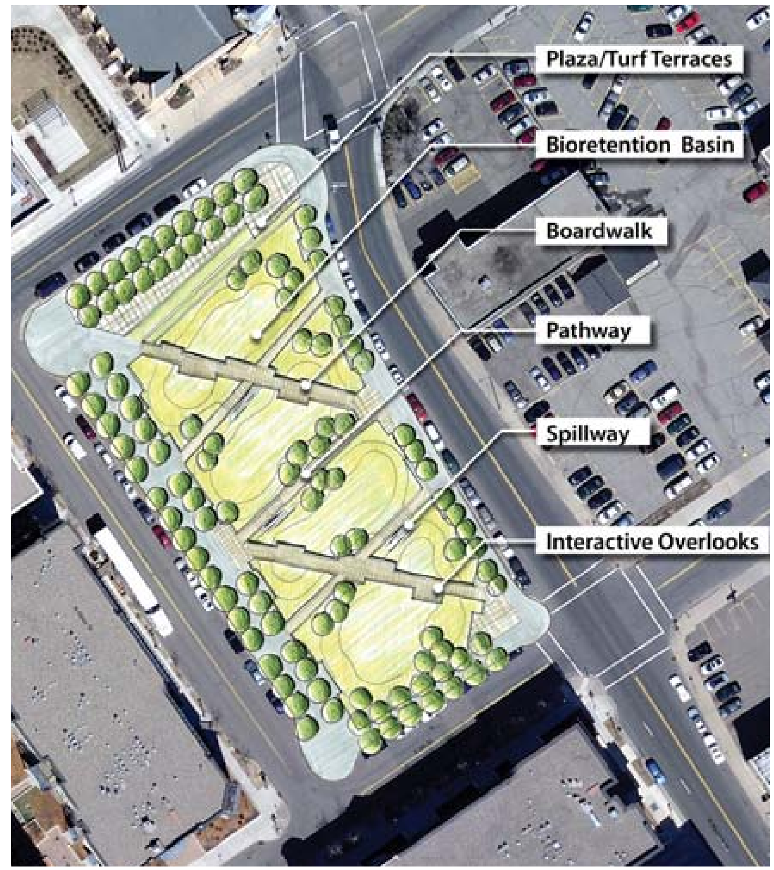


FIGURE 12 Wacouta Commons Concept B

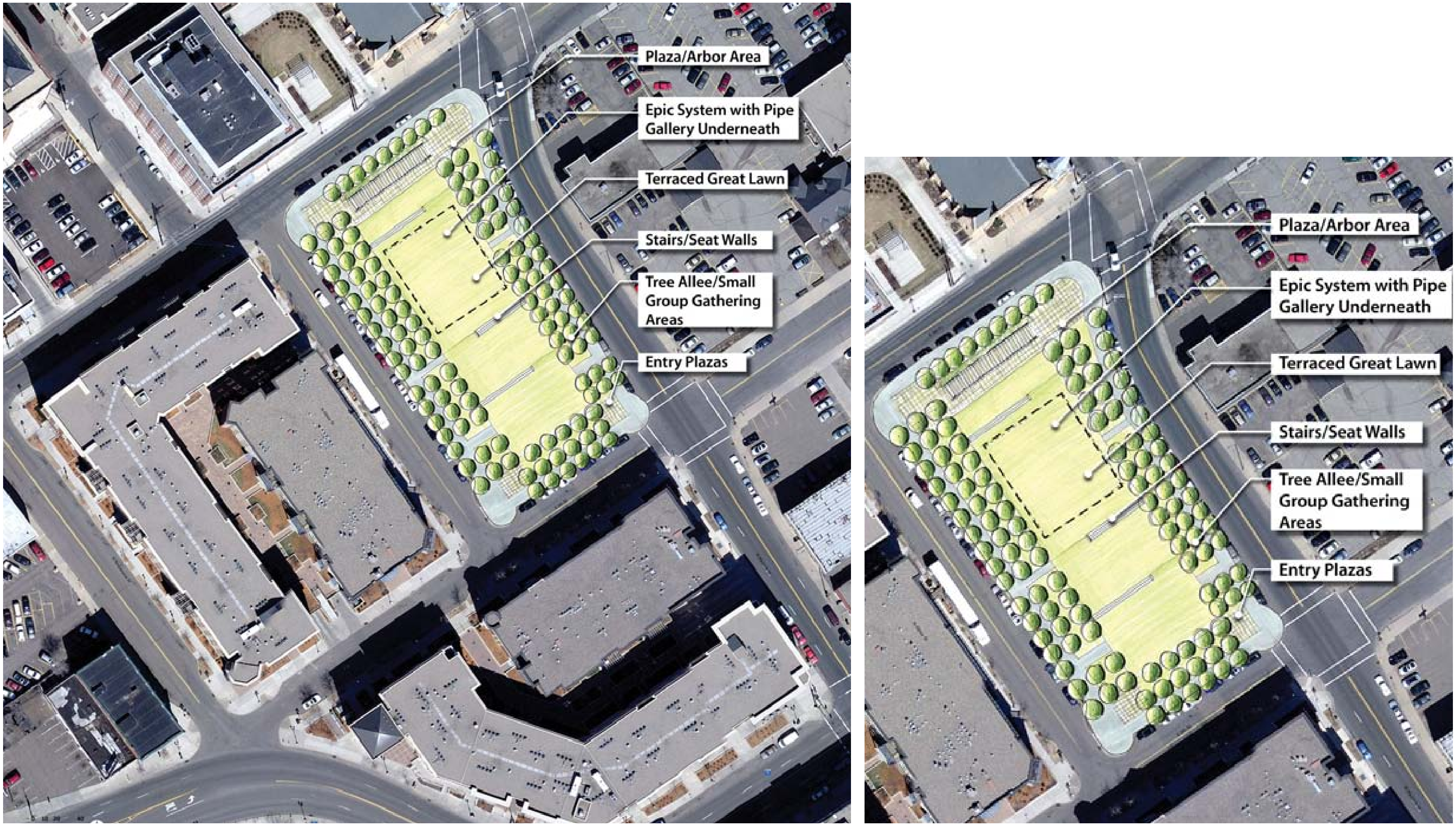


