**2015 BOSC Review**

# SSWR Project Charter
# Green Infrastructure – Project 1 (5.01)

**Project Title:** Green Infrastructure Models and Tools

**Project Lead (PL)**: Michelle Simon (NRMRL), Deputy PL-Steve Kraemer (NERL)

**Project Development Team Members:** (alphabetical) Alice Gilliland, Heather Golden, Mohamed Hantush, Bob McKane, Yusuf Mohamoud, Mehran Niazi, Chris Nietch, Michelle Simon, Bill Shuster, Marilyn TenBrink, Hale Thurston, Michael Tryby, Chris Kloss (OWM.
Project Writing Coordinators:  Yusuf Mohamoud (NERL), Marilyn TenBrink (NHEERL), Michael Tryby (NRMRL).

**Project Period:**

FY16-FY19

**Executive Summary**

The current state of use for existing watershed models to simulate water quantity and quality effects of different Green Infrastructure (GI) types is limited and lacks rigor. This project strives to advance appropriate models and tools that can support decision-making, planning, and implementation of effective GI for:

- Stormwater control in urban settings and their sewersheds
- Wastewater management
- Long term control plans for combined sewer overflows (CSOs)
- Climate change adaptation
- Pollutant load reduction and total maximum daily loads (TMDL) studies
- Agricultural runoff management
- Hazards resilience
- Enhancement of other ecosystem services

This project will address modification and refinement of existing models and develop new tools designed to support decision making for the complete GI project lifecycle. An emphasis will be placed on model/tool verification with field data and sensitivity analysis (in the traditional sense

and to the aggregation of parameters for larger scale considerations). This project emphasizes the need for better model calibration and validation approaches that include uncertainty analyses of tools that modify model structures and parameter sets to optimize functionality while striking a balance between model performance with ease of their use and data requirements. Developing approaches to handle spatial and temporal scaling issues encountered in managing non-point source pollution in watersheds will receive particular attention in order to address the needs of users and decision makers from private-property owners to city government officials and regional water resource managers. Different user skill levels will be accounted for, from non-technical decision makers and planners to professional hydrologists and engineers. Users of these tools will be able to consider scales that encompass households, municipalities, separate sewersheds, and large watersheds with mixed land uses. This work will result in a portfolio of models and methods that will aid increased adoption of GI in communities and will further its inclusion in management plans that support sustainability goals.

**Research Project Description**

Our current portfolio of US EPA Stormwater management tools requires a broader scope to best solve the challenges facing today's communities. These challenges most notably include aging stormwater infrastructure, mitigating combined sewer overflows, adapting to climate change related water stress, and managing nutrient pollution in urban and agricultural areas. Communities need methods to protect ecosystem services, models and tools to help estimate benefits and trade-offs, and assistance in using technical information to choose appropriate actions.

Increased use of GI, both natural and engineered, is a common sense approach for addressing some of these challenges. GI encourages retention (as infiltration or storage) of runoff at or near the point of its generation; it is effective in rural and urban environments and is increasingly considered as an option to assist in meeting water quantity and quality guidelines and regulations. In addition to stormwater management, GI can provide flood protection, habitat protection, recreation opportunities, pollution treatment, more sustainable hydraulic and ecosystem function, enhanced aesthetics, urban heat island mitigation, and cost savings.

In all places, but especially in urban areas, GI approaches fundamentally differ from gray infrastructure methods for stormwater management in that GI encourages maintenance of natural ecosystem function at scale.  For example, local water table recharge, rather than water collection and transport to treatment or discharge elsewhere. By necessity, GI projects involve consideration of spatially distributed deployment of engineered stormwater and flooding controls and naturally-attenuating landscape features. Poor understanding at the process-level of GI units, and how they are best aggregated for implementation at larger scales introduces uncertainty and complexity for which there is no current solution.  Improved models and tools, informed by targeted field data that in turn aids in predicting their functionality, will aid communities in evaluation of GI options. This access to useful technical information and better

coordination of GI deployments will help in achieving the management objectives and cost effectiveness that drive municipal decisions.

This project aims to support increased adoption of GI into community stormwater management plans and sewershed/watershed sustainability goals through advancement of GI models and tools, verification/validation/calibration with targeted field datasets, drawing from experiences and data from increasing GI application throughout the US.  Research will encompass gap analysis, model and tool development and enhancement, model evaluation, and application of methods developed in conjunction with stakeholders; it will focus on improving both the tools and methods and the integration of their use into water management decision processes.

