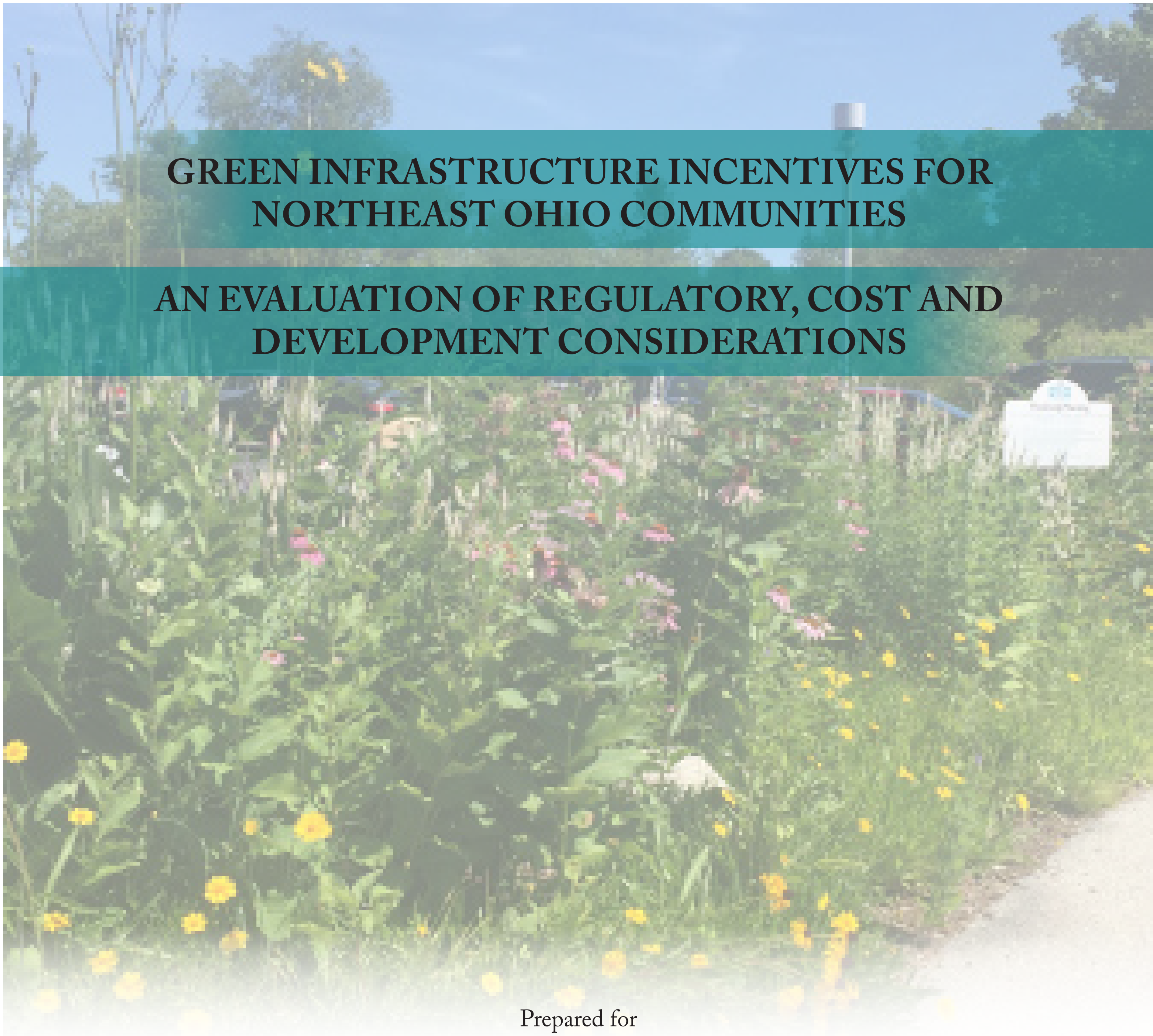
GREEN INFRASTRUCTURE INCENTIVES FOR NORTHEAST OHIO COMMUNITIES

AN EVALUATION OF REGULATORY, COST AND DEVELOPMENT CONSIDERATIONS



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1.0 INTRODUCTION

1.1 Project Purpose

Throughout Northeast Ohio, the use of Green Infrastructure (GI) techniques has become a more common and visible means of managing stormwater runoff from developed land. The multiple benefits of GI practices beyond water quality have been widely recognized in the region, and the Ohio Rainwater and Land Development Manual (ODNR, 2006) encourages the use of Low Impact Development (LID) and GI techniques for post-construction run- off management. A combination of grant programs, notably the Ohio Environmental Protection Agency (Ohio EPA) Surface Water Improvement Fund (SWIF) grants program, and active education and outreach efforts by the Northeast Ohio Stormwater Training Council (NEOSWTC) and its members, have led to the successful installation of green parking lot retrofits, bioretention landscaping, and integrated water quality landscapes in communities throughout the region. Many of these installations were monitored and evaluated in the report on *Innovative Stormwater Solutions for Ohio: Case Studies of LID Implementation and Performance*, prepared by Chagrin River Watershed Partners, Inc. (CRWP) and others in 2015.

