Stormwater Infrastructure Training & Maintenance Needs Assessment

Growing Infrastructure, Growing Economies, Nurturing Investments

Sea Grant
ILLINOIS-INDIANA
IISG21-RRCE-RLA-003

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Prepared by:

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Primary Author:

Margaret Schneemann, Water Resource Economist, Illinois-Indiana Sea Grant

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Cover Image:

"Chicago Skyline from Paxton Landfill," Image by Daniel Bovino.

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Executive Summary:

To assist green infrastructure project managers with understanding long-term maintenance issues, Illinois-Indiana Sea Grant conducted a needs assessment. This assessment grew out of a recognition that declining infrastructure performance and sufficiency is a fundamental challenge to stormwater management over time. Green infrastructure, defined as best management practices that mimic the hydrological function of natural areas, has become an important part of the stormwater management solution. As the popularity of green infrastructure grows, a key challenge for communities is ensuring long-term maintenance of these projects once they have been installed and established. Green infrastructure maintenance is not only important to the long-term functioning and success of projects, but can also provide community development benefits.

The geography for this assessment is the Calumet region, including Chicago's south side and Cook County southern municipalities, which are all part of the Illinois Calumet Stormwater Collaborative (CSC). Compared to the greater Chicago metropolitan region, the CSC region has higher than average unemployment, lower than average income, lower educational attainment, a greater percentage of minority racial groups, a declining population, and lower labor force participation. For these reasons, the dollars that green infrastructure investments bring into CSC communities, and the workforce opportunities provided by the need for long-term maintenance, are particularly important.

Many of the factors affecting inadequate, inconsistent, or ineffective implementation of maintenance point to the need for operationalizing the work. Green infrastructure maintenance can benefit from adapting operational frameworks from wastewater maintenance strategies (asset management systems). Case studies of green infrastructure projects in the CSC region indicate that projects in the region have not yet entered the long-term maintenance period. At the early stages, however, projects included maintenance plans, and assignment of maintenance responsibility. The research also found that those providing program oversight are not familiar with the training requirements of maintenance personnel.

An inventory of training programs in the CSC region found that there are a large number of formal and informal green-infrastructure related education and training opportunities. The diffusion of training opportunities and use of in-house training points to the need to streamline credentialing. There is no widely accepted professional green infrastructure certification at the time of this review, although the DC Water/WEF National Green Infrastructure Certification Program (NGICP), which is the first nation-wide green infrastructure certification program, is a step in this direction. The majority of training opportunities in the CSC region currently require investment in formal post-secondary education and/or professional or industry affiliation, which may limit accessibility by CSC residents to this training to entry-level maintenance occupations. Green infrastructure investment therefore provides an opportunity to address workforce participation.

Stormwater infrastructure investments—both gray and green—translate not only into community benefits (through reduced flooding risk, improved water quality, etc.) of value to residents, but also economic development opportunities. One of the overarching issues in connecting green infrastructure investment to economic development is that there is no generally accepted definition of the green infrastructure cluster, industry, or its occupations. This assessment reviewed the literature on defining the green infrastructure industry and used the results to inform an analysis of the CSC region. The analysis performed for this assessment finds that green infrastructure related maintenance occupations in the Chicago region are projected to grow an average of 8% over the next decade, providing an opportunity for CSC residents.

Introduction

> Fundamental Challenge: Declining stormwater infrastructure performance and sufficiency over time

Illinois's Calumet region, located within the greater metropolitan area of Chicago, is highly urbanized. Because of urbanization, the majority of the land surfaces are impervious and therefore, rainfall that should soak into the ground typically drains into local water bodies or into traditional gray infrastructure systems.[1] Rainfall frequency and intensity has increased over time, leading to underperformance of aging stormwater infrastructure. It is increasingly evident that our infrastructure may not have the capacity at times to handle all of the stormwater runoff, leading to water quality issues.[2]

Urban stormwater challenges associated with flooding and water pollution result from land cover changes that disrupt natural hydrology and harden the landscape. Part of the solution lies in re-creating and restoring the functioning of predevelopment landscape. To manage urban runoff, there has been increasing interest in best management practices (BMPs) that mimic or recreate an area's natural hydrology, as well as in capturing water for re-use. These practices are broadly referred to as green infrastructure. Green infrastructure practices relieve demand placed on traditional stormwater systems, thereby helping to reduce flooding incidence and combined sewer overflows (CSOs). These practices also improve the quality of water returned to the environment, and can enhance community livability.

> Key Challenge: Ensuring adequate and consistent maintenance of green infrastructure

A key challenge to the long-term success of green infrastructure is ensuring adequate and consistent maintenance of both the green and gray infrastructure. This challenge is particularly relevant for green infrastructure, which is highly visible to community residents. There are numerous factors affecting the delivery of needed maintenance, including lack of preventive maintenance planning and accountability, inadequate training for maintenance managers and staff, and insufficient stormwater budgets and funding.

Green infrastructure maintenance can provide notable economic benefits such as supporting local business, increased labor demand and job retention, social equity, and social capital.[3] Community development benefits are of particular importance in the Calumet region. The average income and employment opportunities lag behind that of the greater Chicago region as a whole. This document discusses the Calumet region in Illinois, presents regional green infrastructure maintenance case studies,

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1 Arnold, Chester L. Jr. and C. James Gibbons. (1996). Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. Journal of the American Planning Association. Vol. 62, No. 2.

2 In the Calumet region, combined sewer systems are common. In combined sewer service areas sewage and stormwater reach the same pipe. During heavy storm events, the system becomes overwhelmed, sometimes causing combined sewage/stormwater to back up onto streets and into basements and overflow into local water bodies. Occasionally when this happens, combined sewage and stormwater enters into Lake Michigan, the primary source of drinking water in the Chicago region. These events, called combined sewer overflows (CSOs), have both public health and environmental impacts, due not only to sewage in the CSOs but also stormwater runoff, which contains trash, debris, lawn chemicals and fertilizers, and other pollutants.