FIGURE13 Wacouta Commons Concept C

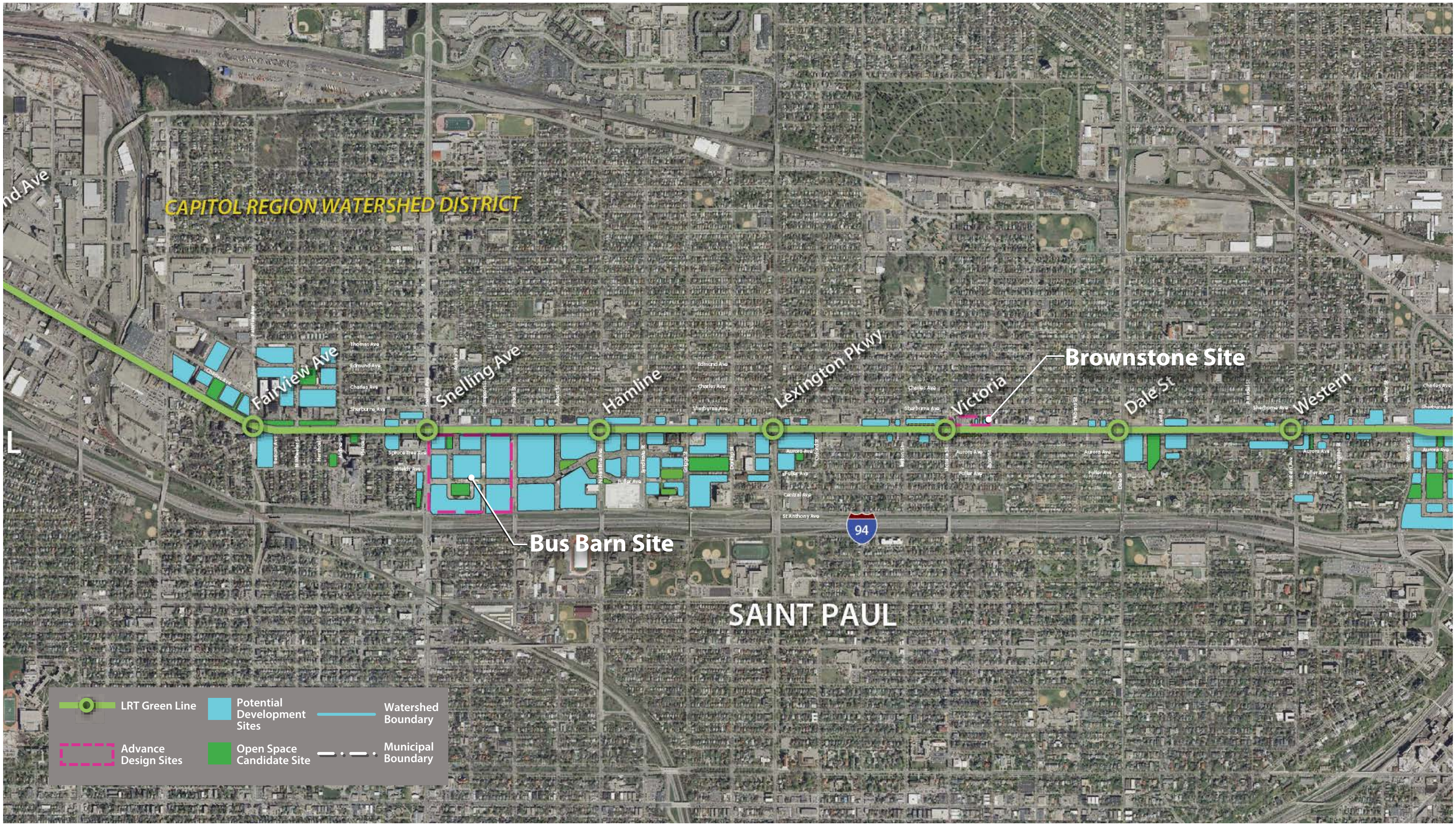


FIGURE 14 SSGI Conceptual Design Locations

