Green Streets Stormwater Management Plan

Prepared for

City of Milwaukee

Prepared by

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Contents

Tables

Flow Charts

Attachment

Introduction

This document provides a menu of green street stormwater strategies that can be used to reduce stormwater quantity and improve stormwater quality through implementation with street and alley repaving or reconstruction projects within the City of Milwaukee (City). The applicability matrix (Table 1) summarizes the type of green street strategies that could be utilized in different street settings. Typical green street strategies - such as bioretention, tree trenches, and porous pavements - in medians, terraces, and parking lanes are included in the matrix. For each of the three primary green street strategies, examples of typical installation locations, benefits, and maintenance considerations are provided. Photos and cross-sectional renderings of example applications have been provided to show a variety of successful installations.

When selecting a green street strategy, it is important to consider the project location and site constraints, street classification, parking needs, and the driving practices that will occur in the area. While green street strategies included in this document can be implemented on most street classifications, careful selection of the green street strategy can help to maximize the benefits and long term success realized from the project. This document develops an ordered process for identifying and selecting potential green street strategies, however site specific evaluations by experienced City staff will be needed to determine the detailed design features and site constraints for each project.

Within the combined sewer area, reducing stormwater runoff volume through storage volume, evapotranspiration, and infiltration capacity are the most important hydrologic benefits that green infrastructure can provide because most of the discharged stormwater runoff will be treated at the Milwaukee Metropolitan Sewer District’s water reclamation facilities to improve water quality. Areas draining to the separate stormwater system may focus more on water quality, however there will be locations where quantity control to reduce surface flooding or water in basements will be important (in addition, water quantity and quality are closely linked). Of the green street strategies, bioretention typically provides the greatest water quality improvement while all of the strategies provide water quantity benefits.

An additional consideration in green street strategy selection is the type of traffic that will be driving on or near the green infrastructure. Porous pavers are expected to be more durable in parking lots and parking lanes, whereas porous asphalt and concrete may be better-suited to low traffic areas or in areas where there is minimal traffic turning or starting and stopping.

Retrofitting existing right-of-way to include green street stormwater strategies will generally fall into the following categories:

- Using less impervious area in a reconstructed street or alley;
- Using existing or newly created green space for green street stormwater strategies;
- Implementing porous pavement within the pavement cross section in low traffic areas.

For example, a key green street stormwater strategy application will include reducing impervious area by narrowing streets. Where roadways are wider than needed for existing traffic capacity, narrowing the pavement width will reduce pavement costs and create green space. This reduces runoff by having less impervious pavement and the new green space could potentially provide additional opportunities for the placement of bioretention in medians or terraces. For example, if the grassed terrace along a residential street is too narrow for a tree trench or bioretention and the existing street width is wider than necessary, the street could be narrowed to meet current design standards while widening the terrace to accommodate green street stormwater strategies.

Similarly, converting existing green space from a raised median to a depressed median with bioretention or tree trenches could occur. Other possible scenarios exist for modifying medians or terraces, and adding curb bump-outs to incorporate green street stormwater strategies, such as bioretention. Where medians do not exist or terraces are too narrow for bioretention, streets could incorporate porous pavement or tree trenches as a green street stormwater strategy.

The information in this document provides planning level information to guide in the selection of appropriate green street strategies for planned street and alley repaving or reconstruction projects and serves as a starting point to be ground-truthed through a site-specific Department of Public Works (DPW) evaluation.

TABLE 1
Green Street Strategy Applicability Matrix

Street Classification	Bioretention	Porous Pavement	Tree Trench
Local (residential streets, low traffic volume, typically no median)	Yes. Applicable on wide terraces. Applicable on medians, but few medians exist on local streets.	Yes. Applicable on entire low traffic volume streets or in parking lanes.	Yes. Applicable on terraces. Applicable on medians, but few medians exist on local streets.
Collector (feeder street for arterial street, medium traffic volume, few medians)	Yes. Applicable on wide terraces and on medians.	Yes. Applicable in parking lanes.	Yes. Applicable on terraces and on medians.
Minor Arterial (similar to Major Arterial)	Yes. Applicable on wide terraces and on medians.	Yes. Applicable in parking lanes.	Yes. Applicable on terraces and on medians.
Major (Principle) Arterial (high traffic volume, likely median, likely parking restrictions during peak traffic hours)	Yes. Applicable on wide terraces and on medians.	Maybe. Applicable in parking lanes where parking lanes are not used for peak traffic travel lanes.	Yes. Applicable on terraces and on medians.
Alley	Not Likely.	Yes, depending on traffic characteristics (trash and delivery trucks, etc.).	Not Likely.
Service Drive (parallel road to major road which provides local access, low traffic volume)	Yes. Applicable on wide terraces.	Yes. Applicable on entire low traffic volume streets or in parking lanes.	Yes. Applicable on terraces.

Note: The applicability of the green street strategies is a general classification for the varying street types. Several factors will determine if a strategy can be implemented on a specific street or location, such as the street slope, existing drainage infrastructure, soils, traffic patterns, utilities, etc.

Green Street Stormwater Strategy Examples

The following section provides a description of example green street stormwater strategies, typical maintenance requirements and design guidelines. Each strategy includes a summary table with several metrics, including typical unit cost, application parameters, and typical design criteria. A summary of the metrics and how they can be used for planning and design is included in Table 2.

TABLE 2
Green Street Stormwater Strategy Metric Definitions

Metric	Description
Typical Range of Impervious Area Managed Per Unit Area of Strategy	Green street stormwater strategies have the capacity to treat impervious area draining to them that varies by strategy. This metric provides the range typically within the limits of each strategy.
Assumed Impervious Area Managed Per Unit Area of Strategy	The impervious area managed value used for the green street stormwater strategy in the analysis. This metric provides the value used in the ODB to estimate strategy area needed and the associated cost.
Typical Incremental Costs	Typical total cost per square foot of green street stormwater strategy if completed as part of a resurfacing or reconstruction project (i.e. not implementing the strategy as a stand-alone project). Cost effectiveness depends both upon the per square foot cost of the strategy and the range of impervious area that can be managed by the strategy.

TABLE 2
Green Street Stormwater Strategy Metric Definitions

Metric	Description
TSS Reduction	Estimate of total suspended solids reduction based upon impervious area treated. Varies by strategy type. All stormwater strategies assume similar pollutant removal. However, note that porous pavement may not receive the same pollutant reduction from the WDNR as bioretention. WDNR's current policy on porous pavement, which is under review, is to allow the water infiltrated to count towards TSS reduction goals. Actual performance will depend upon site specific soil infiltration rates.
Total Phosphorus Reduction	Estimate of total phosphors reduction based upon impervious area treated. Varies by strategy type. All stormwater strategies assume similar pollutant removal. However, note that porous pavement may not receive the same pollutant reduction from the WDNR as bioretention. WDNR's current policy on porous pavement, which is under review, is to allow the water infiltrated to count towards phosphorus reduction goals. Actual performance will depend upon site specific soil infiltration rates.
Provides Flooding Benefit	Each strategy provides benefits to regional flooding problems by reducing the volume of runoff and/or reducing runoff rates.
Combined Sewer Benefits	Types of benefits for each green street stormwater strategy most relevant within the combined sewer service area.
Separate Sewer Benefits	Types of benefits for each green street stormwater strategy most relevant within the separate sewer service area.
Slope Limitations	Typical slope considerations for each green street stormwater strategy.

Bioretention

Description

Bioretention consists of an excavated area back-filled with an optional high void ratio crushed stone bottom layer and engineered soil, providing good growing characteristics and high infiltration rates, and planted with woody and/or herbaceous vegetation. In some cases, it can include trees.

Stormwater runoff directed to bioretention will percolate through the engineered soil and stone medium, which provides filtering before infiltration to native soil, or returning through an underdrain to the drainage system. An underdrain is typically placed above the bottom of the crushed stone layer to provide positive drainage once the stone void storage is filled. An overflow mechanism is sometimes included when surface storage is exceeded and overflow to the adjacent roadway or property is not desired.

Maintenance

Short Term (years 1-2): Include as a contractor requirement in installation contract. Typical maintenance includes:

- Weeding and Mulching
- Watering
- Infiltration Verification
- Care/Replacement of plants

Ongoing

- Trash and debris removal
- Check for clogging
- Mulching
- Removal of unwanted plants

Placement Opportunities

- Center medians
- Terraces
- Off street (e.g. parks, open space, vacant lots)
- Curb extensions/bump outs
- Traffic circles

Placement Considerations

- In the separate sewer service area, consider horizontal separation from sanitary sewer or take steps to minimize infiltration if sewer infiltration is known
- Minimum width of 5 feet; consider a tree trench in narrower terraces
- Native soil infiltration rates can limit total infiltration (design underdrain as needed)
- Inlet placement to maximize entry into bioretention
- Positive drainage to street curb when bioretention fills to capacity
- Energy dissipation at inflow locations
- Coordinate plant selection for salt tolerant species with Foresty

Terrace Bioretention Installation, Milwaukee, WI

Terrace Bioretention Installation 2, Milwaukee, WI

Median Bioretention Installation, Milwaukee, WI

Performance

Typical Range of Impervious Area Managed Per Unit Area	Assumed Impervious Area Managed Per Unit Area	Typical Incremental Cost Per ft^2	TSS Reduction	Total Phosphorus Reduction	Provides Flooding Benefit	Combined Sewer Benefits	Separate Sewer Benefits	Slope Limitations
10 to 20	12	$17	80%-100%	40-80%	Yes	Flood reduction, CSO reduction	Flood reduction and water quality benefit	Must have relatively flat area for bioretention footprint