3 McEwen, B., T. Aubuchon, H. Crawford, M. Davison and K. Seidman. (2013). Green Infrastructure & Economic Development Strategies to Foster Opportunity for Marginalized Communities. Massachusetts Institute of Technology Community Innovators Lab Green Economic Development Initiative. Retrieved from https://colab.mit.edu/sites/default/files/gedi-green-infrastructure-economic-development.pdf.

reviews previous literature to define the green infrastructure industry, discusses best practices in connecting green infrastructure to economic development, and examines existing green infrastructure training and workforce opportunities in the region.

Calumet Regional Context

The Calumet Stormwater Collaborative (CSC) region includes Chicago's south side and Cook County southern municipalities, encompassing a total of 140,000 acres that includes 15,000 acres of open space.[4] While regional green infrastructure opportunities have been identified and mapped, no comprehensive inventory of green infrastructure investments was available at the time of this writing.[5] Drivers of green infrastructure investment include both regulatory (to meet water quality standards) and conservation (for open space and habitat preservation).[6,7] Green infrastructure investment is a primary driver of demand for workforce to perform green stormwater maintenance.

CSC region socio-economic data was collected to better understand the regional context (Table 1, Figure 1).[8] Compared to the greater Chicago metropolitan region, the CSC region has: higher than average unemployment, lower than average income, lower educational attainment, and a greater percentage of minorities, declining population and lower labor force participation. CSC residents have 1.7% lower high school diploma attainment as compared to the rest of the region, and 12.8% lower bachelor's degree attainment.[9]

Demand for green infrastructure comes from:

- public sources
- private property owners (via public grants, incentives, stormwater fees, regulations for new development, growing environmental awareness)
- public and private ecological restoration

4 In this discussion, the CSC region refers to the Calumet Core geography of the Millennium Reserve in Illinois.

5 Chicago Wilderness (2015). The Chicago Wilderness South Cook county Communities Millennium Reserve Green Infrastructure Project. Available at: setaskforce.org/wp-content/uploads/2016/02/cw_millennium_reserve_gi_october_2015.pdf

6 Environmental Finance Center. (2013). Encouraging Efficient Green Infrastructure Investment. Report prepared for the National Urban and Community Forestry Advisory Council and the US Forest Service.

7 Examples of regulatory drivers include the Illinois statewide stormwater MS4 Permit, existing county and municipal stormwater management ordinances, and consent decrees issued in response to Combined Sewer Overflows (CSOs). The Clean Water Act Safe Revolving Loan Funds (SRF) program additionally contains earmarked money for green infrastructure stormwater management. GI can also be included in transportation projects (for example, complete streets), and Green Building projects (for example, LEED certification).

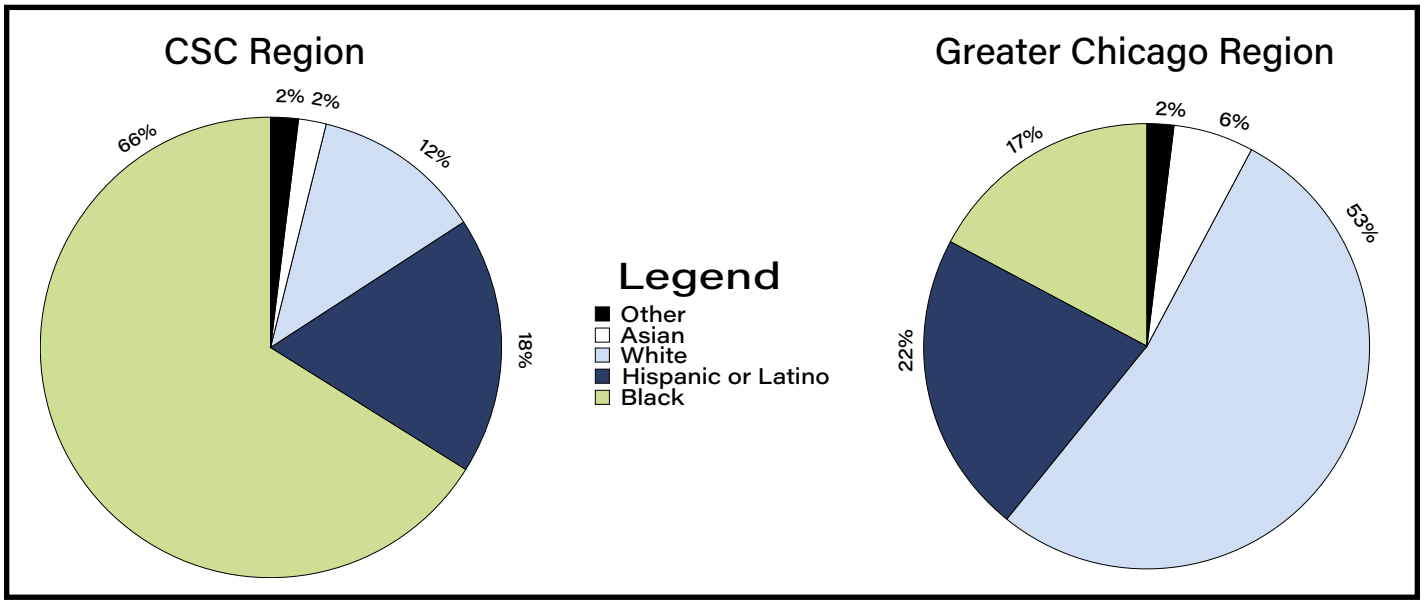
8 The Chicago Metropolitan Agency for Planning (CMAP) is the official regional planning organization for the northeastern Illinois counties of Illinois counties of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will. This geography is referred to as the Greater Chicago Region.