When land development projects are proposed in the region, however, applicants and their engineers often propose conventional water quality ponds or underground detention/ infiltration systems instead of integrated, landscape-based methods of

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managing runoff. Water quality ponds and subsurface infiltration galleries are recognized and readily engineered means of meeting both water quality treatment and peak discharge (aka flood protection) detention objectives, with readily estimated construction and maintenance costs. However, these "all-in-one" methods do not yield the co-benefits that a surface green infrastructure approach can provide, such as reducing urban heat island effects (particularly from surface parking), and adding tree canopy visual quality, and other people-oriented benefits (commonly called "placemaking"). The question for greater implementation of GI techniques is thus why – from a specific financial, permitting, or operational standpoint – these measures are selected as post-construction control measures over GI options, and what policy and financial tools might shift these choices.

This report was commissioned by the NEOSWTC and funded by Ohio EPA to assess the financial and operational decision-making around the choice of stormwater treatment practices for development in the region. Orion Planning & Design (OPD) led a collaborative effort that included (1) background research by OPD and NEOSWTC partners; (2) in-depth interviews with consulting engineers, facilities managers, and municipal officials involved in preparing or reviewing post-construction stormwater management plans, designing stormwater retrofits, and managing the bid and construction process for stormwater controls; and (3) a NEOSWTC workshop on June 14, 2016 dedicated to the topic. The participants listed on the previous page contributed generously of their time, expertise and valuable insights, and helped develop a body of knowledge and important insights to guide policy, training, grant funding, and regulatory initiatives around Green Infrastructure.

1.2 GI Cost and Feasibility: Beyond Per-Unit Costs

In order to develop effective incentives, and to eliminate disincentives, to greater GI use, participants in this study worked together to understand the specific regulatory, cost and human factors driving both specific choices

PER-UNIT COSTS OF GI PRACTICES ARE PART OF A COMPLEX CHOICE PROCESS INVOLVING:

- **Zoning standards, especially parking requirements & some landscape standards**
- **Municipalities applying the Critical Design Storm detention standard**
- **Interpretation of technical standards for permeable pavements**
- **Need for clarity on runoff & volume reduction methodologies**
- **Contractor knowledge level & installation practices**
- **Maintenance costs in early years of bioretention systems**

in site designs, and common perceptions around cost: That GI is "more expensive," "harder to maintain" and potentially more challenging to permit. This effort builds on and revisits several recent studies of barriers, costs and incentives including CRWP's 2015 study *Innovative Stormwater Solutions for Ohio* (CRWP 2015), *Demonstrating Innovative Approaches to Distributed Storm Water Management in Northeast Ohio, 2004-2011* (Brennan and Scharver 2012), and *Implementing Credits and Incentives for Innovative Stormwater Management* (National Estuarine Research Reserve System Science Collaborative, 2015). Each of these studies listed technical, regulatory, policy and 'human' barriers, without addressing the specific cost considerations of green infrastructure versus conventional (water quality pond and underground infiltration) practices.

This study sought to examine the common perception that green infrastructure is not chosen because it is "more expensive" than conventional practices. The findings of this study suggest that while permeable pavements and bioretention may be more costly on a per square-foot or per gallon of design volume to install, **per-unit costs of green infrastructure are (1) relatively well-understood and becoming more predictable from project to project in Northeast Ohio, and (2) not the principal driver in selection of practices.** Instead, per-unit costs play into a complex equation involving adopted and interpreted design standards, local reviewer knowledge and interpretation, community preferences, operator expectations, and bid and construction phase issues – each of which affects costs in different and sometimes unexpected ways. When overlaid with the cost differential between conventional and bioretention landscaping, or conventional and permeable pavements, there are persistent – but identifiable, and solvable – disincentives to GI that point towards regulatory, planning and management solutions.

Fundamentally, for Ohio's land development community to utilize surface GI practices, practices such as permeable pavements, bioretention, green roofs, stormwater tree wells, soil amendments, native plantings, and rainwater harvesting – need credit towards local requirements in order to be equivalent to, or less expensive than, a conventional site development approach. Planning Commissions and local zoning codes must allow GI practices to meet requirements for parking lot landscaping, vegetated buffers, ground cover and required trees; and municipal plan reviewers must credit these practices for their contribution towards reducing runoff volumes from development lands, and towards the management of the required stormwater volume on site. In short, GI must be treated as a principal means of compliance with landscaping, parking and stormwater requirements – rather than an "add-on" to conventional practices.

1.3 Report Summary and Specific Topics Addressed

Table 1 on the next page summarizes this report's findings with respect to barriers, costs, and recommended strategies. A summary of the cost information from this project follows in Section 2; technical issues are addressed in Section 3, and bid- and construction-phase issues in Section 4. The recommended steps for Moving Ahead are highlighted in Section 5.

2.0 GREEN INFRASTRUCTURE INSTALLATION & MAINTENANCE COSTS

2.1 Methodology

Cost is among the most difficult parameters to establish since every site and project is materially different. Costs of materials and labor also vary dramatically depending on the scale of the project, time of year, economic conditions and complexity of the project.