How best can models and tools development be leveraged to promote successful integration of GI projects and programs with community and regional management plans (e.g., stormwater, sustainability, climate, economic, transportation, water quality)? Adoption of GI is slowed by lack of experience with GI practices, their decentralized nature, uncertainty about performance under future conditions, and complexity in addressing impacts on hydrology and water quality at the interface of urban economic and social matters.  Changing urban land-use over time also presents challenges to effective GI implementation. To be effective, US EPA GI and stormwater management models and tools must adapt to these new realities. Models and tools that meet the needs of various levels of decision makers from private property owners to city government officials, and various types of users from planners and decisions makers to professional hydrologists and engineers must be developed.

One critical component of the research will be attention to the needs and perspectives of the users of ORD's GI models and tools.  EPA researchers, in collaboration with partners and stakeholders, need to create capacity building exercises or training for stakeholders to learn how to use the tools and models developed and refined in this research. EPA should receive feedback from stakeholders about how they're actually using the tools and models. Gap analysis and iterative evaluation of model/tool usability with GI decision makers will increase the capacity of regions, states, tribes, and municipalities to determine where and how GI is effective.   For example, municipal government officials would find cost-benefit analysis data useful at the conception of a stormwater management project when choosing between green and gray infrastructure alternatives. Access to predictive scenarios that illustrate both monetary and non-monetary benefits and co-benefits of using GI would help in developing integrated approaches to health and environmental challenges.  Watershed collaborative efforts would benefit from understanding the trade-offs and commonalities among urban GI, natural GI (e.g. existing natural wetlands used for stormwater management), and GI-like conservation practices used in agricultural settings in mixed use areas. City planners would benefit from integration of stormwater models with the GIS based planning tools that they already use to assess the effect of zoning decisions on runoff generation. Stormwater engineers need tools for locating distributed GI stormwater control practices (SCPs), modeling their effectiveness and cost, and detailed unit process design. Private property owners would benefit

most from basic design, cost, construction, and maintenance guidelines. Planners would benefit from understanding the effectiveness of GI practices under future scenarios of climate change.

Another critical component of the research will be iteration between model predictions and measured data in order to better understand sensitivity, monitoring needs, and uncertainty. This important linkage between field data (SSWR Project 5.02 as well as other data sources) and model simulations will demonstrate to user communities that the quality and type of inputs can affect the accuracy of model outputs.  It will also serve to guide the direction for enhancements of specific models toward evaluation of uncertainty and using model output to identify, qualify, and possibly quantify risk profiles for GI adoption.  The general activities of this research and development work will involve balancing and improving the scientific understanding of how aggregating, lumping, and generalizing (e.g., of assumptions, parameters, etc.) in stormwater models and tools affects model output and prediction while retaining functionality/user-accessibility and the accuracy of parameter sets. This can happen only after testing assumptions that are structural to the models and tools with both measured data and more complex physically-based model simulations.  One approach that is underway to meet these demands combines empirical studies with modeling that inform each other (thus imparting a clear goal and rationale for field work) and thus are linked hand-in-hand from the ground up.

The shift in approach for the FY16-19 SSWR GI Tools and Modeling research is, therefore, to be engaged at multiple levels in user-feedback and data-feedback throughout the model development process.  This will verify that models are performing well in simulating processes where GI interventions are used, best match the model or tool to the application or need, and to the objectives of the decision maker.  Model improvements and tools to assist in GI implementation will strengthen relationships between rigorous modeling efforts, GI implementation at multiple scales, and the outcome of increased contribution of GI to meeting sustainability and regulatory goals. To implement such an approach it is imperative that we first understand our community partners' needs through timely feedback on GI models and tools. In some cases meeting these needs will involve optimizing our existing tools. In others, new models and tools may need to be developed. For instance, we currently lack models and tools for comprehensive management of urban wet weather, water quality impacts, and agricultural pollution at multiple watershed scales. We expect to have a number of synergy points with ORD partners in other projects within SSWR (especially GI Project 2), Sustainable and Healthy Communities (SHC) (especially Decision Tools and Models), EnviroAtlas, Ecosystem Services measures, and the Sustainability Portal "CSAS") and Air Climate and Energy (ACE) (especially Community Climate Adaptation).  We also expect to take advantage of evolutions in IT, data management, visualization, and citizen science.