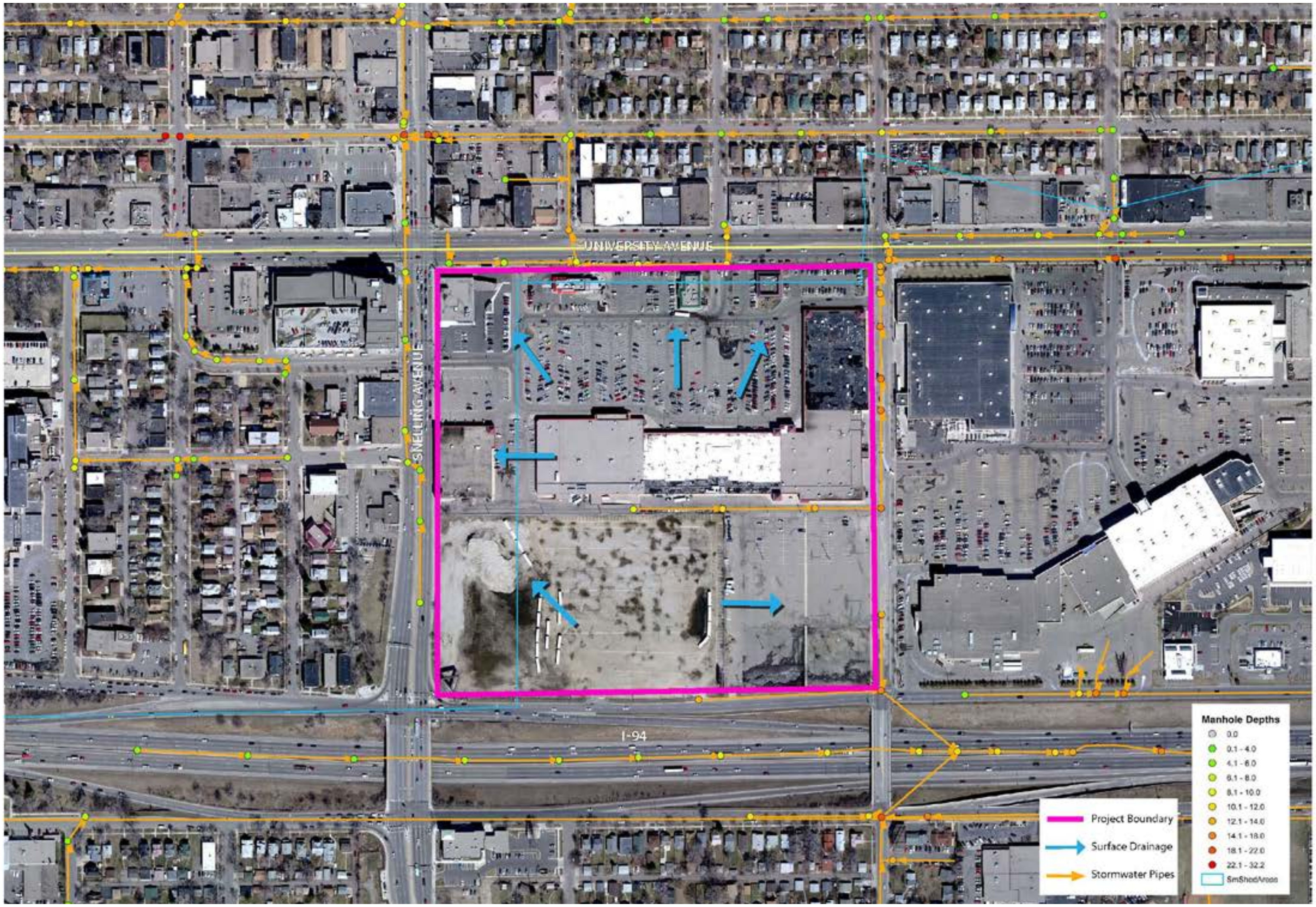
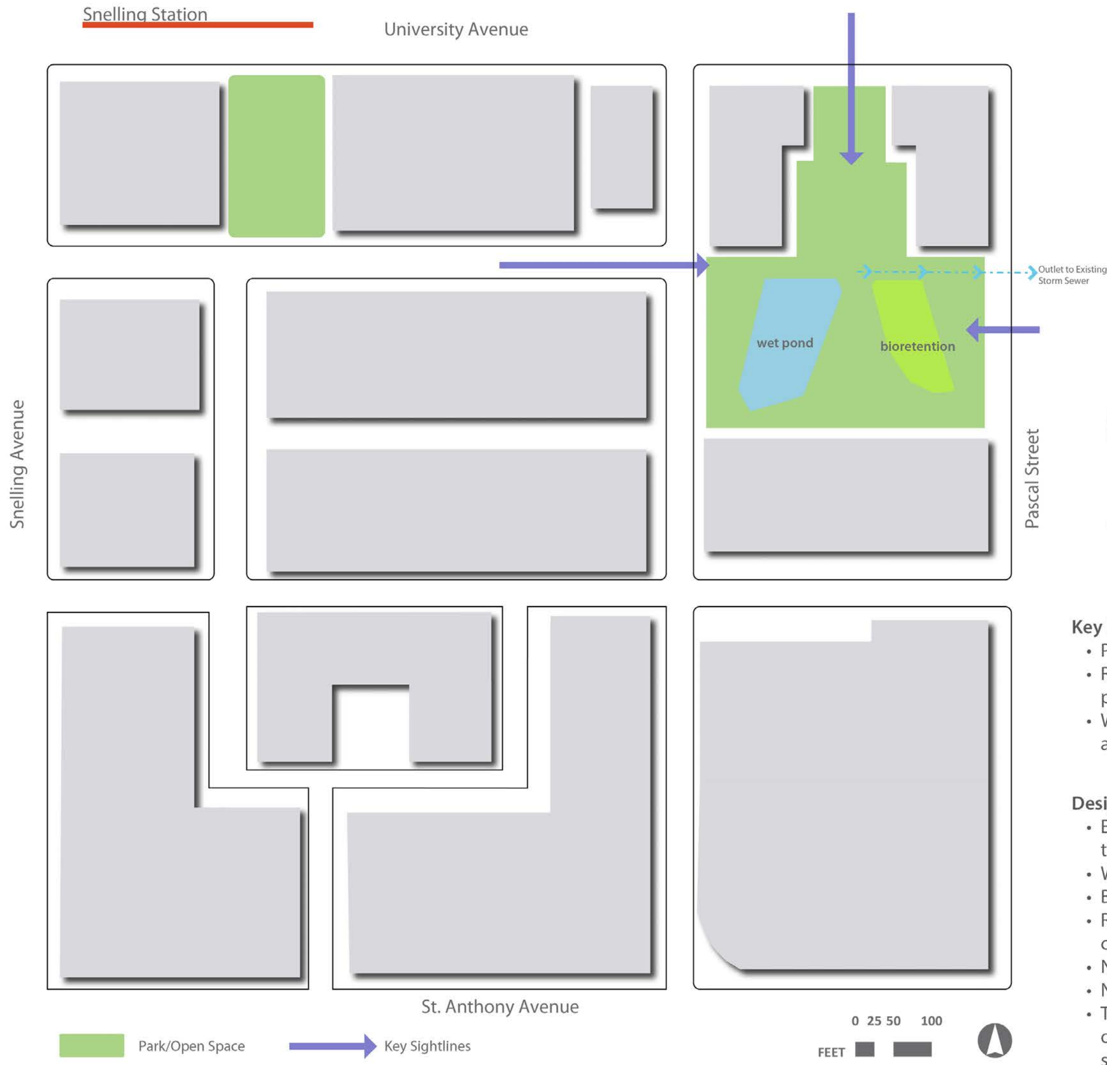
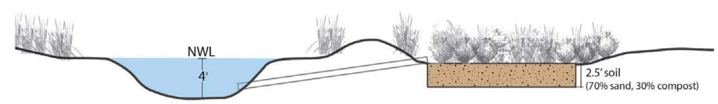