Consistent and predictable cost ranges for bioretention and permeable pavements are emerging in Northeast Ohio, which facilitates project planning.

Much of the challenge stems from the non-linear nature of site construction and GI practice installation costs. Very often, rather than being scalable on a per-square foot or per-gallon basis, the answer to cost questions for development projects is "It Depends." For example, participants in this project reported significantly lower per-unit costs for larger permeable paver block installations, the smaller ones reflecting economies of scale for manufacture, delivery and installation. Underground infiltration systems do not have a purely linear relationship of volume to cost, since the increment of stormwater volume managed may be less than the minimum capacity of an additional treatment unit. And, as discussed in Section 4, the cost to remediate poor installations has plagued bioretention systems, adding to uncertainty about what costs will be required, and when.

Nonetheless, some general parameters are emerging in Northeast Ohio that, taken together with the regulatory, construction and technical issues outlined in this report and others, can facilitate the use of GI. To establish these ranges, private-sector practitioners, managers, regulators, NGOs and granting agencies were interviewed to gauge the cost, policy, financial and 'people' issues with use of GI in public and private land development projects, including SWIF grant-funded retrofits. Wherever possible, cost information from projects was solicited and incorporated into the research, which identified important baselines. As larger-scale maintenance and monitoring efforts move forward, notably through the Northeast Ohio Regional Sewer District (NEORSD), tracking material and labor inputs relative to the number and size of bioretention facilities will be of great use.

2.2 Findings: Construction/Installation Costs

In Northeast Ohio, there are relatively reliable cost ranges for installation that can help make the process more predictable and demonstrate why GI must be able to be co-designed with landscaping and pavement for the cost equations to work. The consistency of the range of costs demonstrates the maturing of these practices in the Northeast Ohio region, in contrast to other metropolitan areas in the eastern Great Lakes where GI costs presently are higher, and less predictable.

Data were not available for this study on the cost of green roofs, rainwater harvesting (cisterns) for in-building or landscape reuse, planter boxes, stormwater tree wells, and other less commonly used GI practices. Participants reported that all of these practices are at a demonstration project phase in the region, and have not become part and parcel of conventional stormwater system design. As described in Section 3, standardizing a system of runoff reduction calculations for these practices (as well as preservation of landscaping and trees on site) will facilitate greater use. At the present time, however, robust cost information was only available for bioretention and permeable pavements, which are described in Table 1 below.

Table 1. Cost Ranges for Pavements and GI Practices in Northeast Ohio

	REPORTED RANGE	COST POINTS REPORTED IN PROJECT	TYPICAL $/SF OF AREA	NOTES
Green Infrastructure Landscaping (i.e bioretention)	$11 - $34/SF	$11/SF (2800 SF/2014) $34/SF (520 SF, 2013)	$16/SF	Ohio EPA recommends $18/SF
Asphalt Parking Lot			$3.60/SF	
Concrete Parking Lot			$4.75/SF	
Permeable Asphalt			$6.25/SF	One recent value reported
Permeable Concrete		$8.08/SF (10,000 SF/2012)	$8.50/SF	One recent value reported
Permeable Paver Blocks (without subgrade)	$6/SF - $21/SF	$6/SF (345k SF/2014) $9/SF (1,200 SF/2007) $10/SF $11/SF (4,000 SF/2013)	$11/SF	Lowest numbers reflect large sites & economies of scale. Highest price was part of bid but not selected.

Bioretention: As a "rule of thumb," bioretention projects are ranging from **$14 to $18 per square foot of GI practice area constructed**. This is consistent with Ohio EPA's informal use of $18 per square foot as a metric for project cost estimates. Given that bioretention must be sized at 5% of the contributing watershed area to meet state regulatory requirements, a bioretention practice would thus range between $24,000 and $31,000 per acre of impervious surface treated. Maintenance costs are discussed in Section 2.3.

Permeable Pavements: As use of permeable pavements, particularly paver blocks, has grown more widespread in the region, project sponsors are reporting **a range of $11 to $18 per square foot as the "all-in" installed cost** including subgrade, and a range of $6 to $11 per square foot for the surfacing material itself. Project participants did report a wide range of bid costs for the permeable pavement material itself in recent years, ranging from a high of $21/SF (in a bid that was not selected) to a low of $6/SF on a site where over 300,000 SF of paver blocks were used as a method to protect wetland buffer areas and provide stormwater treatment and control. In providing guidance, it will be useful for Ohio EPA, NEOSWTC and others to note that significant economies of scale can be realized with permeable pavements.

It is also important to qualify costs of permeable pavements in terms of the run-on ratio utilized (i.e. the size of the area from which runoff is directed to a permeable pavement installation, relative to the size of the permeable area). While the State allows a ratio of up to 2:1, which reduces the amount of permeable pavement required, many participants in the study reported that installations using a 1:1 run-on ratio were proving more effective and requiring less maintenance, since the amount of sediment-laden runoff coming onto the permeable pavement is reduced. Whatever the preference of the designer or regulator, the ratio selected affects the total cost of an installation and is important to note and consider when evaluating costs.