**Project Impact**

ORD has a two-fold approach for model use and application. First, it frequently uses models and tools to support important policy decisions.  Second, it leverages models and tools to support programmatic activities resulting from policy initiatives. In either case, we must develop

scientifically defensible and technically sound models and continue to refine (using both experimental and field data) existing models toward these goals. In the latter case, models and tools must be relevant to programmatic activities, and usable by community partners. EPA is currently engaged in a major policy initiative to promote the use of GI SCPs for "next generation" stormwater management and sustainable community development. This project will provide greater capacity for decision-makers to (1) understand the benefits and tradeoffs of including GI in urban, suburban, and rural development, (2) access and apply the data, tools, and models that they need to select and implement the most appropriate GI across landscape types in mixed use systems, and (3) make significant advances in larger goals of maintaining long-term ecological, human health, and water quality protection sustainability and resilience.

**Project Scope**

This project will involve four core components: (1) Identifying potential community partners and understanding their needs, (2) Developing an inventory and gap analysis of current models and tools used for implementation of GI, (3) Refining and advancing existing model and tool capabilities to align with the scales, issues, knowledge from field data, and decisions that stakeholders and partners most need, and (4) Developing analytical tools to inform the potential range of benefits/trade-offs and life cycle cost analyses for GI options.  Agency, federal, academic, local community, and private sector partners will likely provide critical collaborations that will increase the scope and impact of ORDs research in this area.

The project will involve evaluating the current suite of EPA stormwater and related external management tools and models for the implementation of GI practices at multiple spatial (e.g., project site, subwatershed, watershed, basins) and temporal (e.g., daily, seasonal, annual) scales. This evaluation is a cross-cutting exercise and will be coordinated with the development of the FY16-19 SHC and ACE research programs as well as EPA's Program Offices.  Part of this process will include a thorough gap analyses that considers how different GI practices are incorporated into EPA models and additional tools, the effectiveness of the model structures for evaluating the efficacy of such practices, suggested improvements in the model structure and equations to better capture hydrological and water quality (loading) response to GI practices, integration of these suggested changes into existing models, and the usability and usefulness of the models and tools.

The evaluation of EPA stormwater models will also include case studies to demonstrate how models could be used to simulate the impact of GI on runoff and water quality (loading) at different scales and land use scenarios.  The strengths and weaknesses of each model will be assessed at a variety of spatial and temporal scales (specifically targeting multiple watershed scales) and across a spectrum of complexity (e.g., parsimonious tools to complex models), the effects of spatial and temporal aggregation/lumping of model parameters (e.g., hydraulic conductivity and its relationship to runoff formation and infiltration processes), and how to best leverage modeling data needs with data monitoring and collection practices.  Each study will build upon and/or integrate current or planned partner case studies.

Research to increase our understanding of community partner needs will occur both in the gap analysis and in discrete study of:  decisions that may include a GI option; technical capabilities

of users; accessibility of data, tools, and models; usefulness of EPA tools and models; and case study analyses of model and tool application and usefulness.

GI implementation will be increasingly embraced as a viable management option when it is clear to those responsible for selecting, financing, installing, maintaining, and monitoring GI that the benefits of using it outweigh the direct costs and life-cycle costs (including operation and maintenance) and that co-benefits of significant value also accrue including company and job creation in sectors associated with installing, maintaining and monitoring GI. Hence, research on the societal and economic aspect of GI will increasingly complement the environmental focus that GI implementation has historically received.

The workflow for this project will proceed along the following lines: a) GI type-specific process review, b) GI algorithm review and development, c) develop and evaluate GI modeling methods, d) create a newly aligned GI modeling toolbox, e) conduct exchange with end users, f) GI modeling application at demonstration sites, and g) benefit-cost (BCA) and life cycle (LCA) analyses. The BCA and LCA components will include land valuation and incentive mechanisms and performed simultaneously with the research proposed in a through f above.