Urban Street Before, Syracuse, NY

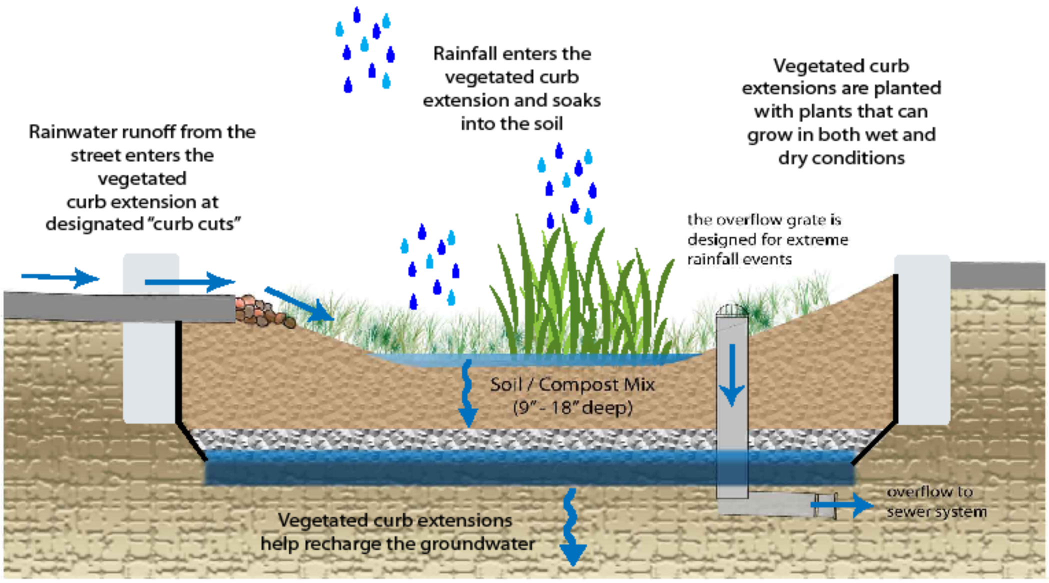
Urban Street After Curb Extension, Bioretention with Tree Planting and Overflow, Syracuse, NY

Urban Street Before, Syracuse, NY

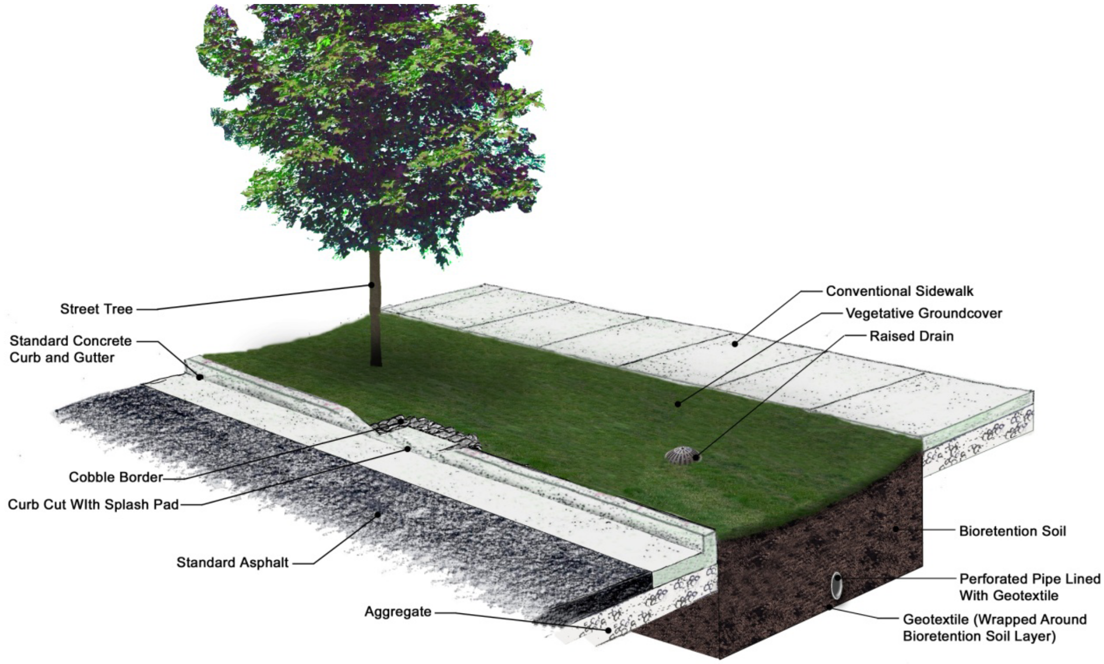
Urban Street After Rendering with Curb-side Bench, Grass Planting Bioretention, Underdrain with Overflow, Syracuse, NY

Urban Street Before, Syracuse, NY

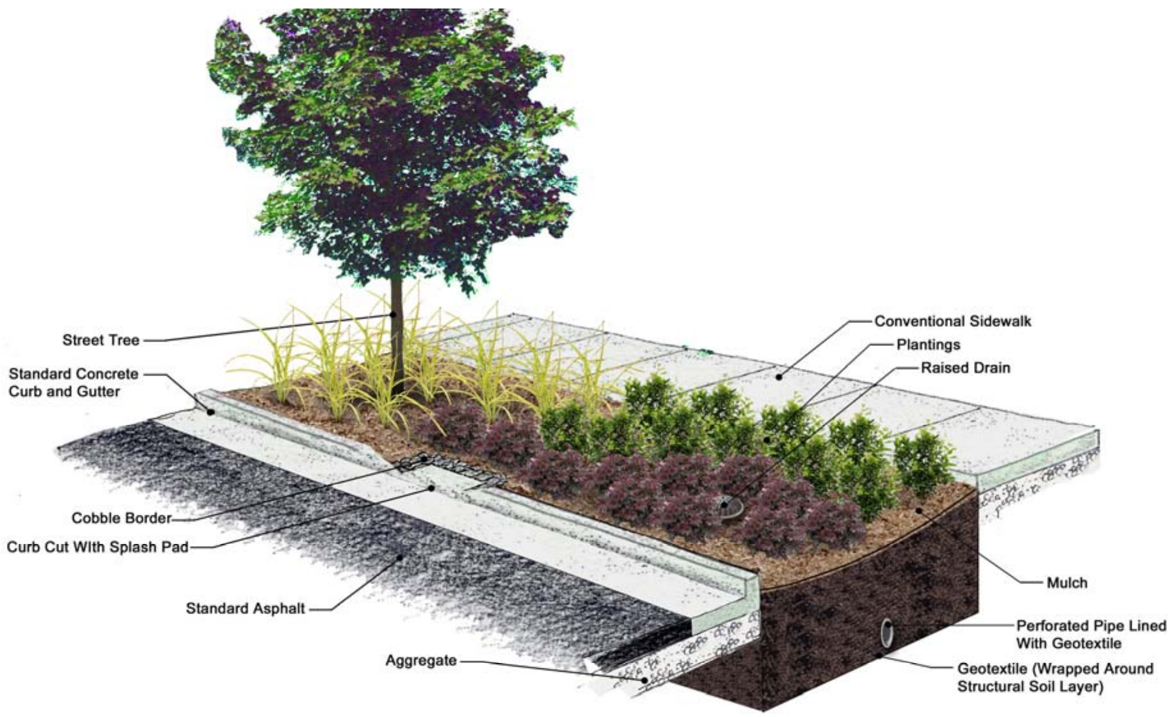
Urban Street After with Bioretention and Trees, Syracuse, NY



Typical Cross Section of a Bioretention Facility with an Overflow



Typical Cross Section of a Bioretention Facility with an Underdrain, Overflow, and Tree and Grass Plantings (e.g. typical residential or local street installation)



Typical Cross Section of a Bioretention Facility with an Underdrain, Overflow, and Native Planting

Porous Pavement

Description

Concrete, asphalt, or paver block surface constructed so water can flow through the surface and into a storage or infiltration area underneath.

Typical Maintenance

- Vacuuming 1-4 times a year
- Performance inspections during rainfall to observe infiltration and general observations (spalling, cracking, missing paver blocks, etc.)
- Inspection of general cleanliness of pavement and surrounding/adjacent landscape every 2 months during the first year and reduce if performance is meeting expectations
- Infiltration Verification

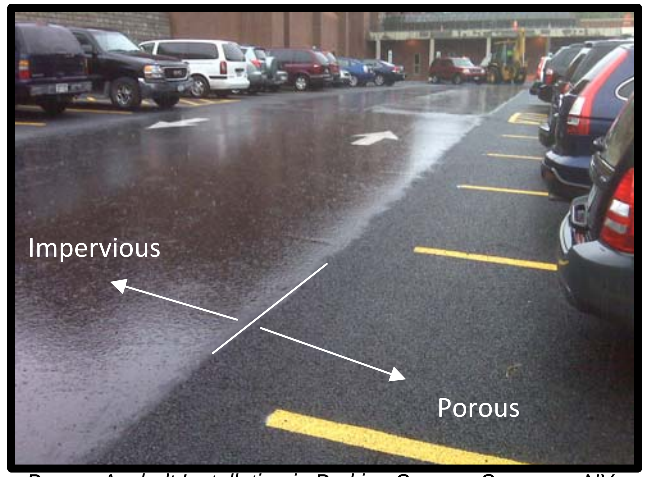
Placement Opportunities

Placement of porous pavement can potentially be over the entire areas noted below, or they can be used in partial areas based on traffic patterns, site grading, and tributary area.