9 Source: 2014 American Community Survey estimates. Universe: population 25 and older.

Table 1: Calumet Stormwater Collaborative Regional Snapshot[10]

	CSC Region			Greater Chicago Region		
Year or Percent	2010	2015	% Change	2010	2015	% Change
Total Population	1,226,071	1,161,044	-5.3%	8,450,837	8,487,546	0.4%
Total Households	444,081	430,255	-3.1%	3,024,683	3,058,278	1.1%
Average Household Size	2.72	2.66		2.75	2.73	
Population in Labor Force	572,394	555,822	-2.9%	4,438,726	4,523,067	1.9%
Unemployed	86,348	106,522	23.4%	364,544	474,670	30.2%
Percent Unemployed	15.1%	19.2%		8.2%	10.5%	
Median Age		35.9			36.2	
Median Income		54,792			62,903	

Figure 1: Calumet Stormwater Collaborative Regional Race and Ethnicity Composition[11]



Maintenance and Training Background

Information on green infrastructure maintenance activities and frequency is typically contained in maintenance manuals and maintenance plans accompanying green infrastructure projects. Despite availability of such resources, delivery of maintenance services is often uneven. Concerns over green

10 Source: American Community Survey estimates. ACS 05-09 and ACS 10-14. Regional medians calculated based on group frequency distributions. CMAP Community Snapshots.

11 Source: 2000 and 2010 census, 2014 American Community Survey estimates. Regional medians calculated based on group frequency distributions. Universe: total population. *Includes Hispanic or Latino of any race.

infrastructure maintenance have been extensively documented in cases and surveys across the U.S.[12] A number of factors contribute to uneven green infrastructure maintenance implementation, including:

- Incomplete or inaccessible information identifying and locating installations.
- Insufficient tracking of responsible parties for maintenance.
- No dedicated inspection staff.
- Green infrastructure designs not being conducive to maintenance.
- Vandalism.
- Lack of authority to enforce maintenance and associated access to green infrastructure.
- Increasing numbers of green infrastructure installations that require maintenance and therefore overwhelm staff.
- Lack of training for municipal staff and/or contractors.
- insufficient funding for maintenance and inspection activities.[13]

In general, many of the factors affecting inadequate, inconsistent, or ineffective implementation of maintenance point to the need for operationalizing the work:

- ✓ Knowing the location and condition of green infrastructure.
- ✓ Scheduling and tracking maintenance.
- ✓ Ensuring staff or contractors are assigned to carry out the maintenance tasks.
- ✓ Ensuring staff or contractors are trained.
- ✓ Conducting inspections and monitoring to assess the condition and performance of stormwater control measures.
- ✓ Clearly specifying and communicating performance requirements.
- ✓ Allocating resources for needed maintenance work in budgets.

> Green infrastructure maintenance can benefit from adapting operational frameworks from asset management systems.

12 Including: American Rivers. Detwiler (2013). Staying Green: Strategies to Improve Operations and Maintenance of Green Infrastructure in the Chesapeake Bay Watershed; Feehan, C. (2013) A Survey of Green Infrastructure Maintenance Programs in the United States. Hixon Fellowship Final Report. Yale School of Forestry and Environmental Studies; U.S. EPA (2015) The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure reviews Clean Water State Revolving Fund projects. U.S. EPA. (2015). Elements of a GI Maintenance Business Plan: A Stakeholder-Driven Process to Determine the Preferred Approach to Green Infrastructure Maintenance in Southeast WI. EPA 832-R-15-005; Delta Institute (2015) Great Lakes Region Sustainable Models for Green Infrastructure Maintenance. Cleveland Botanic Garden; Vacant to Vibrant.

13 See, www.swmpc.org/downloads/operationmaintenance.pdf

Each of these factors is discussed below.

Knowing the Location and Condition of Green Infrastructure Assets

> Green infrastructure stewards should maintain an up-to-date inventory of the assets including information on location, design, age, and maintenance needs.

Many communities have a large and growing inventory of green infrastructure. These may have been installed at different times by different people, are likely located in different community areas, and have specific maintenance needs. Green infrastructure stewards should maintain an up-to-date inventory of the assets including information on location, design, age, and maintenance needs. The inventory should be linked to a calendar or scheduling program, which can provide reminders when maintenance activities are due. The inventory should be reviewed during the budget process to ensure inclusion on an annual basis, and reviewed periodically to ensure that funding is continually in place to maintain the assets.

Scheduling and Tracking Maintenance

> A tracking system can be used to plan and schedule activities, identify staffing and resource needs, and track the completion of maintenance activities. Tracking may include:
>
> - activities completed and time to completion
> - project condition
> - installation scale
> - any issues needing follow up
> - costs

Maintenance activities and frequencies are typically specified or outlined when green infrastructure plans are in development, and are included in the design phase of the project. Elements influencing the maintenance program include: type of green infrastructure practice; site-specific elements (runoff volume, traffic volume, trash/debris volume, sediment loading, materials specifications, soil composition and health, topography, scale, right-of-way, groundwater table depth, etc.); seasonal variations (snow removal, leaf cover, etc.); adjacent site activities (construction, pedestrian traffic, etc.); and irregular weather events. Maintenance activities are generally divided into two categories: routine (conducted at regular intervals) and non-routine (performed in response to a certain performance issue). In addition to maintenance activities, maintenance plans can also include monitoring and inspection frequencies.