FIGURE 15 Bus Barn Site Drainage Area



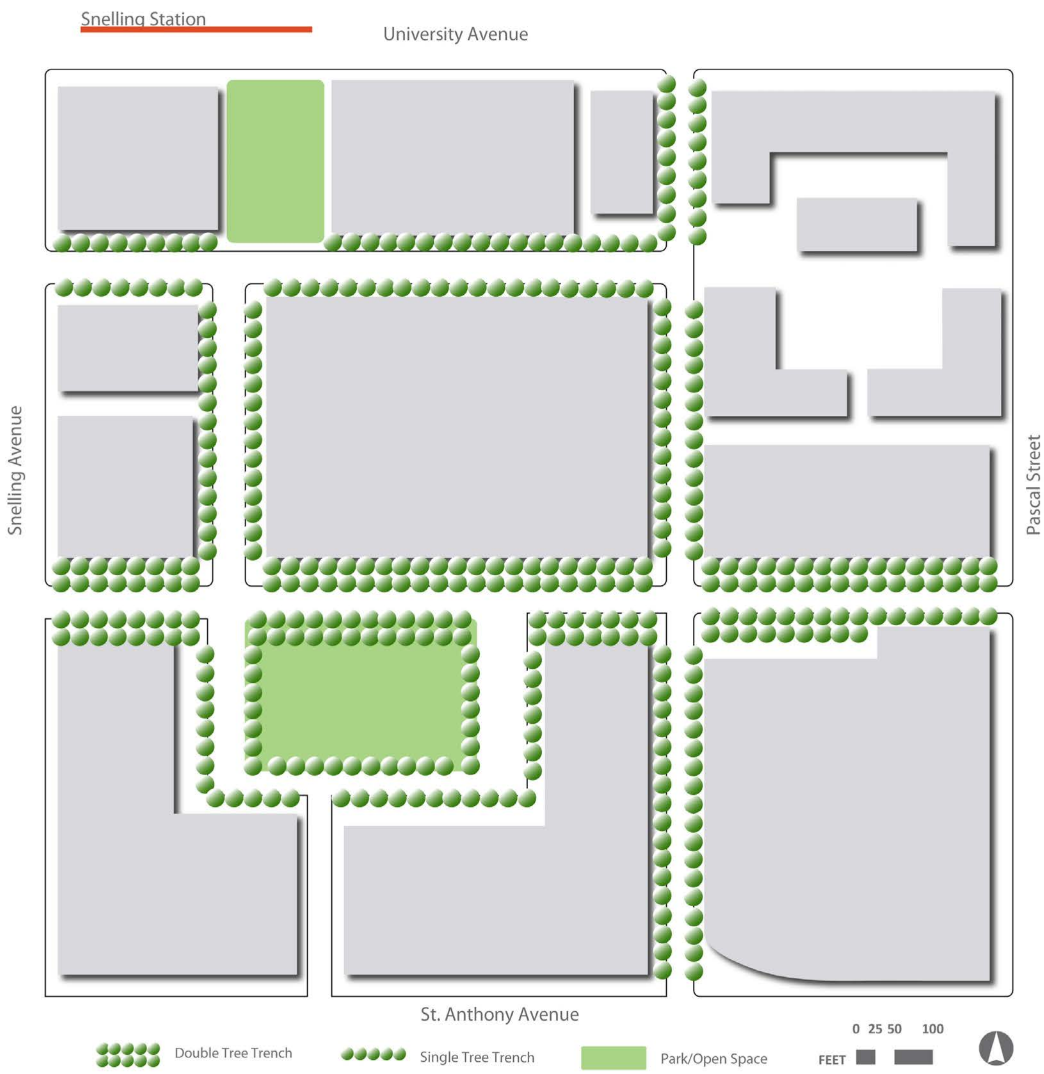


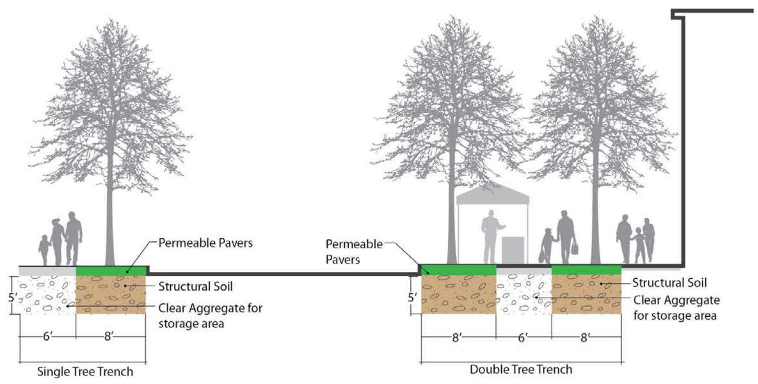
Wet Pond & Bioretention Basin Section

Key Design Points:
- Provides public & private stormwater treatment
- Reconfigure buildings and relocate park to reinforce key sightlines to park to promote connection between University Avenue and open space
- Wet pond and bioretention area to be shaped to further reinforce sightlines, and provide park amenities

Design Assumptions:
- Entire site drains to and is treated in NE corner of the site, which is the lowest point of the site.
- Wet pond has a 21,900 sq. ft. surface area and is 4' deep.
- Bioretention basin has a 12,600 sq. ft. surface area with 30" of bioretention soil.
- Rate control is through outlet control structure connection to storm drain in NE corner of site.
- Necessary rate control volume = 170,400 cu. ft.
- Necessary retention volume = 127,400 cu. ft.
- Total storage volume achieved = 127,500 cu. ft. below normal water level and surface of bioretention basin. (Assumes active pool can be achieved with the footprint of the system.)

FIGURE 16 Bus Barn Open Space Concept





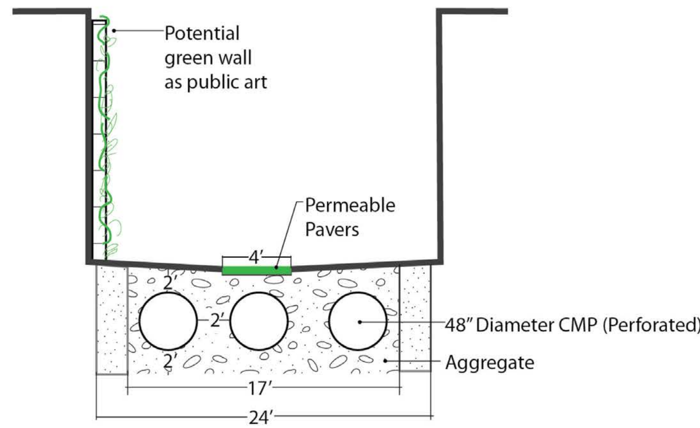
Tree Trench Section

Site Plan Note:
- Block and building configurations taken from Snelling Station Area Plan

Key Design Points:
- Tree trenches in street right-of-way
- Provides public & private stormwater treatment
- Double tree trench creates a strong green spine/promenade that could extend east
- Double tree trench could host farmers market
- Street trees support street life and street character
- Street trees reinforce wayfinding between station area and open space
- Street trees provide environmental benefits (shade, water uptake)

Design Assumptions:
- Single tree trenches are 14' wide by 5' deep
- Double tree trenches are 22' wide by 5' deep with a 6' concrete walkway between
- Aggregate has 30% void space
- Necessary rate control volume = 174,700 cu. ft.
- Necessary retention volume = 127,400 cu. ft.
- Total storage volume achieved = 174,900 cu. ft.