- Local streets
- Parking lanes (without bus traffic)
- Service drives
- Alleys
- Parking lots
- Sidewalks

Placement Considerations

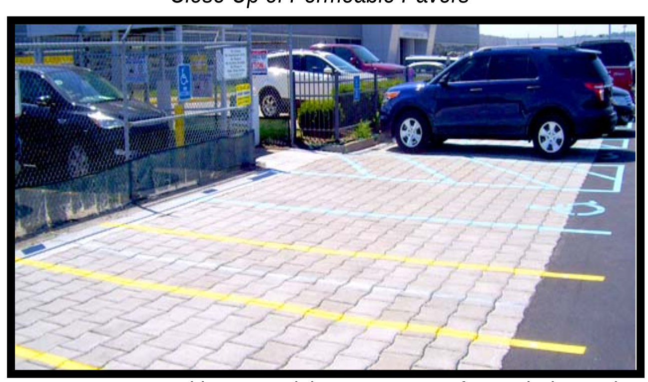
- Typically avoid high traffic areas
- Cautiously select areas with high frequency of starting and stopping, and wheel turning in stationary or slow moving speeds for porous concrete and porous asphalt applications
- Adjust snow plowing technique
- Typically avoid areas with contaminated soils
- Typically avoid heavy equipment or vehicle traffic (e.g. bus stop)
- Underdrains may be needed
- Carefully specify installation requirements, including appropriate weather limitations for porous asphalt and concrete



Porous Asphalt Installation in Parking Spaces, Syracuse, NY


Pervious Concrete in Sidewalk, Syracuse, NY


Close Up of Permeable Pavers


Porous Paver Parking Lane (photo courtesy of pavedrain.com)

Performance

Typical Range of Impervious Area Managed Per Unit Area	Assumed Impervious Area Managed Per Unit Area	Typical Incremental Cost Per ft^2	TSS Reduction	Total Phosphorus Reduction	Provides Flooding Benefit	Combined Sewer Benefits	Separate Sewer Benefits	Slope Limitations
1 to 8	4	$7	Credit for infiltration; DNR reviewing current standards	Credit for infiltration; DNR reviewing current standards	Yes	Flood reduction, CSO reduction	Flood reduction, water quality benefit	<5% (typical)

Urban Street Before, Syracuse, NY

Urban Street After with Porous Paver parking Lanes and Bioretention, Syracuse, NY

Porous Concrete Parking Lane, Syracuse, NY

Alley Before, Lancaster, PA

Green Alley with Permeable Pavers After, Lancaster, PA

Typcial Cross Section of Standard Pavement (left) and Porous Pavement

Tree Trench

Description

A tree trench consists of an excavated trench back-filled with high void ratio crushed stone, soil, and trees. Water is fed to the tree trenches through infiltration, porous pavement, curb-cuts and inlets, or subsurface drainage media. Pretreatment of stormwater through inlets with sumps and filter inserts are good practices to prevent clogging the tree trench media with garbage, debris or excessive sediment in the runoff. Water evaporates, infiltrates, and is filtered of pollutants within the tree trench section. Tree trenches can include underdrains that discharge stormwater to the sewer system if the volume of water delivered to the trench is in excess of its storage and infiltration capacity.

Tree trenches are applicable as stand-alone green street strategies or implemented in combination with porous pavement. Tree trenches could also be installed as an alternative to bioretention. Tree trench installation decisions will need to be made apart from the ODB process through site-specific consideration.

Maintenance

Short Term (years 1-2): Include as a contractor requirement in installation contract. Typical maintenance includes:

- Watering while trees establish (2 years)
- Pruning and Mulching
- Replacement of dead trees
- Infiltration Verification

Ongoing

- Cleaning tributary catch basins
- Check for clogging
- Tree care (e.g., Pruning)
- Weeding

Placement Opportunities

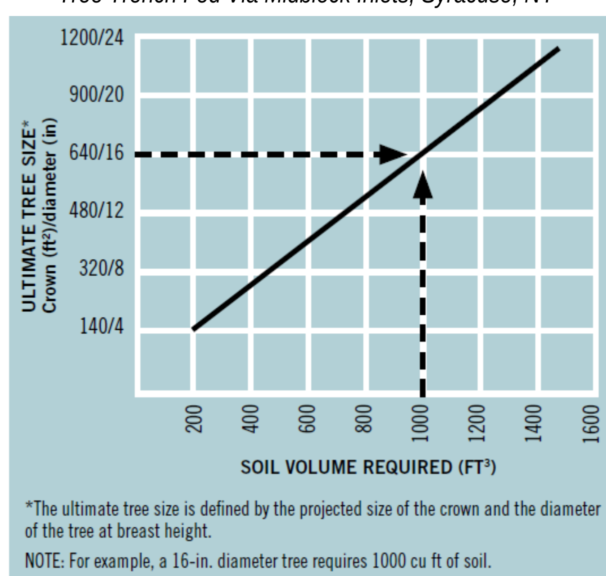
- Terraces require minimum width sufficient to plant tree

Placement Considerations

- Soil volume is important for tree health (soil volume is made up of open soil not under pavement or soil under pavement that has been designed to allow root growth)
- In separate sewer service area, consider horizontal separation from sanitary sewer or take steps to minimize infiltration if sewer infiltration is known
- Prefabricated tree pit systems exist for easier installation, although they should be evaluated carefully for cost and the ability to support long-term tree health

Tree Trench Installation, Syracuse, NY

Tree Trench Fed Via Midblock Inlets, Syracuse, NY

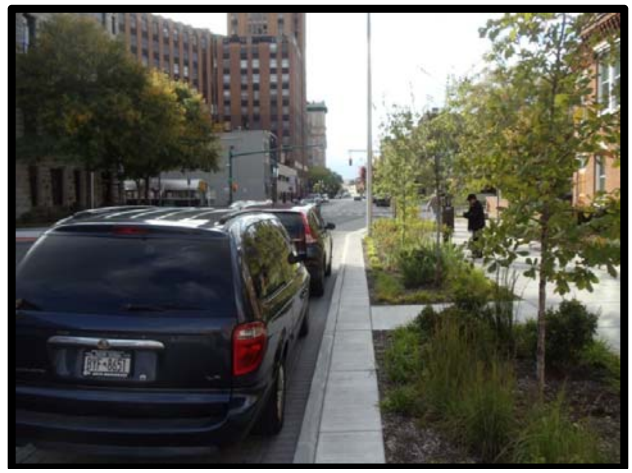


Required Soil Volumes Based on Ultimate Tree Size, Source: New York City Department of Parks and Recreation

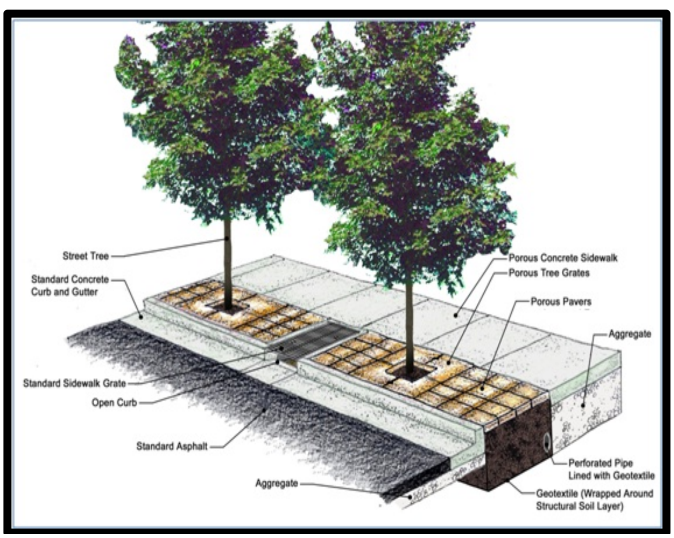
Performance

Typical Range of Impervious Area Managed Per Unit Area	Assumed Impervious Area Managed Per Unit Area	Typical Incremental Costs Per ft^2	TSS Reduction	Total Phosphorus Reduction	Provides Flooding Benefit	Combined Sewer Benefits	Separate Sewer Benefits	Slope Limitations
10 to 20	12	$7-$11	Infiltration dependant	Infiltration dependant	Yes	Flood reduction, CSO reduction	Flood reduction, water quality benefit	On steep slopes trench is somewhat limited and typically becomes a series of individual enhanced tree pits

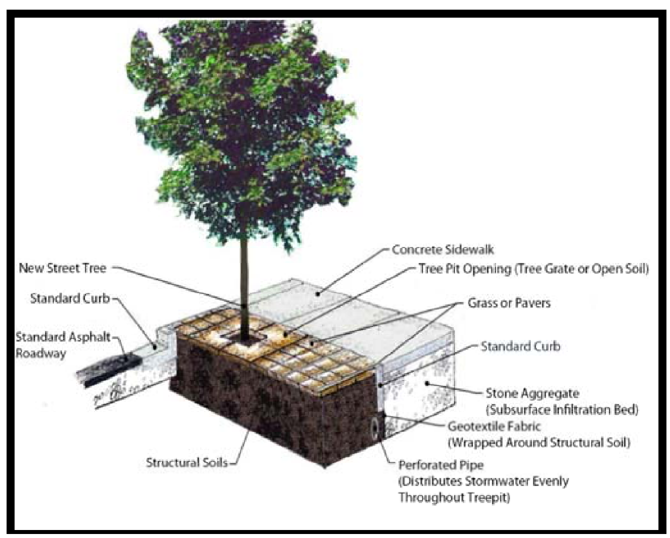
Urban Street Before, Syracuse, NY



Urban Street After with Tree Trench and Bioretention, Syracuse, NY



Conceptual Tree Trench Components



Conceptual Tree Trench Section

Green Street Inspections and Performance Verification

The benefits detailed for each green street strategy are contingent on the use of the correct materials and proper construction techniques. Compaction of native soils, improper soil mixes and the use of heavy equipment in areas designed for infiltration can cause problems that may be difficult to observe visually but will have detrimental impacts on performance. It is recommended that green street strategies receive an infiltration test to confirm that they were constructed properly and are achieving the design goals before maintenance of the devices is handed over to the City. Ideally this test would be conducted after new plantings had a chance to become established. Infiltration testing could include double ring infiltration tests, filling of devices to capacity with water trucks, or monitoring during a specified storm.