This information can be used in planning future projects and establishing budgets. The tracking system also provides for accountability to ensure planned maintenance work was actually carried out. Ideally, planning and tracking information can be managed in an electronic asset management system similar to what a wastewater agency would do to manage and maintain its gray infrastructure. Agencies and municipalities may include green infrastructure components in a larger asset management system to schedule and track maintenance, including contractor reports and inspections.

Ensuring Staff or Contractors are Assigned to Carry out the Maintenance Tasks

Planning who will perform needed maintenance and assigning responsibility is key to the entire maintenance cycle. Identifying the responsible party is critically important, along with the calendar system to prompt the activity and an accountability system to ensure performance.

Deciding who will have maintenance responsibility often takes into account two key factors: property ownership (public or private), and the age and condition of the green infrastructure asset. In terms of the age and condition of the asset, and what may change over time, responsibility is often divided into two phases:

- An initial warranty period (or short-term period), frequently is included in the construction or maintenance contact or memorandum of understanding and typically lasting 1-3 years. For example, if a contractor is hired to install the green infrastructure features (particularly the plants), that contractor may be contractually obligated to maintain the plants while they are becoming established.
- A long-term period occurs when maintenance is typically handed off from the funding agency or contractor. Additional contractual or funding provisions may be made for this period.

Maintenance responsibility can be assigned to one or more of these entities:

- Agency in-house personnel
- Other city departments
- Contractors (both general and landscape)
- Informal community groups.
- Stewardship programs.
- Non-profits (both educational and green-jobs)
- Residents

Ensuring Staff or Contractors are Trained

Green infrastructure installation and maintenance requires different skills and resources than gray infrastructure.[14] In some cases, skills and resources may be present in other city departments, as well as other local partners. Whether conducting maintenance in-house or through a contractor, it is important that on-site supervisors and maintenance workers have had appropriate training to ensure the maintenance is according to plan and is effective.

Ensuring that contractors bring the needed experience to the job may require the municipality to develop a list of qualified contractors who can bid on the work. Standardized training and certification will ideally be part of the certification

Training for maintenance and inspection may include formal (classroom) training, in-house training, on-the-job training, internships, and apprenticeships.

14 For example, installing and maintaining vegetated practices may require knowledge about what plants will thrive under what conditions, how new plants need to be placed and nurtured, and when they should be irrigated, and how vegetative and engineered components interact. Maintaining permeable pavement may require knowledge about how to plow the surface in winter, and when and how the surface should be cleaned or vacuumed.

process. Unfortunately, there is a lack of standardized training content and associated training standards. Having a set of training standards, and potentially a certification program for trainees, is useful for a municipality or agency to ensure its staff has had the training needed to do green infrastructure work, and to assure contractors are qualified.[15] In some cases training for supervisors and staff on green infrastructure is a requirement in a permit of regulation. This is particularly true where green infrastructure is a component of a community's CSO control program or its municipal separate storm sewer system (MS4) program, for example, training is a requirement in the Illinois MS4 general permit.

Conducting Inspections and Monitoring for Condition Assessment

> Inspection and monitoring of green infrastructure is important in assessing the functioning of projects.

As noted above, inspections can be a key element of a maintenance program. Typically, this may involve a visual inspection to note condition and functioning. For example, a bioretention practice can be inspected after a rain event to check if there is standing water, which should soak in within 24-48 hours. If problems are noted, non-routine maintenance may be required. Inspections documenting maintenance needs to ensure green infrastructure functioning and performance are typically part of a larger maintenance agreement.

Beyond inspections, monitoring is important in assessing the efficacy of BMPs in terms of meeting their intended performance criteria over time. Monitoring may involve a simple infiltration test, or water sample collection and testing. The International Stormwater BMP Database (www.bmpdatabase.org) has standardized monitoring and reporting protocols, as well as a collection of performance data sets. This resource addresses the lack of monitoring standards when assessing the performance of green infrastructure best management practices. See footnote for additional resources focused on monitoring of stormwater BMPs and green infrastructure.[16]

Clearly Specifying and Communicating Performance Requirements

The primary goal of inspection and monitoring is to ensure that the installation is meeting its intended functional criteria. Green infrastructure with vegetative elements, however, has community co-benefits that may make additional criteria important for its management, such as aesthetics. Being clear about these criteria with project partners and the community is important in ensuring green infrastructure success. A clear understanding of the required maintenance schedule is needed ensure green infrastructure continues to perform as anticipated.

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15 DC Water and Water Environment Federation (WEF) created a National Green Infrastructure Certification Program (NGICP) for construction, inspection, and maintenance (http://ngicp.org/).

16 (1) Geosyntec Consultants and Wright Water Engineers, Inc. (2009). Urban Stormwater BMP Performance Monitoring. Retrieved from www.bmpdatabase.org/Docs/2009%20Stormwater%20BMP%20Monitoring%20Manual.pdf; (2) NCSU Stormwater BMP Inspection & Maintenance Certification Workshops; (3) Erickson, A., P. Weiss, and J. Gulliver (2013) Optimizing Stormwater Treatment Practices: A Handbook of Assessment and Maintenance University of Minnesota. (4) Colorado Stormwater Center at Colorado State University. Permanent Stormwater Quality Best Management Practice Inspection and Maintenance Field Guide Retrieved from stormwatercenter.colostate.edu/wp-content/uploads/2015/06/BMP-IM-Field-Guide.pdf

Allocating Resources for Needed Maintenance Work in Budgets

Because water quality funding programs typically fund only green infrastructure construction, maintenance is typically supported with local funds, including in some cases a community's general fund. When there are competing priorities for use of local dollars, maintenance programs can sometimes be short-changed. It is challenging to develop a budget for maintenance as consistent and reliable information on costs for maintenance of stormwater infrastructure is limited. Maintenance costs vary depending on the entity responsible for maintenance, program experience, original design criteria, specified maintenance level of service, site visit frequency, weather conditions, travel time between sites, staffing needs, and types of maintenance included in the cost estimates (routine, non-routine, replacement).