Finally, it is important to bear in mind that if a permeable pavement system meets water quality and detention requirements, the area does 'double duty' as parking lot surfacing (at $3.60 to $4.75 per square foot) and stormwater management (foregoing the cost of a water quality pond or other practice). Practitioners participating in this study reported consistently that 'double-duty' use of permeable pavement is key to making it a cost-competitive choice. Where permeable pavement systems are not credited by approving regulators towards water quality requirements, or where expensive modifications to pavement systems are required to meet performance standards, the per-square-foot difference in pavement cost becomes an added cost and permeable pavement will not be selected. Thus the interpretation of water quality standards in permeable pavement system design, which is discussed in Section 3, may be a direct cost issue in the region.

2.3 Maintenance Costs

Information gathered in the research process focused on maintenance of

It is helpful to plan for higher early-year bioretention and native planting maintenance costs, and declining costs over time as areas become established and needs for weeding, mulching, fertilizer and herbicide/ pesticide application decrease.

bioretention areas rather than permable pavement, green roofs or other practices. Data included information from Ohio SWIF grants, Chagrin River Watershed Partners cost compilation, NEORSD maintenance bids, project-specific costs, and a number of "rule-of-thumb" measures from Ohio EPA, private sector managers and consultants, and communities in the Great Lakes facing similar research issues.

Labor and materials costs for maintenance of bioretention include sediment/ debris removal and disposal; trash removal and disposal; vegetation weeding and pruning; mulching; watering; fall cleanup (e.g. deadheading or cutting back plants, debris & trash removal); plant replacement for trees, shrubs and perennials; herbicide and pesticide application (which generally is recommended to be limited or not used in bioretention); periodically-specified mowing and de-thatching of native planting areas; replacement of stone at inlet areas; and soil media. Other maintenance practices requiring labor include removing trash and debris from inlet structures in constructed wetlands (which is not unlike management of pond inlet and outlet structures), and removing invasive species from vegetated swales. Study participants noted that bioretention maintenance is more complex than maintaining a pond or underground system, but also consists of more low-level, routine activities such as mowing and weeding, rather than requiring large equipment and hired contractors as is the case with pond dredging or major repairs.

Two important cost insights came from participating property managers. First, where installation/construction and early maintenance has not been performed well, property managers reported that large consequential costs to remove and replace dead plantings and amend soil media have been incurred that were outside of standard maintenance budgets, required substantial time and effort, and left a "bad taste" with managers for using bioretention as a practice. Section 4 lists the specific recommendations made to address these problems, including more stringent standards for contractor and landscaper experience, having onsite responsible landscape architect or designer inspection at key times, and holding a financial guarantee until two full growing seasons have passed. Any and all of these measures would help reduce exposure to these unexpected maintenance costs, providing a greater likelihood of success.

Second, in a more positive vein, successful native planting and bioretention areas have resulted in declining maintenance costs over time. As these areas become established, the need for pesticides, herbicides, mulch, weeding, and associated labor declines substantially. Study participants who have managed these areas encouraged others to plan for intensive maintenance costs (both labor and materials, particularly mulch) initially, as plants become established, and then to expect declining maintenance costs over time. Early maintenance needs and costs for bioretention systems and plantings include mulching around plant plugs, plant replacement, and intensive weeding to remove undesirable plants, which likely requires contractor training and greater involvement by experienced landscaping and nursery contractors. Temporary irrigation also may be needed and was cited as a means of ensuring plant establishment. Over time, one study participant reported that mulch requirements and fertilizer, herbicide and pesticide costs declined by 50% as native plantings and bioretention areas grew in and became largely self-maintaining, eliminating ongoing labor and material costs for mowing as well.

While intuitive, the concept of a cost curve with initially higher costs declining over time has not been stressed in presentation, training and literature, and has not been captured in GI research and literature. Upcoming periodic maintenance of large-scale public bioretention systems by NEORSD, for which labor and material costs are broken down at a fine level of detail, offers an opportunity for the region to begin looking at where and how maintenance costs change over time. An evaluation of these costs, along with those provided by private landowners, would provide helpful points of reference both for the "mechanics" of good installation and maintenance, and the cost inputs over time. As NEORSD bids are brought in each year, these costs will be important to track, and communicate for planning purposes.

There also would be a benefit to improving the characterization of bioretention maintenance over time versus the true cost of ponds and underground systems, if these are maintained according to recommended

schedules. Ponds often are seen as straightforward and inexpensive from a maintenance perspective; sediment removal from forebays, inlet and outlet cleaning, limited vegetation maintenance, and periodic dredging costs are expected and require less new information and training on the part of contractors than is required for GI practices which, as noted throughout this report, are still affected by contractor issues. However, participants in this study also reported that pond and underground systems are treated as "build and forget" when practices are selected, and are not perceived to have ongoing maintenance costs. Tracking and publicizing actual costs incurred for these conventional practices, particularly with respect to any that have failed and required expensive remedial work, would provide an instructive counter-point to the cost discussion.