Using the Oracle Database for Green Street Planning

The City has an Oracle database (ODB) that is used by several departments within the DPW and includes detailed street information, budgeting, and scheduling for reconstruction and resurfacing projects. Because of the database's significance with project planning, it will be a critical tool for the implementation of green street stormwater strategies. The database will be used to provide an initial screening of each street project for its potential to implement green street stormwater strategies.

Background

The DPW and several units within the DPW (e.g., streets, stormwater, forestry, and water) utilize the ODB for tracking, planning, and design of street and alley resurfacing and reconstruction projects. The ODB has historically focused on pavement reconstruction and resurfacing; however, the database includes detailed information about City streets and alleys that can support implementation of green street stormwater strategies.

The street repaving and reconstruction process is initiated by Project Programming. After evaluation using the ODB process, Project Programming issues a City Engineer Letter (CE Letter) that identifies street resurfacing or reconstruction project extents and details about the project. The CE Letter is circulated to several units within the DPW, including streets and transportation, environmental, water, sewer and stormwater, traffic signals and signs, street lights, forestry, and underground communications. The letter is also distributed to other entities with buried infrastructure along the street reconstruction route, such as Milwaukee County, WE Energies, Time Warner, AT&T, and others. Each recipient of the letter has the opportunity to comment on the projects; however, not all units comment and some hold comments until final design. In many cases not commenting or holding comments until final design does not impact the ability of implementing green infrastructure. However, this practice can also lead to missed opportunities.

Incorporating Green Infrastructure into the ODB and CE Letter Processes

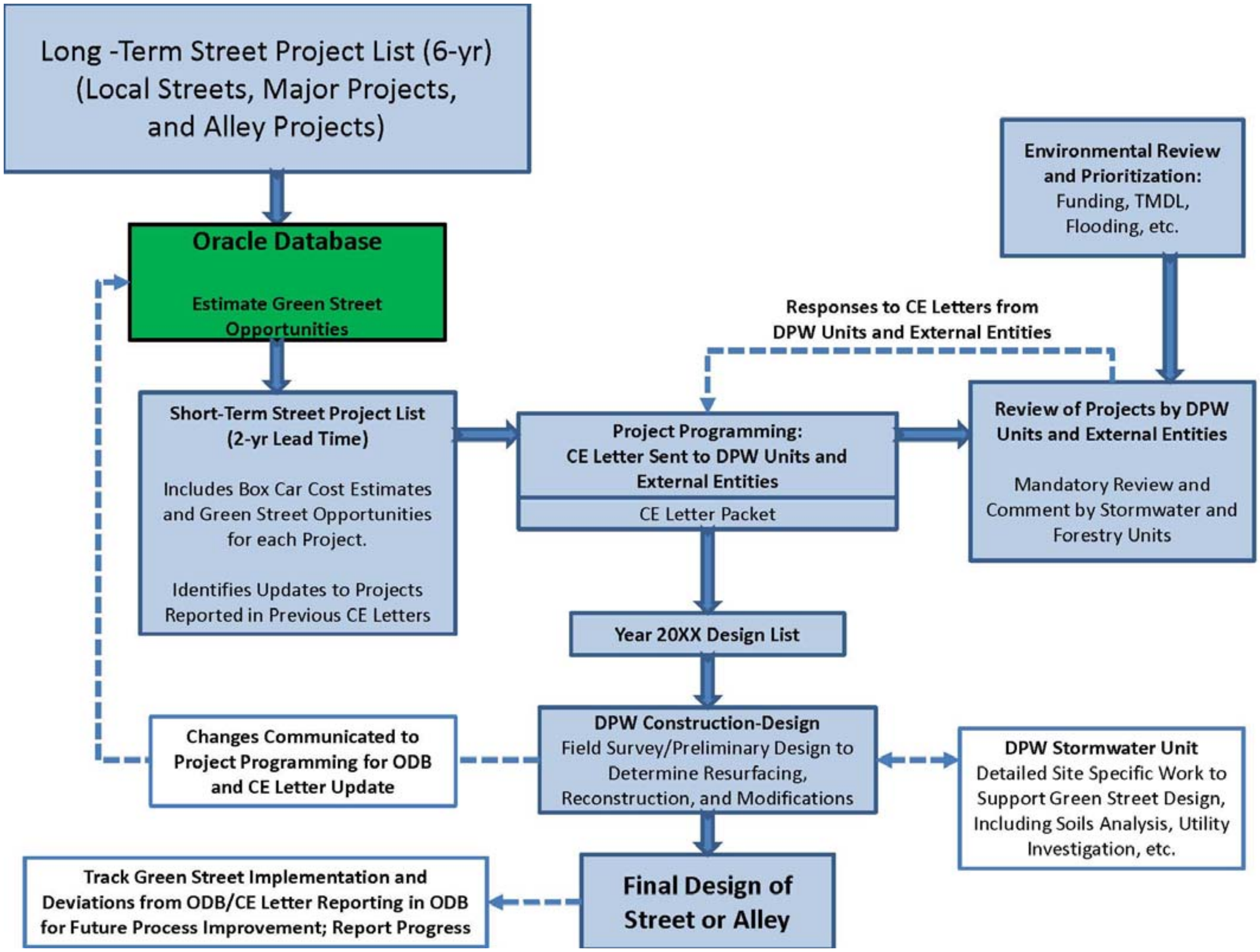
Several meetings between units within DPW, including Project Programming, were held during the development of this evaluation process. The meetings summarized current practices for tracking, planning and designing street and alley reconstruction and resurfacing projects, and they also identified opportunities to modify the current protocols to improve the implementation of green street stormwater strategies. These proposed modifications are summarized below, along with a process flow chart for tracking, planning and designing green stormwater strategies on street and alley resurfacing and reconstruction projects.

- The CE Letter is distributed to each unit within DPW and to entities with infrastructure in the vicinity of the project. There is a feedback loop for some of the entities to verify that they received the letter, to encourage them to comment, and to confirm that the unit or entity has "no comment." It is recommended that the CE Letter encourage a response by each recipient so that any comments can be incorporated at the earliest time possible. It is also recommended to require each recipient to confirm receipt of the letter even if they have no comment. The goal of this modification is to encourage comments from City units and external entities early in the process, track comments in the ODB so they are disseminated to appropriate units and incorporated in the planning and design, and to track if comments or receipt of the letter were not acknowledged. This is, in part, required in the current CE Letters for utilities, but is not required for DPW units.

- Each project included in the CE Letter starts as a resurfacing project. It is only changed to a reconstruction project if specifically requested after field work is completed by the streets/transportation unit. Currently, the change from resurfacing to reconstruction is not always reported back to the Project Programming and other DPW units until final design is complete. Consequently, some of the DPW units and external entities may not know that the project has changed from resurfacing to reconstruction until final design is complete and therefore opportunities for implementing green infrastructure are likely missed. Because of the cost efficiencies of implementing green street stormwater strategies during reconstruction, it is very important to know if a resurfacing project is switched to a reconstruction project so that opportunities for cost-effective green street stormwater strategies are not missed. For example, to make porous pavement implementation more cost-effective, it may not be recommended on resurfacing projects but should be considered for reconstruction projects. Similarly, a reconstruction project may make bioretention a viable option because curbs are being replaced thereby impacting medians or terraces. These examples demonstrate that changes in the project type will have significant impact on the opportunity for green street stormwater strategies. Therefore, it is recommended that the ODB and Project Programming be updated with any change in the project from resurfacing to reconstruction so this information can be tracked and communicated to DPW units and external entities (e.g., through the CE Letter) and the projects can be reevaluated for green street stormwater strategy opportunities.
- Tracking decisions or changes related to green infrastructure implementation will be an important step for improving the ODB analysis and subsequent reporting in the CE Letter, and for shaping policy within the DPW. By tracking changes to the recommendations generated by the ODB analysis, the City will be able to evaluate potential changes to the analysis for improved future planning. For example, the ODB analysis will be evaluating green street stormwater strategies for each street project and making recommendations when evaluation criteria are met. After the stormwater or forestry units conduct a site specific review of the ODB screening recommendations for green street opportunities and constraints, those units may conclude that modifications to the initial ODB screening analysis recommendations are needed. If a pattern in the ODB analysis becomes apparent it may suggest the analysis should be refined to improve the resultant recommendations. A pattern may also suggest that a policy change within the City should be reevaluated. Tracking these changes could simply be a field in the ODB that provides space for a brief statement of the change to the ODB analysis and the outcome of that change.
- Identifying potential project partners may be an important aspect of implementing green street stormwater strategies. Potential partners may include City parks and other City properties, schools, county parks, or other public parcels. Communicating this information to the stormwater unit (possibly in the CE Letter or as an attachment to it) for review with the initial ODB evaluation will allow the DPW to evaluate the potential for partnering with adjacent land potentially offering significant cost savings to the City. These types of partnerships can require significant lead-time, and therefore this information will be important to communicate as early in the process as possible. This will be especially important if a project is (re)categorized as a reconstruction project, where there are likely greater opportunities for green street implementation.
- Major Projects will coordinate with Local Street Project Programming for ODB evaluation opportunities on Major Projects. Major Projects are developed using a different methodology than the Local Street program and consequently are usually not evaluated using the ODB for planning purposes. Major Streets usually only have several projects each year while the Local Street program has many projects. Major Projects consequently should work with Local Street Project Programming to access the initial green street screening process available through the ODB.