Maintenance costs issues or problems may include:

1. lack of good data on maintenance costs, since municipalities often do not track cost information.
2. synthesizing data due to variances in budgeting, record keeping, units of cost (stormwater volume, surface area, maintenance practices, responsibility, site differences, regional cost differences).
3. multiple departments responsible for maintenance on the same BMP.
4. contracts for maintenance not being itemized (contractors not wanting to share cost information).
5. differing design metrics across BMPs leading to different maintenance requirements and costs; (based on training and bidding issues as well as securing certified contractors, discussed in a previous section).
6. inconsistencies with what is actually included in the costs (labor, maintenance, scheduling, gas, equipment amortization, and materials disposal costs).

Better information on green infrastructure maintenance costs is needed and is important in understanding the full life-cycle costs of green infrastructure. Nevertheless, there are some cost estimating tools and resources that can be consulted to estimate and budget for costs.[17]

> Communities need to know:
>
> - What is the anticipated life cycle for green infrastructure?
> - How long will it last if taken care of into the future?

Maintenance Funding and Capacity

Financial considerations may be the largest challenge to long-term maintenance. Currently, funding for maintenance is diverse, including sources such as United States Department of Housing and Urban Development funds, foundation grants, property owner fee assessments, general operating funds, parks, MS4 education funding, sewage districts, and volunteer labor like Extension Master Gardeners and Master Naturalists. Ideally, maintenance funding could come from dedicated revenue sources such as stormwater fees, to provide reliability and consistency. There are many other maintenance funding ideas, from mitigation

17 EPA's National Stormwater Calculator; U. of Minnesota Stormwater Center/MnDOT; 2009 WERF Whole Life Cycle Cost Tool; 2005 WERF/UKWIR Whole Life Cycle Costs; NCHRP Report 792; UDFCD BMP REALCOST (Colorado); North Carolina State BAE; 2006 Narayanan & Pitt (WINSLAMM).

> Financial considerations may be the largest challenge to long-term maintenance.

banking to public-private partnerships.

Delta Institute has developed a checklist for communities to use in assessing maintenance capacity.[18] The assessment first takes communities through identifying green infrastructure maintenance stakeholders and provides them with ideas on where to find expertise. The second part of the checklist assesses existing conditions in terms of the project location, purpose, site characteristics, maintenance responsibility, potential partners, and skill levels, as well as co-benefit considerations such as aesthetics, workforce development, etc. The third step considers readiness for maintaining green infrastructure relative to whether the community has a maintenance criteria, financial resources, human capital, landscape design, materials, and policy.

CSC Region Training and Maintenance Case Studies

Case studies of green infrastructure projects in the CSC region were gathered to improve knowledge and capture local stories illustrating why there is a concern about training and maintenance issues.[19] While there are a wide variety green infrastructure stakeholders, the workgroup broadly defined case study participants as municipalities and other organizations funding and implementing green infrastructure. The case study gathered information on the green infrastructure project, maintenance of the practice, and training of the personnel performing maintenance. Five case studies were completed, including: Big Marsh Park, Mayor Taylor Trail, Streetscapes, Space to Grow, and Rain Garden Project.

In summary, the case studies indicate:

- Green infrastructure funding is provided by a combination of state and federal sources.
- Projects include maintenance plans, with maintenance responsibility contracted out.
- Training is most often being provided in-house.
- The reason for installing green infrastructure is primarily for stormwater management.
- Green infrastructure provides a workforce development and community volunteer opportunity.
- Green infrastructure case study projects have not yet entered the long-term maintenance period.
- Program directors are not familiar with the training requirements of maintenance personnel.

18 See, www.cbgarden.org/userfiles/files/Great%20Lakes%20Sustainable%20Models%20for%20GI%20Maintenance%20-%20Final%20Report%2005232016.pdf

19 In addition, the American Society of Landscape Architects has a collection of green infrastructure and stormwater management case studies available, two of which are contained in the CSC region, Ball Horticultural Corporate Campus and Cermak Road Sustainable Streetscape. These case studies collected information on the site, project specifications, costs and jobs and performance measures. No information was available in either case study on job hours devoted to maintenance, however, the Ball Horticultural Corporate Campus case study indicated that maintenance costs had fallen over time, but didn't provide specific cost information. See, www.asla.org/stormwatercasestudies.aspx#illinois.

Regional Green Infrastructure Education and Training Capacity

An inventory of training opportunities (professional and volunteer), workforce initiatives, and credentialing (certifications, degrees, professional associations, etc.) was undertaken to better understand the existing green infrastructure education and training capacity in the CSC region. Green infrastructure training is provided by a range of local, regional, and national organizations, and their partners. A number of other governmental, education, human services, and economic development organizations provide workforce development. Organizations providing green infrastructure-related education and training include educational institutions, occupational and continuing education programming, non-governmental organizations (NGOs) and private organizations also offer training for specific industry sectors, such as landscaping.[20]

Several assessments have examined green infrastructure training, certification, and credentialing at the national-scale. U.S. EPA (2009) prepared a listing of green infrastructure training opportunities, including formal college and university trainings, non-profit and trade organization trainings, and state certification programs.[21] Harvard Law School (2014) surveyed green infrastructure professional certification programs, finding 18 green infrastructure certification programs differing in content (GI BMP coverage), scale (agency, local, state, national), audiences (professional, regulators, businesses, private property owners), and administering entities (universities, trade associations, businesses). [22]

Harvard Law (2014) recommend government agencies require certification of green infrastructure contractors and provide funds as well as technical assistance for certification development and implementation. Other actions governments can take include: providing support for green infrastructure certification programs (grants, technical assistance, marketing); supporting green infrastructure standards development as the foundation of certification programs (create and codify green infrastructure BMPs, fund the private sector to develop GI standards, or adapt existing standards); promoting green infrastructure acceptance and demand; and giving preferential treatment to certificated contractors. It is not recommended that governments administer certification programs, but rather, support them.