Finally, participants stressed that routine maintenance, while challenging to establish, provides tremendous dividends. Where communities have made a commitment to routine (usually annual) practice inspections, this has resulted in routine maintenance of all practices including surface and subsurface detention. This commitment requires a program structure and resources, including ordinance language that allows the community to complete maintenance if practices or properties are not in compliance.

3.0 DESIGN STANDARDS AND PERMIT REQUIREMENTS

3.1 State and Local Standards Affecting GI Cost and Choices

The cost of any stormwater treatment practice, and the feasibility of using landscape-based practices such as bioretention to meet permit requirements, relates directly to the volume of stormwater that must be managed to meet permit standards and how that water must be managed – i.e. the required extent of pollutant removal and/or infiltration, and the length of time water must be held on site. Peak discharge detention volume requirements generally exceed water quality or channel protection/erosion control volumes; as such, where applied, peak discharge detention requirements generally drive selection and design of practices. Underground systems and water quality ponds can be 'scaled up' easily to deal with larger detention volumes (whether by adding units, changing pond depths, or adjusting outlet structures) without interfering substantially with site planning and design, and this often tips the scales towards the use of water quality ponds or underground systems.

Participants in this project consistently cited local standards requiring critical storm calculation for detention, which is not required by the State for MS4 communities or within the construction storm water general NPDES permit, as the most significant limitation on the selection of green infrastructure practices.

This is very much the case in Northeast Ohio, where participants in this project reported that **peak discharge detention volume requirements in municipal stormwater ordinances are the chief determinant of how much volume must be managed** to meet both local and state stormwater management requirements. In most cases, Northeast Ohio municipalities are using the Critical Storm Method recommended by the Ohio Department of Natural Resources (ODNR, 1980, 2006) to establish peak discharge requirements. This standard, and the lack of knowledge about how to "credit" GI practices towards the required volumes in a regularized and predictable way, is consistently cited as a reason that conventional water quality ponds or underground treatment are selected instead of GI. Other technical standards and their interpretation are complicating the use of GI practices as well, and are discussed below.

3.2 Ohio Critical Storm Sizing Methodology and Runoff Reduction Evaluation

The first and most important standard to address is the municipal or county requirement that projects use the critical storm methodology for sizing stormwater practices. Ohio EPA staff report that this provision has historically been the model provided to local government for sizing peak discharge detention basins and as a model to review state sponsored developments such as state highways, where downstream flooding or stream erosion were a concern. The standard did not have any enforcement prescribed by the law and therefore was largely viewed as guidance. It continues to be provided by the State as a model standard, as the methodology provides guidance both for channel protection (i.e. release of the critical storm at pre-development 1 year, 24-hour frequency rate) and large event flood management.

Re-evaluation of detention requirements and calculation methods in local ordinances, and approval of a standard runoff reduction methodology, will make GI a more feasible choice for meeting performance requirements.

In practice, participants in this project report that the volumes generated using the methodology are too large to be managed cost- or space-efficiently with GI practices on new development sites – particularly without a clear methodology for crediting bioretention or permeable surfacing towards detention volume requirements. Redevelopment sites, where the standards are less stringent, are less affected by these regulations, making GI a more likely choice.

Runoff Reduction Methodology: The second component reported as a substantial barrier to GI is the lack of a standard methodology for calculating, and then crediting towards regulatory requirements, the amount of volume managed and runoff reduced by GI practices – particularly bioretention, rainwater harvesting, and conservation of natural land features such as stands of mature trees. Currently, bioretention and permeable pavement do count toward meeting Ohio EPA regulatory requirements for post-construction runoff control. Green roofs count as impervious area reduction, and thus, can count toward meeting regulatory requirements on redevelopment projects. However, the other practices could be approved by Ohio EPA on a case-by-case basis, but are not on the "standard" menu of post-construction practices.

Most plan review occurs at the MS4 level, and as indicated in this report, the level of understanding or the misinterpretation by the MS4 plan reviewer can lead to the perception that GI cannot receive credit for volume management. Study participants reported that municipal reviewers lack guidance and certainty on specific issues such as how much credit for volume storage (if any) should be attributed to bioretention, or to permeable pavements. The value of natural areas in reducing runoff volumes also is not routinely assessed, leading to one reported case where a stand of trees was cut down and land substantially regraded to make room for a larger water quality pond, in order to meet the detention volume requirement. Accurate runoff calculations, and use of realistic methods of crediting these practices for their ability to reduce runoff (for these and other services) would greatly enhance the potential for GI practices to be selected to meet permit standards.

Ohio Runoff Reduction Methodology/Evaluation: The interaction of peak discharge control volumes and calculations with water quality or pollutant removal standards is complex, and requires technical evaluation and guidance. Participants in this report from State government, local government, non-profit partners and the private sector alike all indicated **a strong interest in and need for the State to concurrently evaluate the critical storm method criteria and the water quality volume criteria, alongside other runoff reduction and stormwater practice sizing approaches,** such as the Unified Stormwater Sizing Criteria. Completing this effort, which is partly underway by the State, and rolling out effective communication and training to the region's MS4 permittees and applicants' engineers alike, would provide much needed clarity and technical support to municipal permit reviewers. Any methodology should clearly address (1) how to credit the volume managed by GI practices towards peak discharge (channel protection and flood control) standards, particularly when used to treat "first flush" stormwater loads and/or when located prior to any detention or volume control measures; and (2) how to credit non-structural practices such as tree planting, soil amendment, and maintenance of undisturbed areas.