**Project Structure and Rationale**

Storm water coordinators and watershed planners want to be able to explore GI alternatives and estimate relative cost-benefits (including co-benefits) to meet water quality criteria and hazards resilience. To meet this need the following broad work areas have been defined for this project **(see Figure 1)**

> *(A) MODEL AND TOOL GAP ANALYSIS*
> *The current inventory of available EPA stormwater related models and tools will be assessed to advance their use for managing stormwater and agricultural pollutant loading at multiple scales and across the full spectrum of decisions that affect implementation.  This will include, but not be limited to the following components:*
>> a. Literature review
>> b. GI User Needs Collaboration with SHC, SSWR other Projects, ACE, Regions,
>> c. Relative to full suite (Non-EPA tools) for GI decisions (Federal, Non-Governmental          Organizations (NGOs) and Tech Centers)
>> d. GI Decision Analysis (e.g., GITAR, DASEES, CSAS, ENVISION & Program Offices)
>> e. Gap Analysis of Capabilities, Capacities, and Needs (e.g., using framework)
>> f. Capability/data gaps specific to GI and SWMM Model (e.g. inclusion of water interception and evaporation from trees)
>> g. Capability/data gaps specific to GI for HSPF, SWAT and VELMA models
>> h. Community Support models (e.g., WMOST for data availability and watershed hazard modeling needs

(B) *GI MODEL AND TOOL DEVELOPMENT AND ENHANCEMENT*
*Tools, models, and approaches will be developed and/or adapted to provide community partners and decision makers the ability to integrate GI practices and stormwater runoff into their planning options at multiple scales.  This will include, but not be limited to the following components:*

a. Maintenance and enhancement of existing of GI related tools
    i. GIS-SWMM integration (e.g.,  sub-catchment delineation, contributing area estimation)
    ii. Web based National Stormwater Calculator
    iii. HSPF and Basins
    iv. WMOST
    v. GITAR/synergy with CSAS
    vi. Monitoring and adaptive management
    vii. GI SCP cost estimation model
    viii. VELMA enhancements for multi-scale GI applications in mixed urban/rural watersheds
b. Support for detailed GI SCP unit process design
c. Algorithm Development (e.g., GIS-SWMM Integration)
d. Simplification of model parameterization (e.g., via automated evolutionary algorithms)
e. Spatial and Temporal Up-scaling  (e.g., project site to city district to watershed)
f. Physical Processes Enhancement (e.g., adding wetland modules)
g. Community-Based Model Development (e.g., Web National Stormwater Calculator)

(C)  *MODEL AND TOOL EVALUATION*
*The current inventory of available EPA stormwater related tools will be assessed to advance their use for managing stormwater and agricultural pollutant loading at multiple scales. This will include, but not be limited to the following components:*

a. Fill  gaps identified (in A) for GI, watershed, and stormwater  models, tools & resources
b. Demonstration pilots (e.g.,  co-located application of models, data, scale, model functionality and capabilities, sensitivity analysis and evaluation)
c. Development of GI SCP water quality process model
d. Post-Processing enhancements
e. Automated Sensitivity Analysis
f. Uncertainty analysis

(D) *MODEL AND TOOL APPLICATION*
*Making existing GI and stormwater modeling tools more relevant, accessible, and useful to the user community. This will include, but will not be limited to the following components:*

a. Tool box organization (e.g. group tools by functionality, central location for tool access)
b. Modeling support center (to address research, development, technical support, and training). This center will be coordinated with another EPA effort on the development of a stormwater model clearinghouse (Drupal microsite for GI, POCs OWOW and OWM).
c. Gathering data and lesson learned from ORD tools through partnerships (e.g., smart growth, OW GI tech assistance) and use feedback for realignment of models and tools
d. Integrate GI with Integrated Water, Materials Management, Energy modeling (in ORD and OP) to address Sustainability goals and Life Cycle Analysis for costs-benefits of green versus gray infrastructure, or combinations of GI and gray infrastructure
e. Literature access (reviews and coordination with OW)
f. BCA and LCA studies (e.g., non-monetary, run off volumes, WQ – linkage to other sectors/national programs)
g. GI functional types (e.g., rain barrels and rain garden)
h. Economic incentives for conversion of private land to GI (e.g. subsidies, retention trading programs)
i. Scaling and data integration
j. GI Model Application and access to Urban and Rural (e.g. Agricultural) users
k. Linkage to Other Models (e.g., Transportation, LCA Models)
l. GI Selection and Placement Optimization
m. Community Outreach (e.g., with Regions, OW, professional trade groups, and watershed management entities)

*(E)* <u>Outcomes</u>
*Verification that the intended outcomes of this research and the uptake of GI occur is an integral component of the research project. This component will support adaptive management on the ground and within our research program. Specific aspects of this work include (a)* Measuring key outcomes, (b) Improvement as indicators of ecosystem function, (c) Removal of gaps in capability and capacity and (d) Increased implementation of GI approaches

**Measure of Success**

Project success will be assessed using metrics that characterize the extent to which the following goals, and users' needs, are achieved. These goals fall under three levels of success defined by our vision for (1) What can be achieved with anticipated funds, FTE and skill sets, (2) What could be achieved with anticipated funds and additional FTE and skill sets, and (3) What could be achieved with additional funds, FTE and skill sets. For all, metrics will include peer-reviewed publications, feedback from EPA partners and community stakeholders and performance indicators.