As with most projects that start with planning and continue into detailed design, adjustments to the green street strategies and maintenance plans will help increase successful implementation as additional site specific details become available. Exhibit 1 is a process flow chart for utilizing the ODB and CE Letter for implementation and tracking of green street stormwater strategy opportunities across the DPW.

EXHIBIT 1
Green Street Evaluation Process



ODB Evaluation Process

The ODB evaluation process for each primary green street stormwater strategy is included in the following series of flow-charts. The modifications to the ODB represented in these flow chart processes will provide a basis for prioritizing projects with cost effective green street stormwater strategies and to identify the opportunities and constraints to green street stormwater strategy implementation.

The ODB process will be used to:

- Include screening level evaluation of green street stormwater strategy opportunities and constraints. Individual flow-chart evaluation processes for green street strategies.
- Develop planning level cost estimates for the green street stormwater strategies and priorities within the available strategies.
- Report green street stormwater strategy potential for each project.
- Document more detailed site specific evaluations and reasons why more or less green street stormwater strategies were included in the final design.

Once the ODB has identified which green street stormwater strategies are potentially applicable, DPW staff will need to evaluate the following site-specific opportunities and constraints during the design process. These have been incorporated into a post ODB review checklist.

- Existing utilities - including depth, location and minimum separation distances

- Evaluate street slopes and grading constraints to confirm applicability and potential locations of green street stormwater strategies
- Evaluate typical traffic volume, type, and travel patterns to determine appropriate locations for porous pavement
- Evaluate roadside parking and pedestrian traffic for the need to provide pedestrian walkway adjacent to the back of the curb if a bioretention facility (e.g. to provide a walkway or step for pedestrians to exit their roadside parked car)
- Verify cost budget implications
- Evaluate site-specific tree opportunities and constraints (low canopy cover, missing trees, overhead wires, etc.)
- Consider other site-specific conditions: soil characteristics, depth to groundwater, depth to bedrock, environmental conditions, etc.
- Consider other site-specific benefits: vacant parcel greening, flood reduction benefit, TMDL implementation support, aesthetic improvements, etc.

Responsibilities

TABLE 3

Responsibility Matrix

Activity in the CIP Process	Responsible Person/Section	Role
Project identification and initial Green Street screening using the ODB process	Local Streets: Project Programming (Mary Dziewiontkoski and Jean Ziller) Major Projects: Streets (Lois Gresl)	Provide review of local street and alley projects for Green Street opportunities. Some manual information entry is needed, but much of the initial screening process is accomplished through the ODB.
Issue CE Letter with Green Street evaluation summary table	Project Programming (Mary Dziewiontkoski and Jean Ziller)	Provide summary Green Street table as attachment to CE Letter.
Review of ODB screening process for CE Letter projects to refine the Green Street opportunities	Environmental (Tim Thur)	Review ODB list of Green Street opportunities based upon utility conflicts, topography, type of traffic, budgets, and etc. to narrow down the opportunities that will move forward in design.
Review for switch from resurfacing to reconstruction projects	Streets (Bob Viktora)	Report immediately if projects have the potential to switch from resurfacing to reconstruction so project is evaluated with ODB process for Green Street opportunities.
Detailed design	Environmental (Tim Thur) and Streets (Bob Viktora), lead varies depending upon type of strategy (pavement vs. vegetation)	Develop detailed design for Green Street strategies coordinating between Environmental and Streets.
Reporting on progress	Environmental (Tim Thur) lead supported by Streets (Bob Viktora)	Provide annual summary report of Green Street opportunities considered compared to those constructed to track progress.

Annual Reporting

Annual reporting provides an opportunity to document green street implementation progress within the Department of Public Works, to City leaders, and to residents. The ODB allows the opportunity to document what opportunities for Green Streets exist and why strategies were or were not implemented. This information will be useful to improving the ODB process in the future and to highlight implementation success. As described in the responsibility matrix, annual reporting will be coordinated between Streets and Environmental. Coordination with Project Programming will also be helpful.

General Green Street Stormwater Strategy Checklist

Y N

- ☐ ☐ Are there utility conflicts (above ground and below ground) located in areas where the green street stormwater strategies are possible? Can the utilities be relocated to accommodate the strategy?
- ☐ ☐ Evaluate street grading/inlets to convey runoff to green street stormwater strategy
- ☐ ☐ Are there existing trees that are to remain and that are constraints to locating strategies?
- ☐ ☐ Are there steep slopes >12% that would limit the ability to implement strategies?
- ☐ ☐ Is there high groundwater that will restrict infiltration devices per DNR requirements?
- ☐ ☐ Is the depth to bedrock sufficient for proposed green street strategies?
- ☐ ☐ Are there environmental conditions such as contaminated soil, monitoring wells, and groundwater wells that are near the proposed strategies?
- ☐ ☐ Has tree planting been maximized within project boundary and is there opportunity for more?
- ☐ ☐ Is this a known area of flooding and has this area been identified by previous works to have flood reduction potential?
- ☐ ☐ Does the watershed location and strategy support the TMDL implementation or City WPDES permitting?
- ☐ ☐ Check for porous sidewalk opportunities to support DPW demonstration initiative

Specific Green Street Stormwater Strategy Checklist

Median Bioretention

Y N

- ☐ ☐ Can flow be routed to median (e.g. via pipes) if crown diverts water away from median?
- ☐ ☐ Can the median be depressed or are there mature trees or other features that cannot support cutting the median below existing grade?

Terrace Bioretention

Y N

- ☐ ☐ Private owner conflicts?
- ☐ ☐ Pedestrian safety?
- ☐ ☐ Is there parking along the road and is a curb-side walking path needed for car passengers to safely exit their vehicle without stepping into the bioretention facility?
- ☐ ☐ Can the terrace be depressed or are there mature trees or other features that cannot support cutting the terrace below existing grade?

Open Space Bioretention

Y N

- ☐ ☐ Is there sufficient elevation difference to direct water from the street to the open space? Are pipes needed to connect the road to the open space?
- ☐ ☐ Are owners of open space willing to be a partner?

Porous Pavement

Y N

- ☐ ☐ Is a bus stop present at the site or is bus traffic known to travel in parking lane?
- ☐ ☐ Is there the potential for excessive sediment load (e.g. adjacent landscaping)?
- ☐ ☐ Are slopes >5% that would limit the ability to implement porous pavement?