> "The entry-level, accessible nature of green infrastructure construction and maintenance jobs offers an opportunity to support job creation and long-term employment opportunities in communities where green infrastructure is being implemented.
>
> *DC Water and Water Environment Federation (2015). The Need for National Green Infrastructure Training and Certification. p. 2.*

Target audiences for certification include design professionals (engineers, landscape architects) and laborers (landscapers, construction). Certifications may be tiered (with differing requirements for different levels) to allow for suitable level of certification for entry-level green infrastructure work, as well as education geared more toward experienced green infrastructure workers. Certification can be delivered locally by third

20 Because it is difficult for lower income, and ESL individuals to access these formal training opportunities, Illinois has invested in bridge programs to prepare individuals for post-secondary training.

21 U.S. EPA (2009). Green Jobs Training: A Catalog of Training Opportunities for Green Infrastructure Technologies.

22 Harvard Law School (2014). Certifications for Green Infrastructure Professionals: The Current State, Recommended Best Practices, and what Governments Can Do to Help, Emmett Environmental Law and Policy Clinic and the Environmental Policy Initiative, Cambridge, Mass.

parties but be centrally affiliated with rules, guidelines, and curriculum. When third parties deliver training, there should be a standard process used by the certifying body for training the trainer, and standard guidelines provided. Enforcement mechanisms such as auditing and penalties can be used to protect the certificate and performance monitoring used to demonstrate certification benefits.

Harvard Law (2014) found certification requirements to vary greatly, but generally include exams (typically written), coursework, experience, and renewal standards (accompanying education and/or certification, prior workforce experience). Five best practices for certification include: design high quality programs that are nationally accredited; incorporate hands-on, field skills into training and testing; use third-party collaboration to develop and implement the program; integrate outreach and community building into the program; and tier certifications for different audiences. Needed research includes (1) an in-depth assessment of green infrastructure best management practice standards and (2) conducting a survey of successful certification programs in other areas (such as Leadership in Environmental and Energy Design (LEED) to distill lessons learned.

> "A green infrastructure facility is at risk if the staff constructing and/or performing maintenance does not have the proper training, background, and knowledge to understand system functions and maintenance requirements. This risk is carried over to the broader green infrastructure movement, which could lose momentum if facilities underperform and do not fulfill their intended benefits because of widespread inadequate maintenance or poor construction.
>
> *DC Water and Water Environment Federation (2015). The Need for National Green Infrastructure Training and Certification. p.5.*

DC Water and the Water Environment Federation (WEF) explored green infrastructure drivers and reviewed green infrastructure certificate and certification programs.[23] Since poor construction and inadequate maintenance is a risk to green infrastructure performance, they recommend the creation of a national green infrastructure certification program, starting with entry level staff and expanding to intermediate (field supervisor), and then advanced (construction/maintenance manager). DC Water and WEF found that green infrastructure certification programs are administered by a range of organizations, including national local, state and regional; educational institutions, NGOs, workforce development groups, product producers, and trade associations. They distinguish between certification programs (participants attend and pass a course-related exam) and professional certification (participants pass an exam based on broad industry knowledge, independent of a particular training course). They recommend separation of the certification exam developer and the developer of the training materials, and designing certifications to meet ANSI/IISO/IEC 17024 standards.[24]

In conclusion, there are a large number of formal and informal green-infrastructure related education and training opportunities in the CSC region. There is no widely accepted professional green infrastructure certification at the time of this review, although the DC

23 DC Water and Water Environment Federation (2015) The Need for National Green Infrastructure Training and Certification.

24 For more information, see www.ansi.org/accreditation/credentialing/personnel-certification/Default.

Water/WEF National Green Infrastructure Certification Program (NGICP), which is the first nation-wide green infrastructure certification program, is a step in this direction. The majority of training opportunities in the CSC region require investment in formal post-secondary education and/or professional or industry affiliation.

Green Infrastructure and Economic Development

Stormwater infrastructure investments—both gray and green—translate not only into community benefits (through reduced flooding risk, improved water quality etc.) of value to residents, but also economic development opportunities for communities.[25] This section considers how other cities across the U.S. have assessed the economic development, workforce education, and training needs provided by infusions of stormwater investment dollars. To develop a better understanding of how green infrastructure investments create training and workforce development opportunities, several economic development studies conducted in other regions were reviewed, including: Philadelphia, Pennsylvania; Cleveland, Ohio; and Portland, Oregon. Several national level summary reports on green infrastructure and economic development were also reviewed, and an overarching summary is provided below.