CRWP Model Stormwater Ordinance: During preparation of this report, it was noted that the Model Ordinance for Comprehensive Stormwater Management developed by CRWP did not address the specific issue of crediting the volume reduction benefits of GI methods, particularly when located upstream of water quality ponds or underground treatment systems. An updated CRWP model states: "The volume reduction provided by permeable pavement, boretention, or other LID SCMs (Low Impact Development Stormwater Control Measures) may be subtracted from the post development stormwater volume". The methodology for this provision currently being developed for the Rainwater and Land Development Manual.

Water Quality Standards and Infiltration for Permeable Surfacing Systems: A final conflict to be addressed is the Ohio Rainwater and Land Development Manual's guidance regarding permeable pavement and water quality standards. Participants reported challenges with reviewers related to the length of the required drawdown time, which has led some reviewers to propose that expensive lining and underdrain systems be added to permeable pavement systems, even where not part of the manufacturers' recommended specifications. There appears to be conflict both over the drawdown time required in a permeable pavement system, and over the appropriate assumptions for infiltration rates for subgrade soils. Participants noted that this standard is reflected in permeable pavement standards in Table 2, Draw Down Times of the CRWP Model Ordinance. With the overall utility and cost-effectiveness of permeable pavements in the region, working through these issues and providing clear written guidance at the State level, and addressing any associated changes in the CRWP Model Ordinance, would be especially beneficial at this time.

3.3 Runoff Generation: Zoning Regulations and Municipal Preferences

The flip side of the volume management calculation is how much runoff-generating impervious surface is developed in the first place. Municipalities in Northeast Ohio have made great strides in recent years incorporating green infrastructure and sustainability principles into local zoning codes and ordinances. Through the consistent and multi-year efforts of the Balanced Growth Program and Chagrin River Watershed Partners, many municipalities' zoning codes now enable or actively promote the use of bioretention areas for required landscaping, parking surface area reduction strategies such as shared/off-peak parking, smaller space sizes, and reduced parking ratios. This is particularly important to the discussion of costs and GI incentives since, as noted throughout this report, larger runoff volumes – a direct function of the amount of impervious cover required – discourage the use of GI in the region.

Despite the many GI zoning success stories in Northeast Ohio, required parking ratios (i.e. the number of spaces that must be constructed per square foot of each building use) were often cited as a problem, and a limitation for GI practices. While most communities have eliminated many of the usual barriers to the use of surface green infrastructure, such as requirements to curb around parking lot islands, participants indicated that some communities continue to require surface parking well in excess of ratios recommended in contemporary practice – and that requirements vary tremendously between abutting jurisdictions. Moreover, this is often a discretionary decision of Planning Commissions, making education important in communities where ratios and preferences still push for more parking. Even minor changes in parking ratios and parking space sizes can have significant impacts on runoff volumes and paving costs, as illustrated in Table 2 below.

Table 2. Impact of A Change in Parking Space Sizes and Parking Ratios

PARKING SURFACE, SPACES ONLY	9X18 SPACES	9X20 SPACES	10X20 SPACES
1/150 SF = 67 spaces	10,854 SF	12,060 SF	13,400 SF
1/200 SF = 50 spaces	8,100 SF	9,000 SF	10,000 SF
Difference	2,754 SF	3,060 SF	3,400 SF
WQ_v difference (.75", CN=98)	1,257 gal/168 ft.^{3}	1,399 gal/187 ft^3	1,548 gal/207 ft^3
Paving cost difference @ $3.60/SF asphalt	$9,914	$11,016	$12,240

Finally, there remains an intangible barrier of municipal preferences and expectations, particularly for landscaping. Throughout the study participants noted municipalities that ask for green infrastructure get green infrastructure. Setting and adhering to standards for GI in the permitting process provides direction and certainty to applicants. Continued work in the region focusing on municipal education, and setting clear standards in zoning (especially landscape requirements) that favors or requires GI practices, is likely to continue to be beneficial.

4.0 CONSTRUCTION AND BID PHASE ISSUES AND POTENTIAL SOLUTIONS

Uncertainties in the bidding, construction, and maintenance phases of GI projects are supporting the perception (and in some cases, reality) that GI is a more expensive and challenging method of meeting stormwater performance standards in Northeast Ohio than conventional wet ponds. This report highlighted a number of problems that participants have encountered after GI is selected and approved, particularly during construction, that lead to "failed" GI practices. These situations, which result in expensive repair and remediation needs, fuel the perception that GI is more expensive. Participants in this project offered many specific recommendations for how to address installation, contractor selection, and other 'people' issues in the bidding and construction process, and stress that this is an important area of investment and education for Northeast Ohio's stormwater professionals.