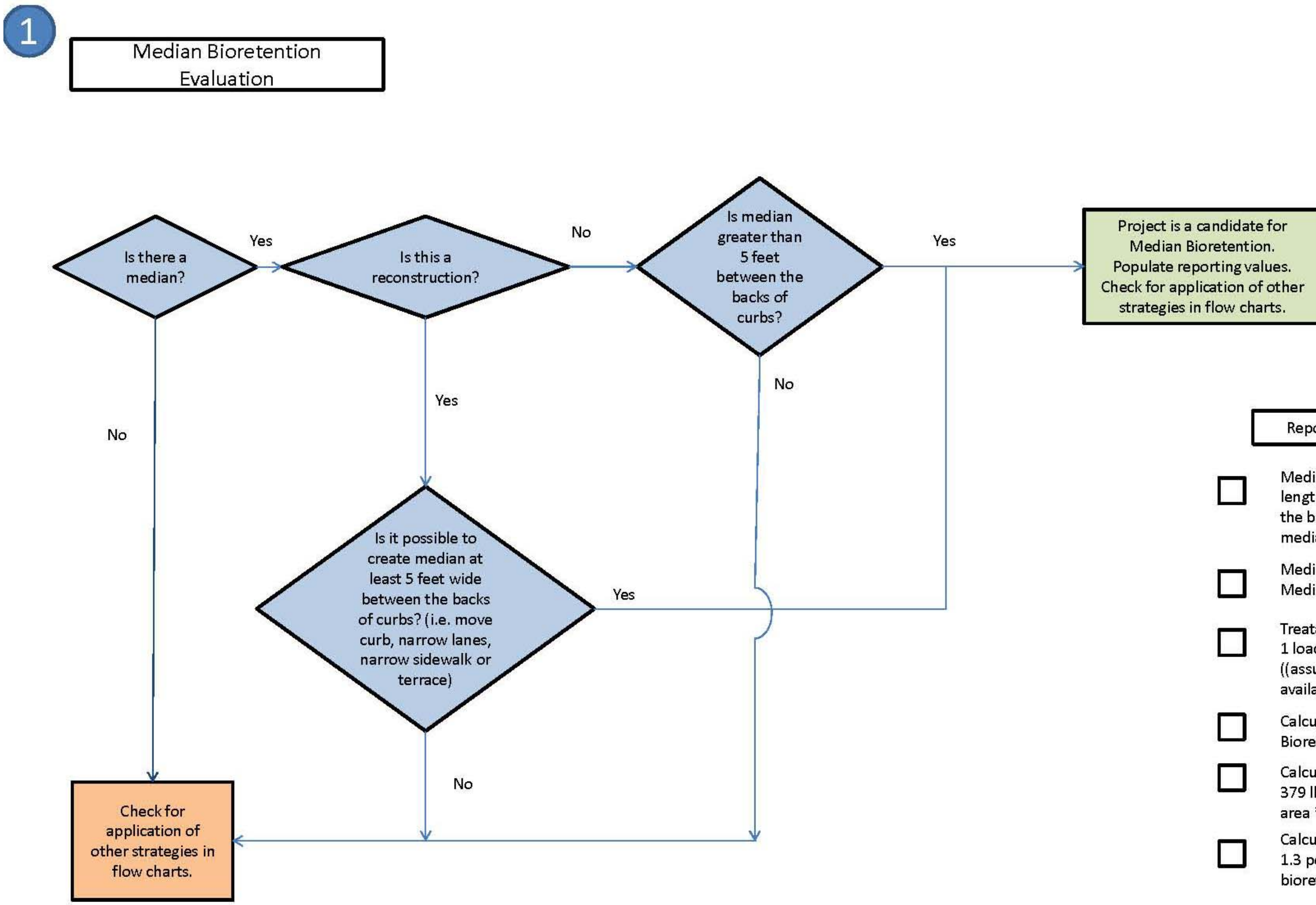
Tree Trench

Y N

- ☐ ☐ Can stormwater runoff from the road and sidewalk be directed to the proposed tree trench location by surface flow, subsurface flow through a stone media, or piped flow?
- ☐ ☐ Has tree planting been maximized on target street?
- ☐ ☐ Are new trees needed along the street for succession planning? Are additional trees needed along the street for streetscaping design?

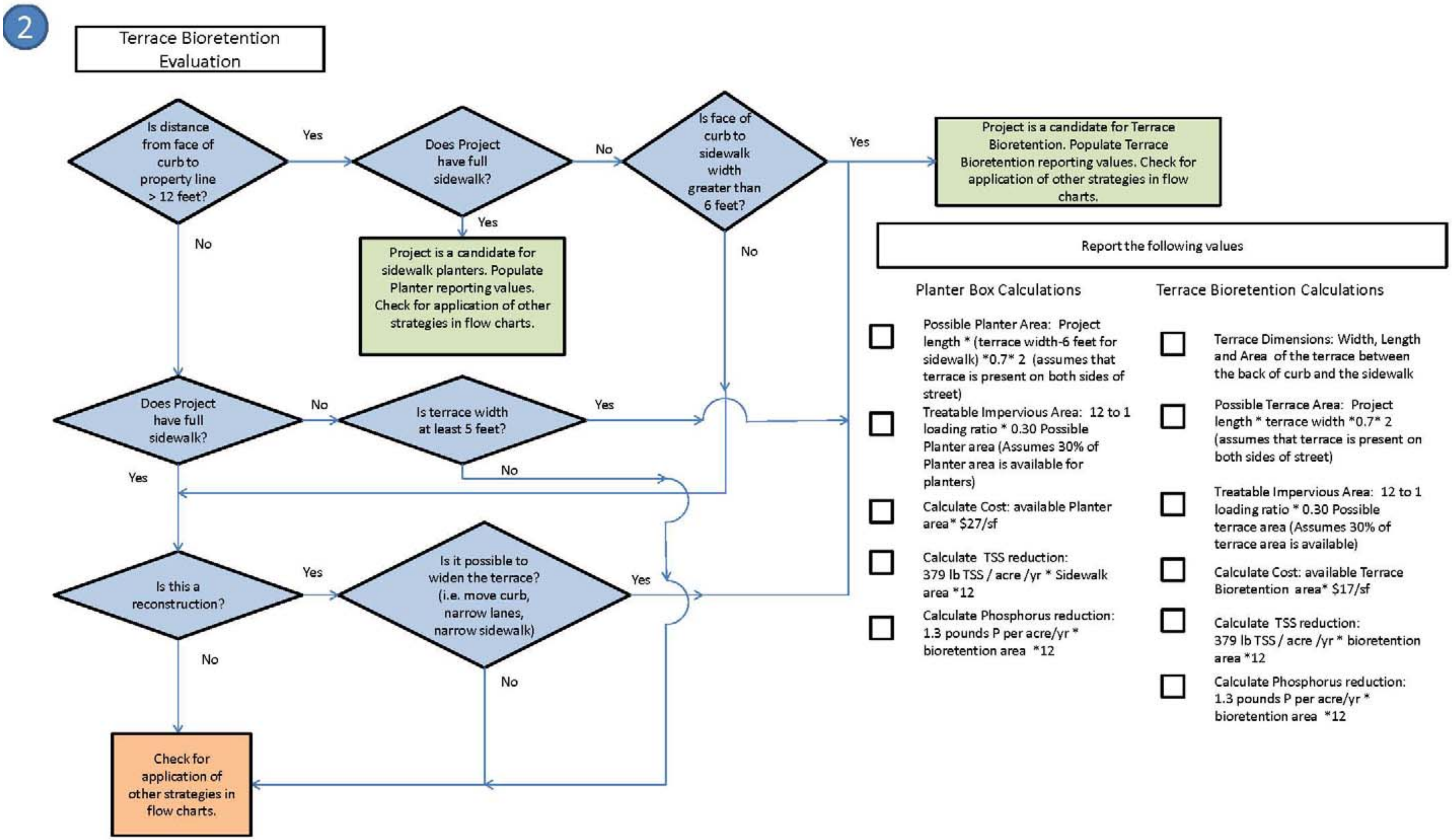
Standard ODB Output for Each Project

1. Is the project located in the combined or separate sewer area?
2. Is there adjacent open space? If so, list property owner.
3. Report results from each Green Street Stormwater Strategy as noted from each flow chart.
4. Pull down tab to track reasons for changes to ODB strategy recommendations.
   - Utility conflict
   - Cost constraints
   - Slope
   - Topography constraints
   - Resident preference
   - Traffic patterns or traffic loadings
   - Adjacent open space property owner not supportive
   - Text box to add project specific notes



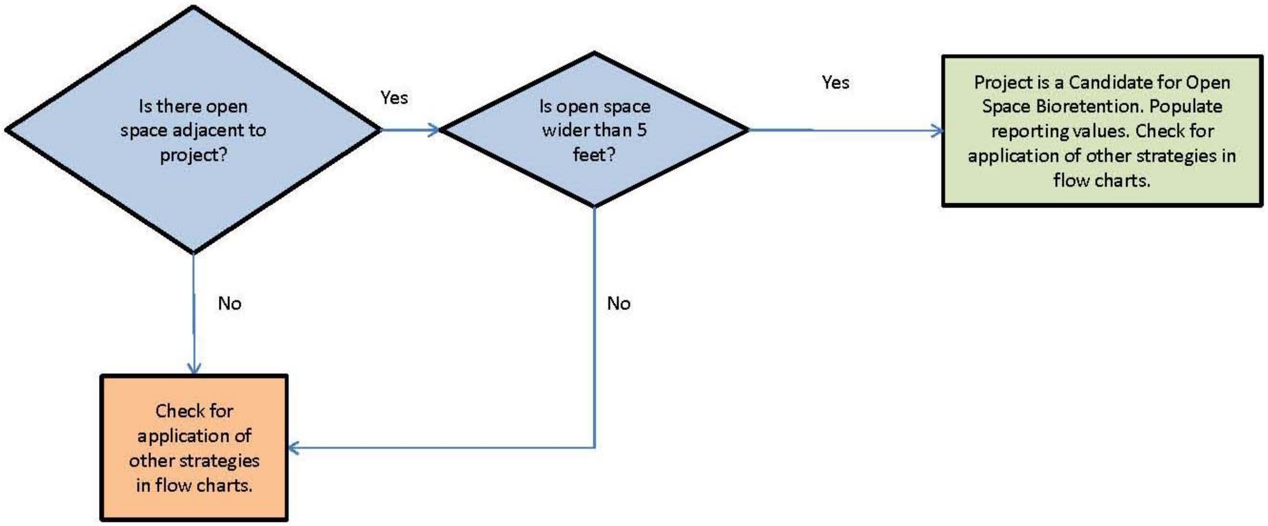
Report the following values

- ☐ Median dimensions: width, length and median area within the back of curb of the medians
- ☐ Median Area : Project length * Median width *0.9
- ☐ Treatable Impervious Area : 12 to 1 loading ratio * 0.30 median area ((assumes 30% of median area is available))
- ☐ Calculate Cost: available Median Bioretention area * $17/sf
- ☐ Calculate TSS reduction: 379 lb TSS / acre /yr * bioretention area *12
- ☐ Calculate Phosphorus reduction: 1.3 pounds P per acre/yr * bioretention area *12


2
Terrace Bioretention Evaluation
Is distance from face of curb to property line > 12 feet?
Yes
No
Does Project have full sidewalk?
No
Yes
Project is a candidate for sidewalk planters. Populate Planter reporting values. Check for application of other strategies in flow charts.
Is face of curb to sidewalk width greater than 6 feet?
Yes
No
Project is a candidate for Terrace Bioretention. Populate Terrace Bioretention reporting values. Check for application of other strategies in flow charts.
Does Project have full sidewalk?
No
Yes
Is terrace width at least 5 feet?
Yes
No
Is this a reconstruction?
Yes
No
Is it possible to widen the terrace? (i.e. move curb, narrow lanes, narrow sidewalk)
Yes
No
Check for application of other strategies in flow charts.
Report the following values
Planter Box Calculations
Possible Planter Area: Project length * (terrace width-6 feet for sidewalk) *0.7* 2 (assumes that terrace is present on both sides of street)
Treatable Impervious Area: 12 to 1 loading ratio * 0.30 Possible Planter area (Assumes 30% of Planter area is available for planters)
Calculate Cost: available Planter area* $27/sf
Calculate TSS reduction: 379 lb TSS / acre /yr * Sidewalk area *12
Calculate Phosphorus reduction: 1.3 pounds P per acre/yr * bioretention area *12
Terrace Bioretention Calculations
Terrace Dimensions: Width, Length and Area of the terrace between the back of curb and the sidewalk
Possible Terrace Area: Project length * terrace width *0.7* 2 (assumes that terrace is present on both sides of street)
Treatable Impervious Area: 12 to 1 loading ratio * 0.30 Possible terrace area (Assumes 30% of terrace area is available)
Calculate Cost: available Terrace Bioretention area* $17/sf
Calculate TSS reduction: 379 lb TSS / acre /yr * bioretention area *12
Calculate Phosphorus reduction: 1.3 pounds P per acre/yr * bioretention area *12