Green infrastructure has been implemented in numerous cities across the nation for over a decade now. Permits and consent decrees drive the initial adoption of green infrastructure but policy changes have helped to continue its implementation. Many local governments and municipalities are starting to realize the social and economic benefits derived from effectively integrating grey and green infrastructure into stormwater management plans. For example, in Philadelphia, it was estimated that an initial investment of $1.6 billion in green stormwater infrastructure will leverage $218 million in direct supporting activity and $284 in indirect activity in the region, creating over 8,600 jobs, and a gain of $49 million in municipal tax revenue.[26] There has also been a 10% increase in housing values, stemming from the quality-of-life improvement projects completed (beautification, additional recreation opportunities, health benefits, reduced flooding). Altogether property values increased an estimated $1.3 billion, creating an annual increase of $18 million in property taxes for the Philadelphia government and school districts.[27] In Ohio, for the Northeast Ohio Regional Sewer District, an economic impact analysis estimated that maintenance spending over a 5-year period of $11.3 million, or $2.26 million per year would result in 219 jobs created, $11 million in labor income, $13.8 million in value added, and $2.8 million in taxes.[28]

Several national-scale assessments have also considered the relationship between green infrastructure and economic development. For example, McEwen (2013) assessed the economic development potential of green infrastructure, finding that community-based organizations (CBOs) and targeted procurement

25 These benefit contributions to human well-being can be valued (environmental valuation or ecosystem services valuation) using methods applied by environmental economists. Direct contributions to the economy, on the other hand, are determined using economic impact analysis methods applied by economic development specialists in planning and public policy.

26 Business United for Conservation Industry Partnership Business United for Conservation Industry Partnership, Compiled by GSP Consulting Corp. and the Ecolibrium Group (2010) *Capturing the Storm: Profits, Jobs, and Training in Philadelphia's Stormwater Industry*. Retrieved from www.sbnphiladelphia.org/images/uploads/Capturing%20the%20Storm%20-%20BUC%20Needs%20Assessment.pdf.

27 Econsult Solutions (2016) *The Economic Impact of Green City, Clean Waters: The First Five Years*. Retrieved from http://www.econsultsolutions.com/the-economic-impact-of-green-city-clean-waters-the-first-five-years/.

28 LAND studio (2013) *Seeing Green: Green Infrastructure Maintenance Training and Workforce Development Opportunities in Northeast Ohio*. Retireved from: www.greenforall.org/new_report_seeing_green_green_infrastructure_maintenance_training_and_workforce_development_opportunities_in_northeast_ohio.

policies have been the main drivers of green infrastructure-related economic development [29] and that help is needed for economic development organizations (EDOs) to identify opportunities and associated strategies. Promoting increased use of green infrastructure and connecting residents to employment can be difficult, due to a lack of participation by city or regional economic development organizations in green infrastructure planning and a lack of integration of local economic development benefits from green infrastructure investment into plans.[30]

Bowler (2013) examined the economic development opportunities provided by long-term management of green infrastructure through maintenance and stewardship opportunities.[31] While green infrastructure investment is growing in terms of dollars directed towards installations, it is unclear what proportion of funding is being applied to maintenance. This is despite the importance of maintenance activities in realizing the return on investment in green infrastructure. Bowler explains, "...it is undeniable that GI performance directly relates to maintenance; without it, GI solutions are empty investments."[32] Bowler notes that the New York City green infrastructure plan does not identify maintenance funding and does not assign performance responsibility.[33] New York City does not have a long-term plan resulting in maintenance responsibilities falling to community volunteers. This may be a positive benefit for the community because it is linking the maintenance needs of the GI projects with the workforce needs of the surrounding community. Bowler points to the role that community workforce agreements or project labor agreements (PLA) can play in proving workforce opportunities to communities via green infrastructure maintenance and provides several successful PLA case studies.

Several studies have examined the impact of stormwater infrastructure spending on the economy. For example, Green for All (2011) conducted a nationwide assessment of a potential $188.4 billion dollar investment in stormwater management over five years, finding that this investment would result in economic impact of $265.6 billion and create almost 1.9 million jobs.[34] The authors connect public investment in public infrastructure projects to overall economic growth, noting that a 1% increase in public capital investment growth results in a 0.6 percent increase in gross national product growth. Green for All (2011) provide job impacts by state, noting that jobs created in each state are proportional to each state's water investment

29 McEwen, B., T. Aubuchon, H.Crawford, M.Davison, K. Seidman. (2013). *Green Infrastructure and Economic Development Strategies to Foster Opportunity for Marginalized Communities*. Final Report Massachusetts Institute of Technology Community Innovators Lab Green Economic Development Initiative. Using green infrastructure experiences from New York, Portland, Oregon, and Philadelphia; interviews with green infrastructure sector stakeholders (subject matter experts, academics, government officials, trade associations; and an online survey of green infrastructure implementers).

30 Recommended strategies include partnering with community organizations and social enterprises that can engage directly with cities procurement, and creating urban apprenticeships that can serve as a pipeline. Since many firms provide on-the-job training rather than credentialing, therefore, other workforce development tools that focus on hiring retention and advancement may be more important than credentialing. Training program components included life-skills, job-readiness, safety, and basic green infrastructure principles. Culturally sensitive training is also important, as 35% of the natural landscaping workforce is Latino and, therefore, training in Spanish is needed (McEwen, 2013).

31 Bowler, Elizabeth (2013). Workforce Development and the Maintenance of Green Infrastructure. Capstone, Programs for Sustainable Planning and Development Pratt Institute School of Architecture.

32 Bowler (2013) p. 6.

33 Beyond a short-term inter-agency maintenance memorandum of understanding (MOU) assigning maintenance responsibility to the Department of Parks and recreation.

34 Green for All (2011). *Water Works: Rebuilding Infrastructure Creating Jobs Greening the Environment*. Report prepared in partnership with American Rivers, Pacific Institute, and the Economic Policy Institute. Data on investment expenditures were taken from the EPA 2008 Clean Water Needs Survey (CWNS), which estimates 188.4 billion of capital investment is needed for stormwater infrastructure. Operation and maintenance costs not included.

needs. An occupational analysis finds that the majority of occupations for stormwater projects require only a high school diploma or equivalent, plus some post-secondary training. The authors conclude that stormwater infrastructure investments generate economic, environmental, and social benefits, recommending that cities and municipalities (1) create accessible and well-paying jobs,[35] (2) maximize environmental benefits, and (3) use stable, fair and scalable financing.