FIGURE 17 Bus Barn Street R/W Concept

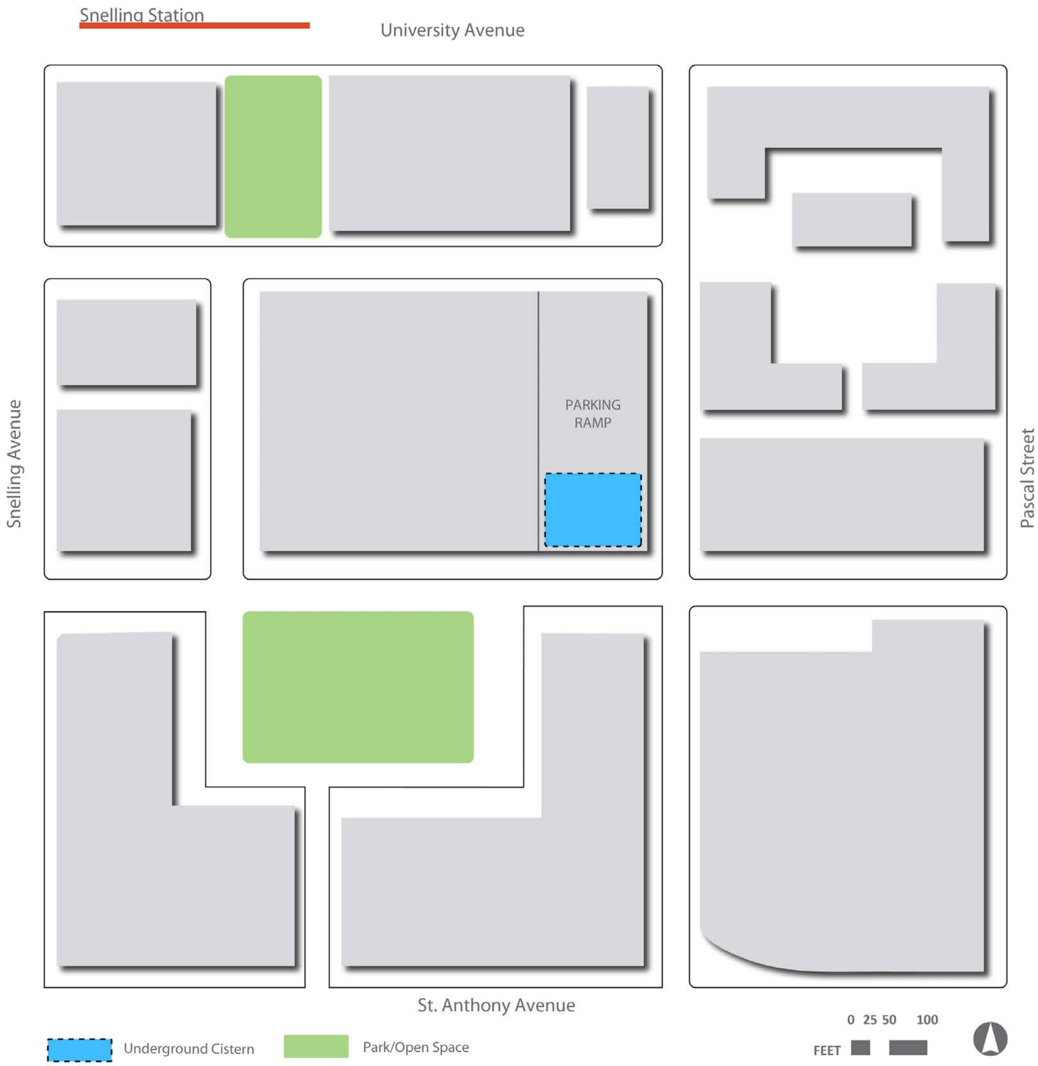


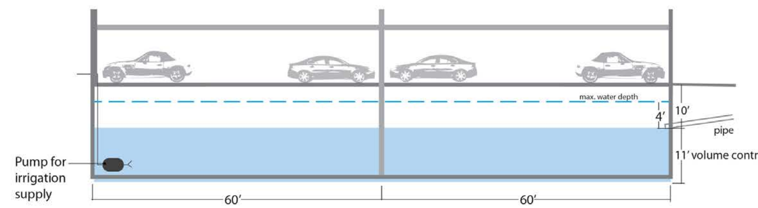
Green Alley Section

Key Design Points:
- Provides public & private stormwater treatment
- Green alleys could support back-door access to retail spaces
- Vegetation and public art could be incorporated through use of structure and native vines
- Permeable pavers allow infiltration of surface runoff

Design Assumptions:
- Alley pavement is 20' wide within a 24' R/W
- Aggregate & pipe storage area is 17' wide by 6.25' deep
- Aggregate has 35% void space
- 4' width is less than wheel path of standard car
- Green walls are not included in storage calculations
- Necessary rate control volume = 174,700 cu. ft.
- Necessary retention volume = 127,400 cu. ft.
- Total storage volume achieved = 176,600 cu. ft.

FIGURE 18 Bus Barn Green Alley Concept





Parking Ramp Cistern Section

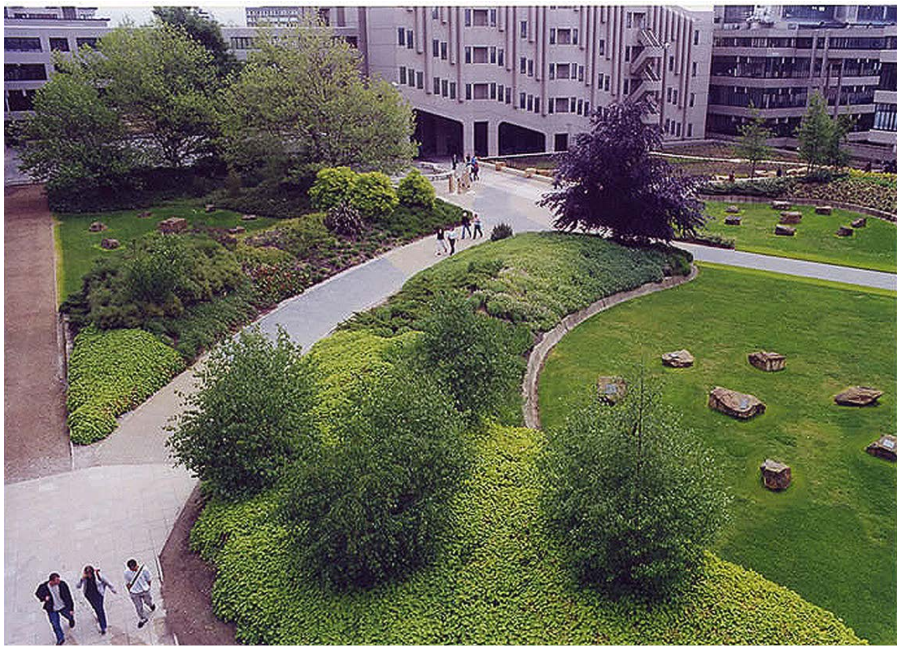
Key Design Points:

- Provides public & private stormwater treatment
- Shared parking ramp would house a below grade cistern that would provide stormwater treatment for entire site
- Stored water would be used to irrigate landscaped area and street trees throughout site to meet volume retention requirements

Design Assumptions:

- Footprint of cistern structure = 120' x 100'
- Freeboard = 3' from bottom of beam to max. water level
- Necessary rate control volume = 174,700 cu. ft.
- Necessary retention volume = 129,950 cu. ft.
- Total storage volume achieved = 180,000 cu. ft.

FIGURE 19 Bus Barn Structured Parking Concept



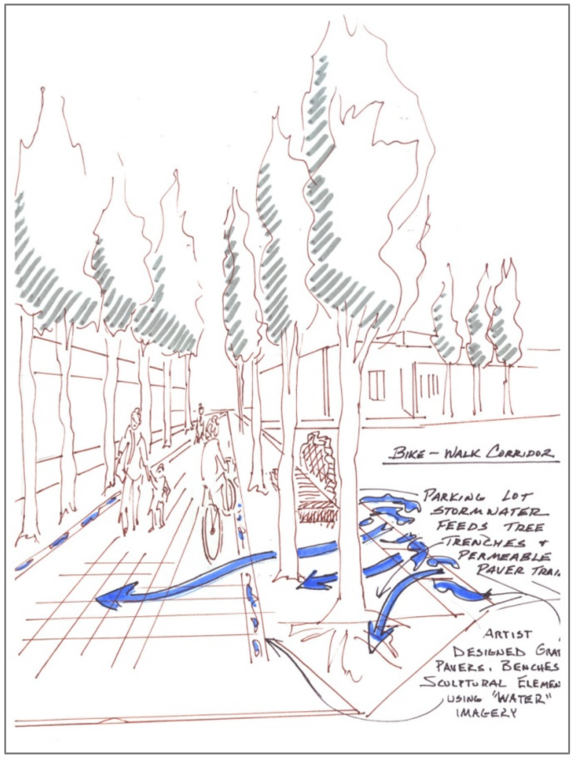
Large open space design

» *"Meet, Sit and Talk" , Lorna Green,1995. The Chancellors Court, University of Leeds. Planting Scheme by Allan R Ruff.*