3

Open Space Bioretention Evaluation

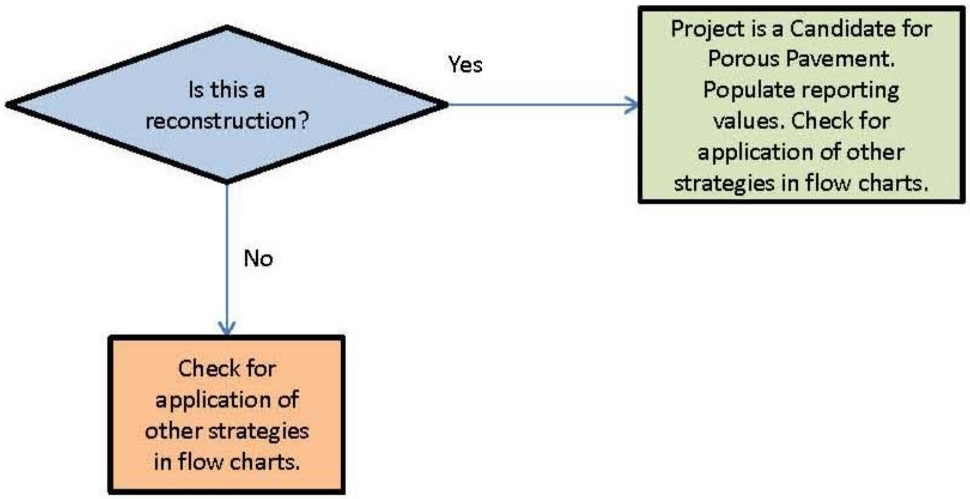


Report the following values

- [ ] Property owner(s) of adjacent open space
- [ ] Area available: Manual Calculation
- [ ] Treatable Impervious Area : 12 to 1 loading ratio * Area Available
- [ ] Calculate Cost: available Open Space Bioretention area * $17/sf
- [ ] Calculate TSS reduction: 379 lb TSS / acre /yr * bioretention area *12
- [ ] Calculate Phosphorus reduction: 1.3 pounds P per acre/yr * bioretention area *12

4

Porous Pavement Evaluation



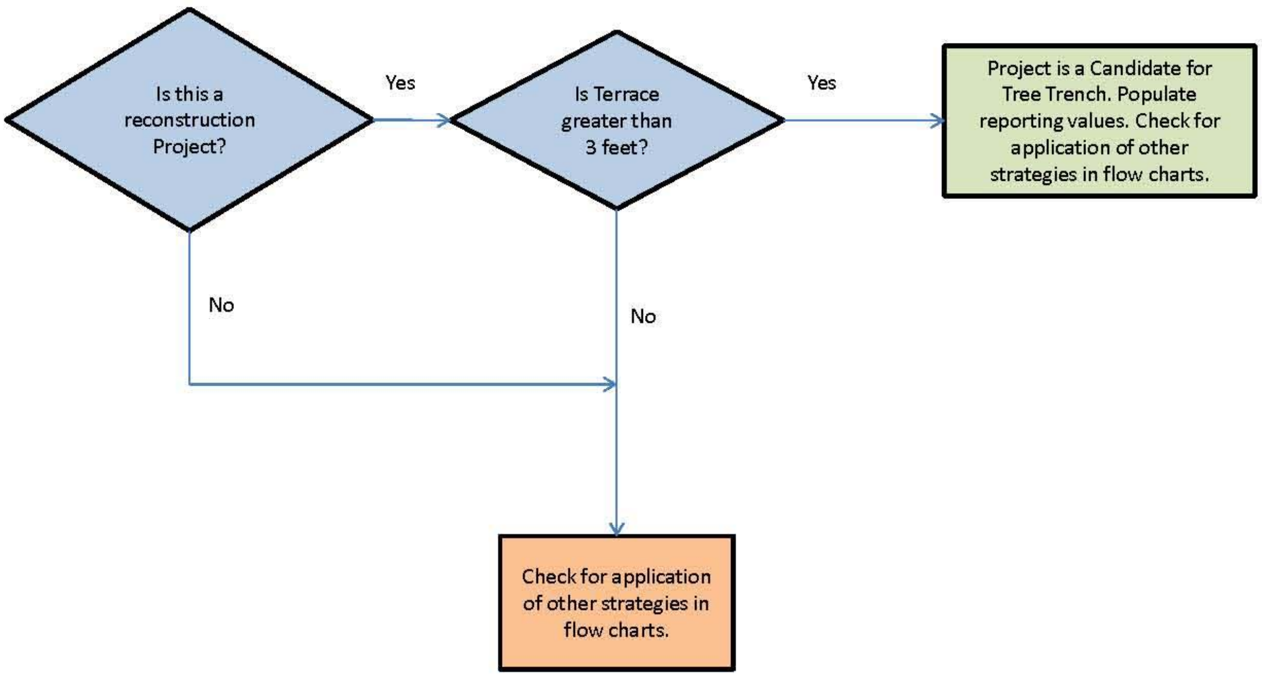
Report the following values

- [ ] Impervious Area Treated by Porous Pavement = Total <u>road</u> pavement area
- [ ] Potential Porous Pavement Area : (Impervious Area Treated by Porous Pavement) / (4 to 1 loading ratio)
- [ ] Calculate Cost: Porous Pavement* $7/sf
- [ ] Calculate TSS reduction**: 264 lb TSS / acre /yr * bioretention area *4
- [ ] Calculate Phosphorus reduction**: 0.9 pounds P per acre/yr * bioretention area *4

** Note: MS4 credit for TSS and phosphorus reductions is dependant on soil infiltration rate.

5

Tree Trench Evaluation



Report the following values

- ☐ Trench Area Dimensions: Available Width, Length and Area from the back of curb to the right-of-way. (Assume 100% of trench area is available)
- ☐ Drainage Area : 12 to 1 Loading ratio * Trench area
- ☐ Calculate Cost: available Tree Trench area * $10 / sf
- ☐ Calculate TSS reduction: 143 lb TSS / acre /yr * bioretention area *12
- ☐ Calculate Phosphorus reduction: 0.5 pounds P per acre/yr * bioretention area *12

Attachment 1
Operation and Maintenance Considerations for Green Street Implementation

Operation and Maintenance Considerations for Green Street Implementation

PREPARED FOR: Erick Shambarger/City of Milwaukee

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Mark Mittag/CH2M HILL

DATE: March 11, 2013

Green street operation and maintenance (O&M) will grow as green street standards are implemented through the normal street repaving and reconstruction process. After the initial maintenance period included in construction contracts, the City of Milwaukee will be responsible for O&M of the green street strategies.

The City Public Works Operations Division is most affected by operation and maintenance, especially street sweeping and winter maintenance provided through Sanitation Services; and the tree, mowing, and landscaping maintenance provided through Forestry Services.

The goal of the operations and maintenance considerations memorandum is to provide useful background information on important O&M issues. This will in turn support the City's proactive planning efforts for operation and maintenance of green street strategies as they become a standard process of street reconstruction. O&M of the green street strategies will adapt over time as the City of Milwaukee's experience with the installed practices grows.

Porous Pavement Maintenance

Vacuuming

a. Recommended Maintenance

1. Preventative Maintenance: Generally recommended at least two times per year, in the spring and fall, using appropriate equipment. Regenerative air vacuums are effective if regular preventive maintenance is performed. Pure air vacuums are most effective for regular maintenance, but are more expensive to operate. Two times per year is recommended for typical applications that do not receive significant sediment, debris, leaf litter, etc. Pristine areas may require less frequent vacuuming while "dirty" areas may require significantly more.
2. Restorative Maintenance: For heavily clogged areas where water ponds longer than 30 minutes after a storm, extra effort, such as pressure washing and/or use of higher end (pure air vacuum) equipment, may be required. Manufacturer recommendations vary for how to restore various types of porous pavement and they should be consulted for the latest restorative maintenance techniques. Developing a standard approach for restorative maintenance will have to consider potential variations in recommendations. Restorative maintenance usually first relies upon an initial vacuum sweeper to remove as much surface debris as possible.
3. Visual inspection for porous pavements will be beneficial after rainfall to observe if clogging is occurring. The appropriate inspection frequency will be site specific and may adjust with the age of the systems. The City should regularly observe porous pavement areas that receive runoff from adjacent areas as these areas are more prone to clogging.

b. Vacuum Sweeper Technologies

1. "Pure Air" Vacuum. Pure air vacuums are the most effective at loosening and removing sediment from the openings in porous pavement. Fine particles are vacuumed out of the pavement matrix in a concentrated vacuum column and are collected in the sweeper hopper. It is important to note whether a given sweeper

model is a pure vacuum sweeper because the word vacuum is misused by some in the industry to describe regenerative air sweepers (described below).