SAMPLE CONTRACTOR QUALIFICATION LANGUAGE FOR PAVER BLOCKS AND BIORETENTION (adapted from Wauwatosa, WI):

Installation Subcontractor Qualifications:

1. Utilize an installer having successfully completed concrete paver installation similar in design, material and extent indicated on this project.
2. Utilize an installer with job foremen holding a record of completion from the Interlocking Concrete Pavement Institute PICP Installer Technician Course.

Landscape Subcontractor Qualifications:

1. Utilize a landscaper having successfully completed bioretention installations similar in design, material and extent indicated on this project.
2. Utilize a landscaper with job foremen holding certification from the WEF Green Infrastructure Certification Program.

One of the most notable issues raised is the type and level of experience of contractors installing parking lot bioretention islands and perimeter landscape areas. These are among the most common settings for GI practices and retrofits, and the most likely to suffer in terms of performance and aesthetics if design, installation and maintenance are not carried out well. Project participants highlighted the critical role of paving contractors, who generally are the prime contractors on municipal and private parking lot construction projects. Anecdotally, it appears many paving contractors in Northeast Ohio are not knowledgeable enough about the nuances of bioretention landscaping to select and propose subcontractors with experience in bioretention.

Landscaping also has been an area of a typical bid package that gets less attention and resources when prime contractors work to produce cost-competitive bids. In both instances, project participants have seen compromises or oversights in the important design details of bioretention systems (e.g. using a particular size of stone for energy dissipation at inlets, providing plant plugs of sufficient size for installation at different points in the growing season, etc.) that put the long-term function of the entire stormwater management system at risk.

One area where Northeast Ohio does appear to have a "leg up" on this front is in permeable pavements. In contrast to neighboring regions, project participants reported that Northeast Ohio has a reasonably strong pool of contractors with knowledge and experience in permeable surfacing installations including permeable concrete, porous asphalt and paver block installations.

Many of the possible solutions offered by project participants, or in practice in other parts of the country, do have implications (sometimes substantial) for cost. Supplemental construction oversight and temporary irrigation both will add to project cost, especially relative to conventional surfacing and landscaping approaches. Nonetheless these are critical measures to ensuring the long-term function of GI practices. The two areas where these costs could be offset are (1) grant/incentive programs, where additional construction-phase and early-year maintenance costs could be required to be incorporated into project budgets and made eligible for grants or incentives; and (2) runoff and volume reduction allowances for the use of GI practices, which could "shrink" the total area of the required practices and offset some of the total stormwater management cost for a project or site. These cost trade-offs are not easily generalized, but the research and discussion in this report highlights their importance to expanding the practice of GI stormwater management in the region.

Table 3. Construction-Phase Issues and Potential Solutions

POTENTIAL PROBLEM	OPTIONS FOR BID & CONSTRUCTION PROCESS
Parking lot construction contractors use landscape sub-contractors who are unfamiliar with GSI in order to reduce cost; results in poor installation, failed bioretention.	Require GSI certified landscape sub-contractors in bid specifications, or pre-qualify landscape contractors.
Soil mixes, grading, energy dissipation at inlets, or plant plugs are not installed correctly, or planting is sequenced incorrectly.	Require contractors to have qualified design professional (either their own, or the project's designer) on site, either at key points in process or throughout. Increase frequency of inspections and require landscape architect, horticulturalist, forester or other landscape professional to conduct inspections/certifications.
Plants fail to become established.	Add temporary irrigation systems to specifications for bioretention areas if permanent irrigation is not part of design.
Failure occurs after financial guarantee has been released (typically two years, which may not cover two full growing seasons after installation).	Extend length of required guarantee to three years or two full growing seasons to ensure establishment, with inspection before release.

5.0 MOVING AHEAD

While commissioned in large part to evaluate cost medians and trends, this report has yielded a broader range of insights and recommendations on policy, people and technical barriers that relate to – and in some cases greatly affect –developers' cost considerations for using GI practices. This section roughly prioritizes the next steps and recommendations in two categories: Cost- and Construction-Related Actions, and Policy and Technical Actions.

5.1 Cost- and Construction-Related Actions

Action Step 1 – Create a Cost and Construction Clearinghouse for Northeast Ohio. Create a clearinghouse for information on costs, including bid tabulations for projects with green infrastructure components as well as yearly maintenance costs, that is accessible to private, public and non-profit practitioners. NEORSD may be ideal to lead or at least contribute to this effort, especially as the District's experience managing multiple distributed bioretention sites becomes more established and robust.

Action Step 2 – Develop Example Language for Bid Documents and Construction Phase Requirements for Green Infrastructure Projects and Encourage or Require Use in Permitted or Grant-Funded Stormwater Projects. Throughout the research process participants stressed the need for examples of good language and conditions to include in permits and bid specifications that would help ensure sound construction and installation practices – especially for bioretention, where construction-phase issues with soil mixes, grading, timing of plantings, and irrigation can 'make or break' a GI practice. State, regional and municipal partners can share examples of standards and requirements that should be included in stormwater permit conditions, grant projects, and bid documents for green infrastructure projects. Items that may be addressed include requiring construction-phase inspection and certification of practices by a licensed professional, extending the duration of financial guarantees, specifications for timing or sizes of bioretention plantings, use of temporary irrigation to establish bioretention areas, and requirements for subcontractor experience and certification.