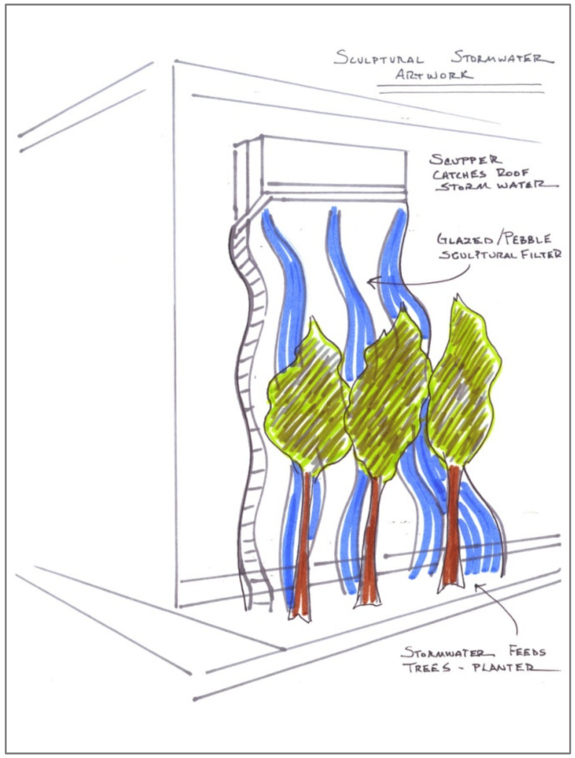
Interactive fountain feature

» *Noguchi Fountain, Hart Plaza, Detroit, MI. Source: blog.modernica.net*

FIGURE 20 Bus Barn Public Art Precedents



Tree trench bike walk corridor



Green Alley Sculpture

Stormwater Sculpture

FIGURE 21 Bus Barn Public Art Concepts

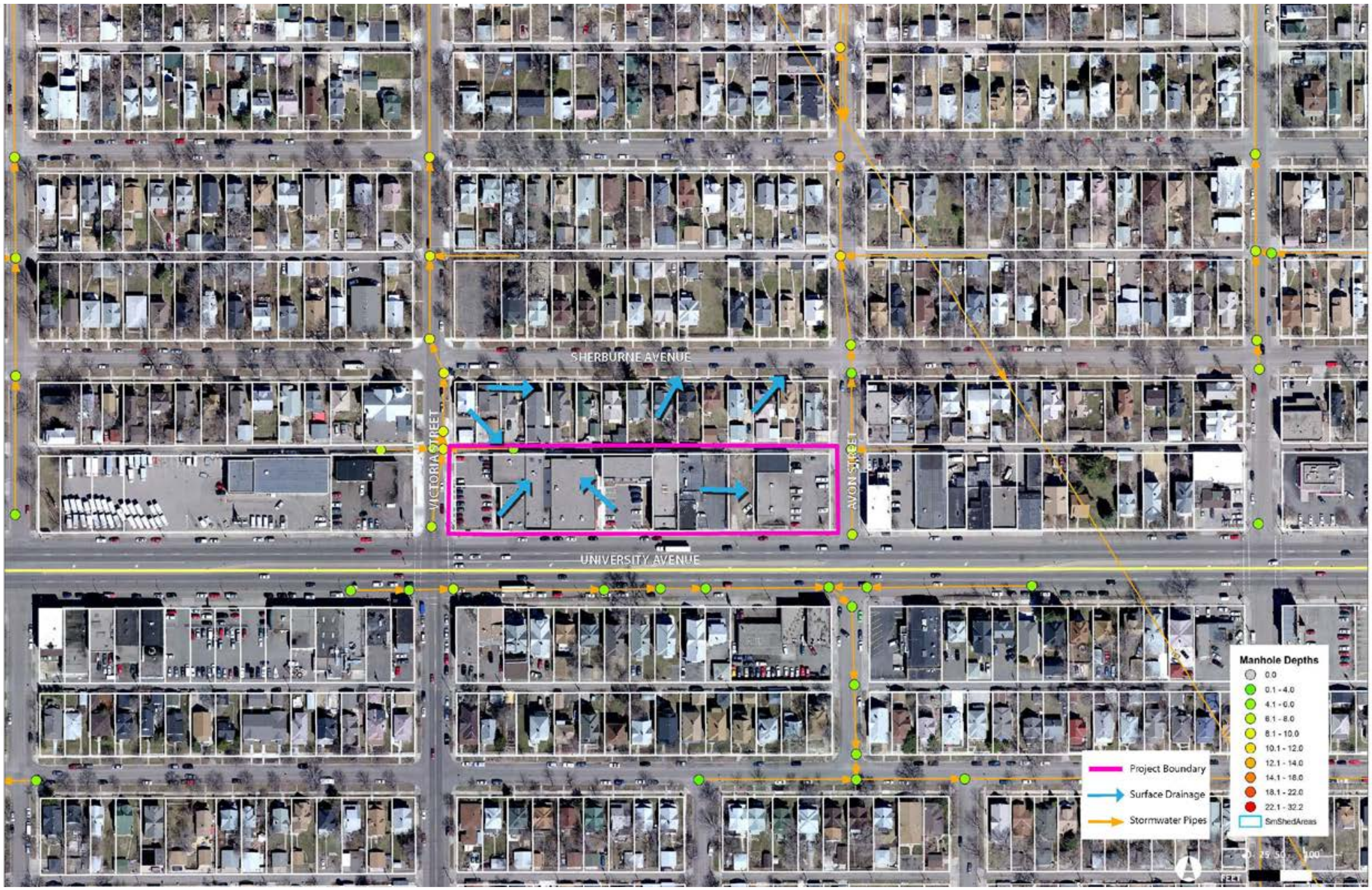
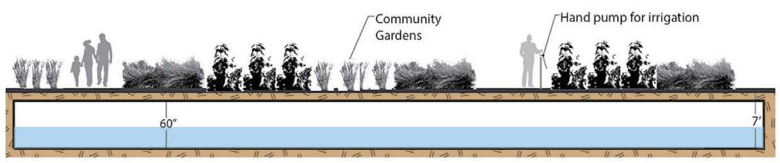


FIGURE 22 Brownstone Site Drainage Area



Irrigation Cistern Section (view looking east)

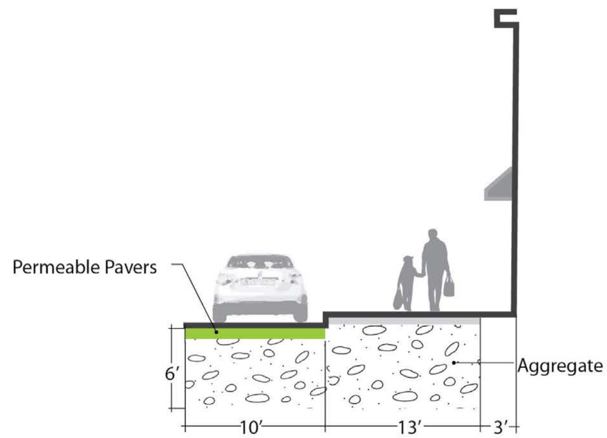
Key Design Points:

- Provides only private stormwater treatment
- Open space treats water from three adjacent buildings
- Open space would serve as a community garden and would be irrigated by an underground cistern
- Water from the future development site would need to be routed into the alley in order to share stormwater BMP

Design Assumptions:

- Cistern for garden irrigation = 88.5′ x 36′
- Cistern is composed of solid 60″ CMP
- Necessary rate control volume = 9350 cu. ft.
- Necessary retention volume = 6850
- Total storage volume achieved = 10,750 cu. ft.