2. Regenerative Air. Regenerative air sweepers contain a blower system that generates a high velocity air column, forcing it against the pavement at an angle, and creating a peeling or knifing effect. The high volume air blast loosens the debris from the pavement surface, then transports it across the width of the sweeping head and lifts it into the containment hopper via a suction tube. Regenerative air sweepers are generally not recommended for heavily clogged areas because the technology may not be effective at all.
3. Both pure air vacuum and regenerative air systems need to be used carefully on paver block systems so as to prevent aggregate removal between pavers if required by the paver specification. Alternatively, some of the aggregate between the pavers can be sacrificed and replaced periodically to maintain a highly permeable system. Some paver types recommend compressed air cleaning between pavers instead of vacuuming.
4. The term sweeper is a partial misnomer, since the vacuum function is not actually providing mechanical sweeping; however, sweeper is the common noun used to describe the unit. Most vacuum sweepers either have or have the option to come with mechanical sweeper attachments, providing a shared benefit for use in sweeping non-porous streets.

Recommended Equipment

a. Sweepers are typically available in three size ranges: large-driven, small-driven or sidewalk models, and walk-behind. Representative, recommended models for each of the ranges is provided in Table 1. Walk-behind models are not suitable for open road use and, as such, are not listed.

TABLE 1
Sweeper Equipment Comparison Metrics

Make/Model	Type	Size (LxWxH)	Cleaning Width	Approx. Cleaning Time for 1 acre[a]	Suction (Water Column)	Noise Level[d]	Approx. New Cost
Elgin Whirlwind	Pure Vacuum [Large-driven]	21 feet x 8 feet x 10.5 feet	32 inches	96 min.	68 inches	83 dB	$220,000
Tymco 600 Air Sweeper	Regenerative [Large-driven]	22.5 feet x 8 feet x 10 feet	87 inches	36 min.	Not available	72 dB	$200,000
Tennant ALTV 4300	Pure Vacuum [Sidewalk]	8.5 feet x 4 feet x 7 feet	46 inches[b]	66 min.	Not available	Not available	$30,000
Tennant Green Machine 636	Pure Vacuum [Intermediate]	11.5 feet x 4.5 feet x 6.5 feet	47 inches	69 min.	Not available	Not available	$100,000
Elgin Pelican[e]	Mechanical Sweeper	16 feet x 8.5 feet x 10 feet	120 inches[c]	27 min.	Not applicable	Not available	$135,000

[a] Assumes a 1-acre area, at 5 miles per hour sweeping speed without stopping, hand labor, or other tasks.

[b] While the pickup width is 46 inches, the vacuum suction hose for the pickup rack is only 8 inches.

[c] Including two side broom attachments. Main broom is 66 inches wide.

[d] Average of decibels at left, right, front, and rear of unit at a distance of 50 feet.

[e] Not recommended for porous pavement maintenance.

NA = Information not available.

b. While each type of sweeper has various driving speeds, the recommended maximum speed for porous pavement vacuuming is approximately 5 mph to maximize the maintenance benefit. Therefore, the only differentiating variable in cleaning time between units is cleaning width.

c. Pure air vacuum sweepers have a longer cleaning time, since the cleaning width is limited to the vacuum nozzle. The narrow vacuum width limitation affects operational costs, sometimes making them less desirable, despite their superior cleaning ability.

d. Regular preventative sweeping using a regenerative air sweeper is economical and commonly used by utilities and contractors maintaining porous pavement.

Photos

(courtesy of each equipment manufacturer)

Elgin Whirlwind

Tennent Green Machine 636

Tennant ALTV 4300

Tymco 600

Additional Sweeping Considerations

a. Slow phase-in of vacuum equipment would be helpful and cost effective in the early green street program stages. Items that may be beneficial to consider when expanding into vacuum equipment include the following:

   1. Conducting vendor trial demonstrations. The demonstrations by vendors are typically offered until equipment preferences can be vetted.

   2. Using the existing Elgin Pelican fleet is not recommended for porous pavement maintenance, since they rely upon mechanical sweeping.

   3. While rental units for the equipment listed have not been located in the Milwaukee area, equivalent units exist and alternative vendors may be available. Rental costs typically range from $5,000 to $10,000 per month. Contingent on the service area and amount of porous pavement installed, rental of one unit for 1 month, in both spring and fall, would likely be sufficient for some time.

   4. Lease-to-own is available on most new units.

5. Contracting or outsourcing vacuum sweeping may also be cost effective, contingent on the service area and amount of porous pavement installed. Contracting has been shown to range from $0.05-$0.10 per square foot, or $2,200 to $4,400 per acre.

b. The Downtown BID currently owns a Tennant ALTV 4300, which could be piloted in smaller porous areas.

c. Street cleaning procedures need to be developed and documented in a standard operating procedure (SOP). The SOP will describe maintenance tasks and labor requirements, night versus day noise concerns depending on the neighborhood, frequency, and logs. The SOPs will be integrated with a computerized maintenance management system (CMMS).

Winter Maintenance: Snow removal/Deicing on Streets

a. Snow removal equipment: The City currently uses a variety of snow removal equipment. On the Jossey Heights porous paver street, the City uses a plastic/rubber blade to remove snow. Other equipment includes large plows/salters and garbage trucks. Front-end-loaders are also mobilized and fitted with plows to remove snow.

b. Materials: The City relies upon salt and plowing for deicing, with a focus on arterial streets, and then on local streets. Occasionally, the City has used a salt/sand mix when salt shortages have occurred, resulting in high salt prices during severe winters. A 50/50 mix of salt/sand was utilized several years ago when salt shortages occurred.

Procedure Considerations

a. Industry recommendations include using light weight trucks on porous pavement and rubber blades or plow guards on snow plows whenever possible. The greatest plowing concern on porous pavement is using large plow trucks with metal blades. It is recommended that large trucks not be used on porous pavement, if possible. If large trucks have to be used, they should be modified with rubber blades.

b. Some communities have experimented with raising the plow blade slightly so that it does not come into direct contact with the porous pavement. There are concerns with consistent application of the process due to the potential for driver error, misunderstanding, or fatigue. However, if proper driver training can be provided, the procedure may pose an alternate porous pavement plowing approach worth considering.

c. Deicing is typically required less with porous pavement, which has been shown to reduce the need for deicing by as much as 75 percent due to heat rising from the soil under the porous pavement and from snow melt flowing through the pavement instead of refreezing on the surface.

d. Parking restrictions during the winter months are in place for some neighborhoods, alternating which side of the street is open for parking, usually on a monthly or seasonal basis. While melted snow quickly drains through porous pavements, piling snow on porous pavement is not recommended because it tends to lead to an accumulation of sediment and debris on the pavement when the snow melts. Adjustments to parking restrictions may be beneficial. Syracuse, New York changes parking restrictions daily to promote snow removal across the entire roadway.

e. Caution should be used if snow stockpiles are placed in medians with bioretention due to snow melt containing salt and debris that could accumulate and clog bioretention soils. This could harm bioretention plants and reduce soil permeability. As bioretention in median areas becomes more pervasive, the City should evaluate potential impacts to bioretention plants. Alternative snow dump sites may be needed. Placing snow dumps where debris can accumulate without clogging the bioretention soil would be helpful. Placing snow in grassed areas adjacent to bioretention is also a possibility as the grass strips would serve to pretreat the snowmelt prior to it reaching the bioretention area.

Sidewalk Maintenance

a. If porous sidewalks are installed, vacuum maintenance would be similar to that of the porous streets described above.

b. The downtown BID already has a Tennant ALTV 4300 that could be used downtown. It may be able to be piloted in other areas in the City if pilot porous sidewalks sections are installed.

Landscape Maintenance by Forestry Services

a. Areas maintained by City Forestry Services are limited to median vegetation and terrace trees. Bioretention in medians is already maintained by the Forestry Services.

b. Maintenance of the terrace is currently the property owners' responsibility. Ongoing coordination with the property owners who have green infrastructure installed in their terrace may be necessary to ensure that proper maintenance is being performed. Tree trenches offer an alternative approach to treating stormwater in the terrace.

c. Visual inspections can prevent a minor problem from escalating into a more significant failure of the system. Visual inspections can be informal, through regular maintenance provided by Forestry Services in median areas and terraces to look for excessive ponding, erosion, plant health, trash, and etc.

d. Inspections should be performed at least once a year, during the growing season, and mulching should occur at least once a year in the spring.

e. SOP maintenance procedures related to bioretention and tree trenches will need to be developed that describe maintenance tasks and labor requirements, frequency, and logs integrated with a CMMS. The SOPs should include features such as mowing, weeding, mulching, trash removal, tree maintenance, photographs of insect infestations and disease, etc.

Inlet/Catch Basin/Manhole Cleaning/Jetting to Support Tree Trenches

a. Inlet/catch basin/manhole cleaning may be needed if the features are used to direct water to tree trenches. Filter inserts or other pretreatment techniques in inlets/catch basins/manholes can help reduce the amount of debris and sediment entering a tree trench. Maintenance should focus on preventing debris from entering the tree trench by maintaining filter inserts, pretreatment devices, and general maintenance of inlets/catch basins/manholes. Equipment types should be similar to what is currently used by City to clean catch basins.

b. SOP maintenance procedures related to inlet/catch basin/manhole cleaning should already be developed within the City due to other cleaning needs. However, as it relates to tree trenches, additional data collection may be beneficial. SOP maintenance procedures could be integrated with a CMMS.