While the environmental benefits of green infrastructure have been extensively researched, not as much attention has been given to the economic benefits.[36] The research focuses on three types of water infrastructure projects: green roofs, water efficiency, and wetland restoration. First, to determine the economic impact of green roofs, data form a study in Washington DC is used and extrapolated to a nationwide green roof initiative that would cover 1% of the nation's potential 48.5 billion square feet of green-roof-ready area, finding this would create over 190,000 jobs. Second, a water efficiency analysis by the Alliance for Water Efficiency found that a $10 billion investment in water efficiency programs would result in $25–28 billion of economic impact and create 150,000–220,000 jobs. For wetland restoration, the authors consider a case study conducted on the Cache River in Southern Illinois. Restoration activities on the Cache River led to the creation of 220 jobs and 12.6 million in economic impact.[37] The authors conclude that green infrastructure and water efficiency projects can contribute to the local, regional, and national economy.

The Green Infrastructure Industry in the CSC

One of the overarching issues in connecting green infrastructure investment to economic development is the lack of generally accepted definitions of the green infrastructure cluster, industry, or its occupations.[38] This is in part because green infrastructure businesses and occupations are difficult to categorize within traditional industry and occupational classification systems, due to the industry's fragmentation and its emerging nature and the hybrid nature of workforce participants.[39] For this analysis, only maintenance occupations are considered.

The top five industry sectors in the CSC region include health care/social assistance, educational services, retail trade, manufacturing, and accommodation/food services.[40] Of these major industry sectors, the primary

> Green infrastructure related occupations in the Chicago region are projected to grow an average of 8% over the next decade. These occupations require no formal education, or a high school diploma or equivalent, with training typically occurring on the job.

35 High-road jobs meet standards, typically including: livable wage, benefits, hiring workers from disadvantaged communities, use community workforce agreements on larger construction projects, connect to apprenticeships and job training, and establishing career pathways.

36 American Rivers and the Alliance for Water Efficiency. (2008) Creating Jobs and Stimulating the Economy through Investment in Green Water Infrastructure.

37 Caudill, James. (2008) *The Economic Impacts of restoration and Conservation-related Expenditures: The Cache River Watershed in Southern Illinois*.

38 Nor a 'green job' in general, though the BLS has issued a definition. See, http://www.bls.gov/green/.

39 Sustainable Business Network (SBN) of Greater Philadelphia. (2010). *Capturing the Storm: Profits, Jobs, and Training in Philadelphia's Stormwater Industry*.

40 U.S. Census Bureau. 2016. OnTheMap Application. Longitudinal-Employer Household Dynamics Program. http://onthemap.ces.census.gov/.

one associated with the green infrastructure cluster is utilities, specifically water systems. Within these sectors, green infrastructure operations and maintenance occupations include: supervisors; landscaping and groundskeeping workers; general maintenance and repair workers; septic tank servicers and sewer pipe cleaners; and water and wastewater treatment plant and system operators.[41] Employment, wages, and projected occupational growth are shown for on-ramp green infrastructure operations and maintenance occupations in Table 2.

Table 2: Green Infrastructure Operations and Maintenance Ocupations and Wages, 2016[42]

Occupation	Total Employment Chicago MSA	Mean Hourly Wage Chicago MSA	Projected Growth 2014–2024 (%)	Typical Entry Level Education	Typical On-the-Job Training
Supervisors, Landscaping and Groundskeeping Workers	2,380	28.76	5.3	HS Diploma or Equivalent	None
Landscaping and Groundskeeping Workers	17,360	15.2	6.1	No Formal Education	Short-Term
Maintenance and Repair Workers, General	34,810	21.46	6.1	HS Diploma or Equivalent	Long-Term
Septic Tank Servicers and Sewer Pipe Cleaners	430	24.73	16.3	No Formal Education	Moderate-Term
Water and Wastewater Treatment Plant and System Operators	1,330	32.21	6.0	HS Diploma or Equivalent	Long-Term

41 LAND Studio. (2013). *Seeing Green: Green Infrastructure Maintenance Training and Workforce Development Opportunities in Northeast Ohio*.

42 See, https://www.bls.gov/oes/tables.htm, https://data.bls.gov/projections/occupationProj.

Conclusion and Recommendations

Green Infrastructure investments positively impact the economy, support jobs, and generate local tax revenues. Positive economic impacts can be particularly important in areas with higher than average unemployment and lower than average income. Green infrastructure in the CSC region is relatively recent, with projects yet to enter long-term maintenance periods. An emerging concern over maintenance, however, has led the CSC to proactively address and learn from other regions' experiences. Given projected maintenance occupation growth rates, there is an opportunity to leverage green infrastructure investment towards economic development. With such a large diversity of relevant stakeholders, creating partnerships can allow for implementation of strategies addressing multiple green infrastructure benefits. Setting green infrastructure standards, performing monitoring, and providing credentialed training can alleviate concerns over proper green infrastructure maintenance.

Recommendations include:

- Using newly completed or ongoing green infrastructure inventories, conduct additional survey of green infrastructure project implementers to build the case study library.
- Provide resources on operationalizing green infrastructure maintenance to funders, project managers, and communities.
- Develop better information on green infrastructure maintenance costs to better understand full life-cycle costs of green infrastructure.
- Assess maintenance financial capacity prior to committing to green infrastructure installations.
- Continue to gather information from green infrastructure training providers, green infrastructure firms, and green infrastructure implementers.
- Incorporate maintenance training requirements in accordance with standardized or national certifications into MS4 permits.
- Deliver trainings in partnership with national certification programs.
- Communities partner with workforce and economic development organizations and university extension.