FIGURE 23 Brownstone Open Space Concept



Permeable Parking Bays Section

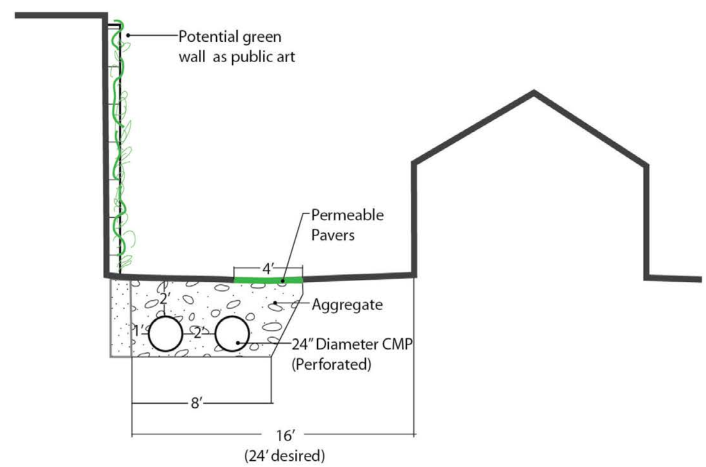
Key Design Points:

- Provides public & private stormwater treatment
- Parking bays and raingardens would be located in the public R/W
- Raingardens would be located in bumpouts

Design Assumptions:

- Takes in water from sidewalk and portions of Avon and Victoria Streets
- Bumpouts are 10' wide x 20' long and 2' deep
- Parking bays are 10' wide and 6' deep
- Additional aggregate storage extends 13' under the sidewalk and has 35% void space
- Necessary rate control volume = 10450 cu. ft. (includes storage for public r/w)
- Necessary retention volume = 7700 cu. ft. (includes storage for public r/w)
- Total storage volume achieved = 10,650 cu. ft.

FIGURE 24 Brownstone Site Street R/W Concept



Green Alley Section

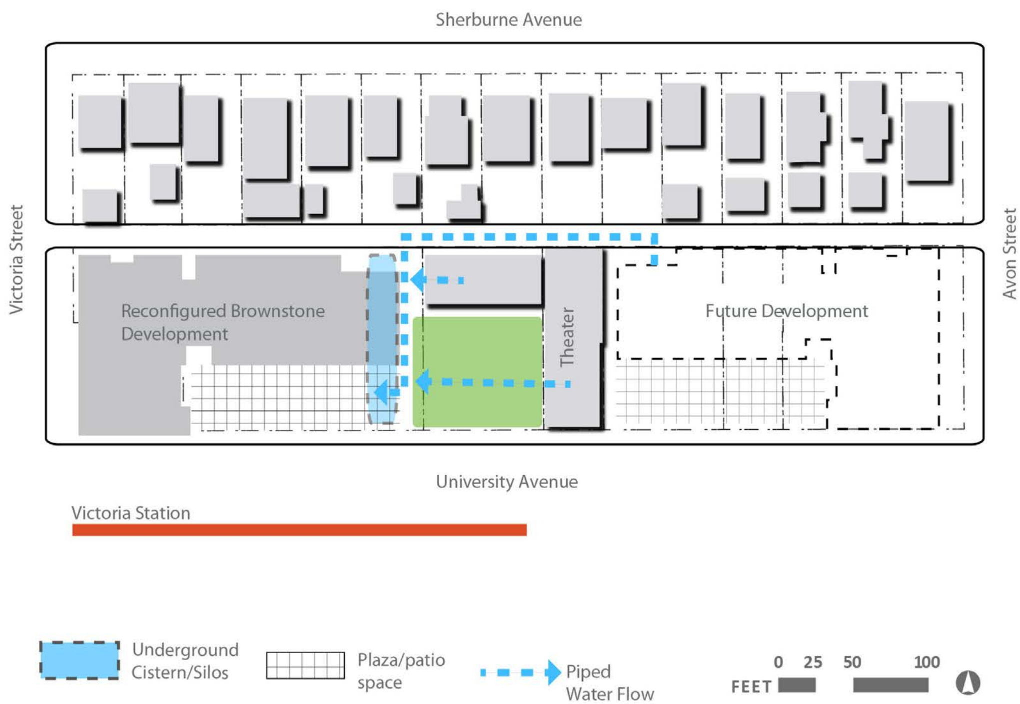
Key Design Points:

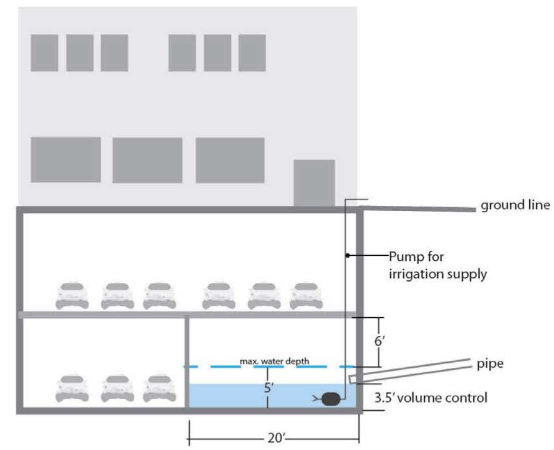
- Provides public & private stormwater treatment
- Green alley treats both new development and adjacent residential that currently drains to alley
- Alley enlarged to the extent possible
- Permeable pavers allow infiltration of surface runoff

Design Assumptions:

- Aggregate is 35% void space
- Green wall is not included in storage calculations
- Necessary rate control volume = 9350 cu. ft.
- Necessary retention volume = 6850 cu. ft.
- Total storage volume achieved = 9900 cu. ft.