What can be achieved with anticipated funds, FTE and skill sets

    a. Improved capability of GI models and tools to accurately quantify the effectiveness of natural and man-made GI to manage runoff volume and water quality.
    b. Improved capability to quantify uncertainty of GI models and tools.
    c. Improved capability for scaling up GI models and tools across multiple spatial and temporal scales – from neighborhood to basin, from hours to decades
    d. Improved integration of field and modeling studies to more effectively achieve the preceding three goals.
    e. For specified urban and rural case studies, demonstrate the applicability, performance and transferability of GI models and tools for managing runoff volume and water quality.
    f. Increased application of  GI for addressing cross-sectoral issues
    g. Improved demonstration of decision case, use case, and case study success
    h. Improved technical transfer and training to assist EPA partners, software developers, GI companies, and community stakeholders in the use of models and tools for implementing GI practices

What could be achieved with anticipated funds and additional FTE and skill sets

    a. Economic analysis of costs and benefits of gray vs. GI for managing water volume and improving water quality.  Additional economic skill sets via ORD cross-laboratory collaboration and HQ and the Regions.
    b. Improved capability of GI models and tools to quantify ecosystem service (ES) co-benefits associated with GI strategies for managing water quantity and quality, including, for example, groundwater recharge, improved air quality, reduced urban heat islands, habitat creation, enhanced aesthetics, improved property values, carbon sequestration, and improved recreational opportunities.  Additional ES modeling skill sets via collaboration with SHC 2.61.
    c. Enhanced outreach and technical transfer of GI models and tools to EPA partners, software developers, GI companies, and community stakeholders.  Additional tech transfer skill sets via coordination with ORD's new Water Quality Centers.
    d. Community and Regional case studies to demonstrate access and application of data, models, tools, and resources. Additional decision science and stakeholder capacity via EPA Region collaborations and academic/contract FTE.

What could be achieved with additional funds, FTE and skill sets

    a. Integrated GI and human health models to assess human health co-benefits of green vs. grey infrastructure strategies for managing water quantity and quality. Additional human health skill sets via EPA postdocs and/or collaboration with SHC, OW, ORD BenMAP developers and others,
    b. Integrated GI and social benefits models to assess human well-being co-benefits of green vs. grey infrastructure strategies for managing water quantity and quality. Additional social science skill sets via EPA postdocs and/or collaboration with SHC and others.

c.  Improved capability of GI models and tools to estimate effects of global climate change and extreme climatic events on water quantity and quality in urban and rural environments.  Additional climate modeling skill sets via EPA postdocs and collaboration with SHC, NCEA, and academics.

**Stakeholders (outside ORD):**

EPA OW/OWM, Regions, other Federal Agencies (USGS, NRCS,DOI, HUD, DOT, Army Corp of Engineers, USFS, BLM) , state agencies, local, tribal governments, regional planning boards, transportation and building industries, municipal officials, private consultants, engineering firms, software developers, GI companies, utilities , academic community,  and NGOs (e.g. Water Environment Federation, Water Environment Research Foundation).

**Output(s)**

As stated in the StRAP, potential outputs include: (1) Performance information, guidance and planning tools for Program Offices and community partners] to facilitate increased adoption of GI (FY 16) and (2) Demonstrate modeling tool approaches [for Program Offices and community partners] to assess GI effectiveness for managing both runoff volume and water quality at multiple watershed scales (FY19).  Where possible, models will be included to predict potential air quality benefits of GI.

**Key Products**

**Product 1**
**Title***:  GI model gap analysis and new modeling approaches.*

**Description***:* This product will develop a set of modeling approaches and data requirement protocols to identify the strengths and weaknesses of current GI models and tools. GI modules will be evaluated and developed (e.g., process models for rain gardens and wetlands). The current inventory of available EPA stormwater related tools will be assessed to improve their accessibility and advance their use for managing stormwater and pollutant loading at multiple scales*.* A literature and gap analysis will be developed for GI, watershed, and stormwater tools. The status of demonstration pilots will be evaluated, including co-located application of models, data, scale, model functionality and capabilities, sensitivity analysis and evaluation. Scaling issues will be addressed here, and approaches documented for comparing and contrasting among GI-types, deployment densities, and GI/Landscape-type interactions.