Action Step 3 – Explore the Potential to Participate in the National Certification Program for Green Infrastructure Construction and Maintenance Contractors. Closely related to the construction phase issues in Action Step 2 is the potential benefit of participating in and linking bid eligibility to a certification program for green infrastructure installation and maintenance. The region has outstanding capacity for supporting this type of training and certification program through its existing partnership organizations including th Balanced Growth Program, NEOSWTC, CRWP, and area Soil & Water Conservation Districts.

One option is to explore participation in the National Green Infrastructure Certification Program (http://ngicp.org/), sponsored by the Water Environment Federation, which will be initiated in 2017. This program will provide a certification exam process that could serve as a first step for certifying installation and maintenance contractors in the region, particularly if incentives were offered for participation. As the program becomes stronger, municipalities may want to require the use of certified contractors in municipally sponsored and permitted projects in order to have greater confidence in the long-term performance of GI practices.

5.2 Policy and Technical Actions

Action Step 1 – Rainwater and Land Development Manual additions that address Runoff Reduction. As discussed in Section 3, one of the most substantial limitations on the use of GI in the region is the lack of a methodology to reduce the size of a conventional practice where GI is used as part of a treatment train. Though an updated CRWP model stormwater ordinance does include provisions for this, a methodology has not been finished and adopted yet. These updates to the manual are urgently needed in order to facilitate selection and sizing of stormwater practices. The manual should include a standard, accepted methodology for the runoff reduction approach as a means of: 1) standardizing the calculation of runoff reduction from key GI practices, 2) promoting the use of naturalized landscape and conservation measures in overall approaches to stormwater and preventing counter-productive actions (such as tree clearing to create sufficient space for a water quality pond), and 3) enabling developers to make more efficient investments in landscaping, surfacing and stormwater infrastructure.

Action Step 2 – Address Technical Issues with Permeable Pavement Standard. Participants described ongoing issues with the interpretation of Ohio EPA's standards for permeable pavement in the Ohio Rainwater and Land Development Manual. As noted in Sections 2 and 3, permeable pavement is not cost-competitive if modifications to the subsurface system are required to meet water quality performance standards. Form a working group with Ohio EPA, NEOSWTC, CRWP, municipal and developer representatives to address (whether through amendments, education, or a clarification memo) two specific issues related to the language and interpretation of the permeable pavement standard in the Ohio Rainwater and Land Development Manual:

- Address design and technical considerations around the ***retention time for achieving water quality volume within a permeable pavement system.*** Contact with staff of the Minnesota Pollution Control Agency may shed light on how this approach to meeting water quality performance standards has worked in practice.
- Address the c***haracterization of infiltration rates and feasibility for soils beneath permeable surfacing systems,*** and how assumptions or requirements could be creating potential conflicts or constraints on the use of these systems.

Action Step 3 – Develop Guidance for Additional GI Practices. When possible, develop and adopt standard guidance for Ohio for additional GI measures such as green roofs, planter boxes for urban applications, and rainwater harvesting-to-landscape applications to facilitate greater use in permitted stormwater projects.

If, when and as a runoff reduction approach is used and/or other incentives are developed to reduce the surface footprint of water quality ponds and other GI practices, work through education, outreach, and the MS4 permit process to ensure that municipalities maintain or enhance zoning standards and landscape requirements so that surface areas are planted and managed in ways that provide water quality, aesthetic and habitat benefits.

Action Step 4 – Continue to Address Parking Requirements and Landscape Standards in Local Zoning. While tremendous progress has been made in revising local codes and ordinances to require less impervious surface – and thus reduce the size and cost of stormwater practices, and increase the likelihood that GI can be utilized – there are still communities where parking requirements and landscape standards are limiting the use of GI. Continued work by regional partners, and evaluation of where a locally-adopted detention standard may be limiting use of GI, will help reduce cost and design barriers to greater use of GI.

REFERENCES

Brennan, Amy and Matt Scharver. 2012. Demonstrating Innovative Approaches to Distributed Storm Water Management in Northeast Ohio, 2004-2011. Final Technical Report 2012, EM-83262401.

Chagrin River Watershed Partnership, Inc. 2015. Innovative Stormwater Solutions for Ohio: Case Studies of LID Implementation and Performance. Accessed at http://crwp.org/files/NERRS_Case_Study_Report.pdf.

Chagrin River Watershed Partners, Inc. Model Ordinance for Comprehensive Stormwater Management. January 2016. Accessed at http://crwp.org/files/comprehensive_stormwater_management_05162016.pdf.

Davidson-Bennett, Keely. 2015. Implementing Credits and Incentives for Innovative Stormwater Management. Final Report to the National Estuarine Research Reserve System Science Collaborative. Accessed at http://crwp.org/files/NERRS_final_grant_report_CRWP2015.pdf

ODNR. 1980. Ohio Stormwater Control Guideook. Ohio DNR, Division of Soil & Water Conservation, Columbus.

ODNR. 2006. (last updated 11-6-2014). Rainwater and Land Development Manual, 2006 Edition. Ohio DNR, Division of Soil & Water Conservation, Columbus.

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