FIGURE 25 Brownstone Green Alley Concept





Underground Parking Cistern Section

Key Design Points:
- Provides only private stormwater treatment
- Proposed Brownstone development would be reconfigured to house additional level of underground parking (replace surface parking stalls)
- Parking could be shared between Brownstone and the future development site
- Building reconfiguration allows for plaza/patio space facing the street
- Stormwater would be used to irrigate landscaped areas throughout the site to meet volume retention requirements

Design Assumptions:
- 112' x 18' concrete vault would be integrated into parking structure
- Freeboard = 3' from bottom of beam to max. water level
- Necessary rate control volume = 9350 cu. ft.
- Necessary retention volume = 6850 cu. ft.
- Total storage volume achieved = 9600 cu. ft. (at 5' depth)

FIGURE 26 Brownstone Site Structured Parking Concept

Urban Community Gardening

» *Glendale Townhome Community Gardens. Photo: makingbettermn.org*

Small Green Stormwater Art

» *Malmo, Sweden Photo: Joni Giese*

Green Wall for Alley

» *Source: greenmuseum.org*

FIGURE 27 Brownstone Public Art Precedents

Project wide

- Volume Control Criteria = 1.3 in. rainfall due to urban soils throughout both sites. Filtration requires an extra 30%.
- Water Quality Criteria based on 2.5 inches of rainfall.
- Rate Control Criteria based on 1.64 cfs/acre of drainage area.
- All soils are classified as urban. C soils were used with initial abstractions of 0.2.
- All costs are in 2012 values, with the exception of costs based on MnDOT average bid prices (2011). Estimated annual interest = 4%.
- Costs of pavers are incremental cost above standard concrete or bituminous pavement.
- Permeable pavers include 15" of aggregate.
- Pipe galleries are jetted out every 5 years.
- Installation of pipe gallery is 60% of material cost.
- Costs do not include any engineering or contingency.
- Costs do not include land.
- Replacement cost= Capital cost unless otherwise noted.
- Life Cycle period of 100 years is used to account for differing maintenance schedules and lifespans.
- Normalized whole life cycle unit costs are based on the storage volume achieved, unless otherwise noted.
- The green roof cost was the incremental cost above a standard roof cost

Bus Barn	Brownstone
General • Parks are assumed to have 30% unconnected impervious. • Nonresidential parcels assumed to be high density development with 95% impervious cover. • NE parcel assumed to be multi-family residential development with land use ratios based on Wacouta Commons: Landscaping= 13%, Roof= 64%.	**General** • Land use ratios for the development E. of theater are based on Wacouta Commons: Landscaping= 13%, Roof= 64%. Assumes one assembled development parcel. • The alley is the only ROW contributing runoff to the site.
Open Space – Wet Pond/Bioretention • Stormwater from all parcels will be routed to NE Park. • Rate Control will be handled by overflow outlet control structure. • Wet pond capital cost: $2/cu ft Water Quality Volume (WQV) (Barr).	**Open Space – Pipe Gallery** • One header used to reduce costs. • Capital costs based on previous bids (recent bid tabs). • Solid Wall Underground Pipe O&M: $1.26/cu ft WQV (Barr), Lifespan: 60 years (Contech).

FIGURE 28 Bus Barn and Brownstone Sites Life Cycle Cost Assumptions

Bus Barn	Brownstone
Open Space – Wet Pond/Bioretention (cont.) • Bioretention capital cost: $14/cu ft WQV (2011 Barr Study- modified). • Bioretention Annual O&M: $0.64/sq ft, Lifespan: 10 years (both averages of WERF and NGVC). • Wet Pond Annual O&M: 4.5% of capital cost (average of Barr and Weiss), Lifespan: 25 years, Dredging Cost: 85% of capital cost. • Normalized unit cost based on rate control volume.	**Open Space – Pipe Gallery (cont.)** • Assumes 1 grit chamber.
Street ROW - Tree Trenches • CU soil would be used in tree area (8' wide x 5' deep), aggregate (6' wide x 5' deep). would provide storage under sidewalks. • CU soil capital cost: $87.13/CY (St. Paul recent RSVP project). • Permeable pavers capital cost: $15/sq ft (SRF recent projects), paver cost is incremental cost above standard concrete walk and grates: $9.25/sq ft for single trench, $8.25/sq ft for double trench. • Tree Trench Annual O&M: $0.50/sq ft (Lancaster, PA), Lifespan: 40 years (NGVC). • Tree Trench Pavers Annual O&M: $0.049/sq ft (WERF and NGVC avg), Lifespan: 20 years (NGVC, altered to fit with tree trench replacement timeline).	**Street ROW – Bioretention Bump-outs/ Parking Bays** • Runoff from Victoria and Avon is added to ROW runoff. • Permeable pavers capital cost: $15/sq ft (SRF recent projects), paver cost is incremental cost above standard asphalt pavement: $13.12/sq ft. • Bump-out capital cost: $69.00/ cu ft (includes walls). • Pavers Annual O&M: $0.049/sq ft (WERF and NGVC avg) , Lifespan: 25 years (NGVC). • Bioretention Annual O&M: $0.71/sq ft (includes bump-out walls), Lifespan: 10 years (both averages of WERF and NGVC).

Green Alleys

- Alleys have headers at both ends to allow for storm sewer connection flexibility.
- Cost of concrete adjacent to pavers is not included in cost estimate.
- St. Paul standard plates for CBs are at least 3’ deep. Pipe inverts from CBs must be at least 3' below surface.
- Permeable pavers capital cost: $15/sq ft (SRF LA Dept.), Paver cost is incremental cost above standard concrete pavement: $9.21/sq ft.
- Green Alley Pavers Annual O&M: $0.049/sq ft (NGVC), Lifespan: 30 years (NGVC adjusted to fit with piping replacement schedule).
- Perforated Underground Pipe O&M: $1.26/cu ft WQV(Barr), Lifespan: 60 years (Contech).

<table>
<tr><th>Bus Barn</th><th>Brownstone</th></tr>
<tr><td>Structured Parking
• A 6" DIP reuse system will be included for irrigation purposes.
• Water in vaults will be available for gray water reuse.
• Assumes 3 grit chambers as pretreatment for storm drain systems.</td><td>Structured Parking
• Excavation would occur anyway for parking, but possibly not as much or in that shape, included in cost.
• Irrigation system not included, would be installed anyway.
• Assumes 1 grit chamber.</td></tr>
<tr><td colspan="2">• Provides 3' of freeboard between max. water height and bottom of 3' T-beam.
• Vaults hold irrigation supply.
• Capital costs for walls, floor slab, and excavation from recent projects.
• Concrete Vault Annual O&M: 2% of capital cost, Lifespan: 50 years.
• Cost includes excavation, but assumes vaults are above water table and bedrock.
• Cost does not include foundation.
• Irrigation uses will not meet volume control requirements based on 1”/sq ft/ week over assumed landscaped areas.</td></tr>
<tr><td>Individual
• 70% of rooftop is green roof.
• Extensive green roof provides minimal retention volume, but reduces rate and volume control requirements.
• Green roof requires other rate and volume control storage; underground pipe galleries added. Assumes adequate space to construct a system with the necessary size.
• Green roof cost includes membrane and modular extensive system.
• Green roof capital cost= $11.37/sq ft (NGVC)
• Green Roof Annual O&M: $0.31/sq ft (WERF), Lifespan: 25 years (NGVC).
• Pipe gallery capital costs based on previous bids (SRF).
• Pipe Gallery Annual O&M: $1.26/cu ft WQV (Barr), Lifespan: 60 years (Contech).
• Pavers Annual O&M: $0.049/sq ft (WERF and NGVC avg), Lifespan: 25 years (NGVC).</td><td></td></tr>
</table>

FIGURE 28 Bus Barn and Brownstone Sites Life Cycle Cost Assumptions, cont.