**Focus areas:**  focus areas may include: 1) literature review, 2) model application tasks, 3) selection of suitable test sites and demonstration pilot areas, and 4) data acquisition protocols and data quality assurance (QA) 5) effectiveness of engineered and natural GI systems in

mitigating flooding and reducing nutrient, sediment, and pathogen loads from urban and rural areas to water bodies.

**Contribution to outputs**:   Primarily to Output 1.
**Intended end user**: This product is primarily intended for use by ORD, OW, EPA's Office of Policy (OP), and the GI user community (e.g. software developers, GI modelers).

## Product 2
**Title**: Enhancing GI models and tools to address current and emerging modeling challenges

**Description**: This product may consist of four tasks that are intended to capture the topics outlined in A1 and the tools identifies in A2. It will be functionally based in order to best inform end-user and decision-makers.

**Focus Areas:** This product will have the following focus areas:  1) development and incorporation of a wetland module to GI models, 2) development and incorporation of a cost-benefit analysis module for GI model use, and 3) development and incorporation of watershed delineation tools for GI models

**Contribution to outputs**:    Contributes to Outputs 1 and 2.

**Intended end user**: The primary users of this research will be the GI model/tools user and development community, which may include Program/Regional Offices, and state program staff involved in 303 TMDL development, 404 wetlands permitting, and CSO consent decrees. Other users include software developers and GI companies.

## Product 3
**Title**: An inventory and GI Toolbox (e.g., models, tools, & methods) for use by GI communities (e.g. municipal planners, watershed modelers).

**Description**: This product will be an interactive website, which houses all the GI related models and tools. The website will track model and tool downloads and will provide information on the demand for and use of GI tools and models. It will have interactive design whereby GI model and tool users can provide feedback to the tool developers. The inventory, toolbox, and other delivery systems (e.g., GITAR and CSAS) will be compatible. This task may be accomplished in collaboration with the National Center for Water Infrastructure Modeling Research.
**Focus areas**: Focus areas may include 1) establishment of interactive websites, 2) community outreach guidelines, 3) information gathering methods on model use and user community satisfaction using surveys and other tools, and 4) collaboration with the National Center for Water Infrastructure Modeling Research.

**Contribution to outputs**: Contributes to Outputs 1 and 2.

***Intended end user*:**   This product is primarily intended for the GI user (e.g. municipal planners, watershed modelers) and software development community.

 **Product 4**

*Title*:   Enhancing the economic and social modeling aspects of GI models and tools

***Description***: This product will focus on the economic and social aspects of GI models and tools. This product is closely linked to project 2 and it may contain several tasks. The product deals with valuation and modeling of the ecosystem services and benefits that engineered and natural GI systems provide. At present, GI models have physical, chemical, and biological process representations and simulation capabilities, but lack capabilities to estimate the economic and social benefits of engineered and natural GI systems including company and job creation in sectors associated with installing, maintaining, and monitoring GI.

**Focus areas**: Focus areas may include: 1) LCAs of selected GI systems, 2) review of existing BCA models and tools, and 3) integration of economic and social analysis tools and models to existing GI models. BCA analyses will focus on municipality implementation of GI.  Any economic valuation research pertaining to regulatory issues will be coordinated with the ORD-OP-OW 3 office Benefits Effort.

***Contribution to outputs***: to be tied to the output section
***Intended end user***: This product is primarily intended for use by the GI user and software development community


**Assumptions and Constraints**

Assumptions include availability of expertise noted in Resources; availability of Regional and community partners to participate in case studies and usability research before/during/after GI installation; effective collaborations with SHC and other SSWR projects; access to efficient computing hardware and technical coding support; and timely coordination with Program Offices and Aging Water Infrastructure technical support to allow methods transfer and testing and support.

Projects with technology transfer, adoption and deployment components will require collaboration with technology developers, water technology clusters, economic development organizations, communities, and/or other stakeholders as appropriate.  The proposed support assumes adequate institutional support and funding.

**Figure 1.  Schematic of Project "GI Models and Tools" Components**
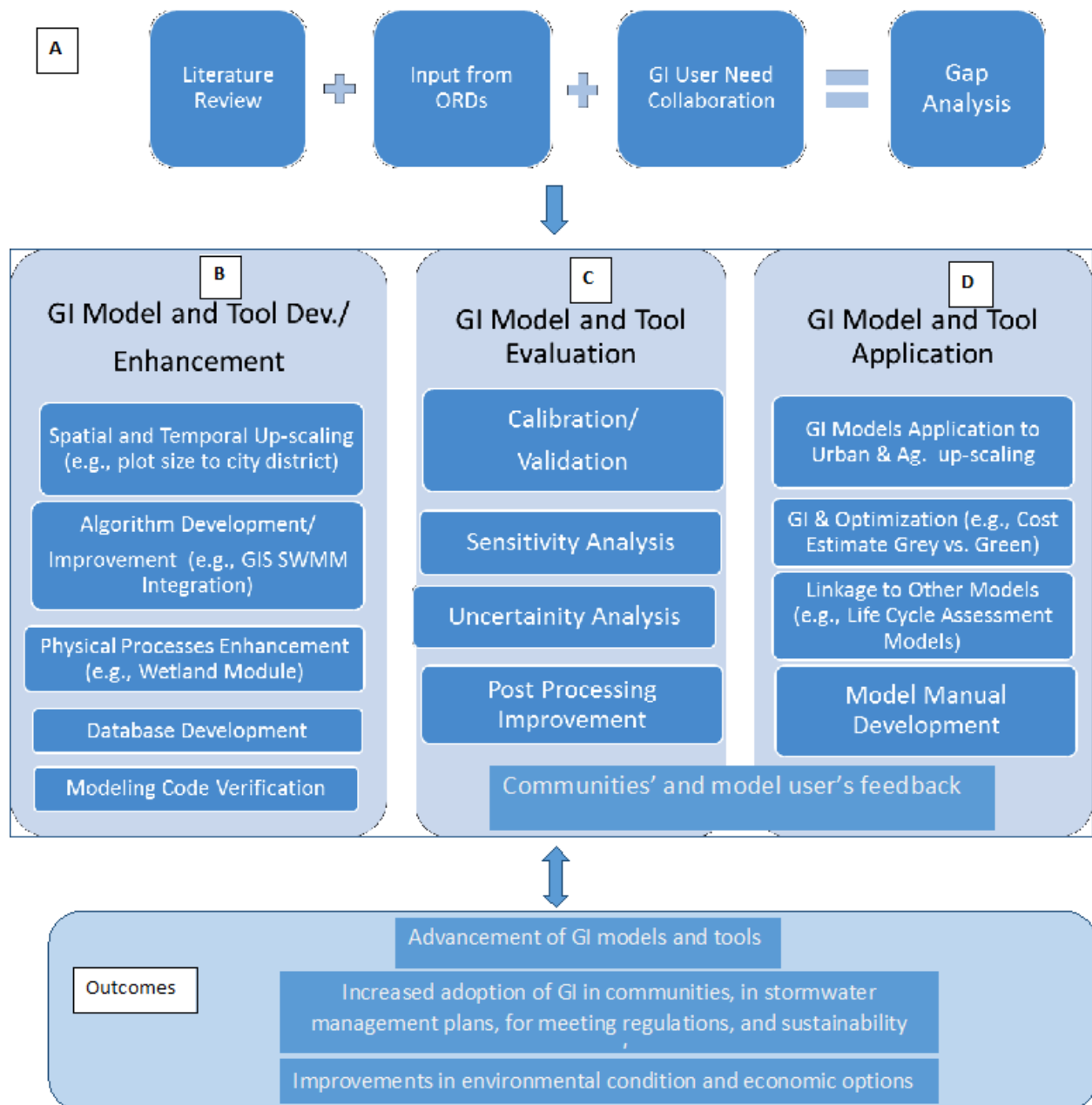
**2015 BOSC Review**

# SSWR Project Charter
# Green Infrastructure – Project 2 (5.02)

**Project Title:** Support increased adoption of green infrastructure into community stormwater management plans and watershed sustainability goals: Information and Guidance through Community Partnerships.

**Project Lead (PL):** Matt Hopton (NRMRL)

**Deputy PL:** Dennis Lye (NERL)

**Project Development Team Members:** Task 1: Naomi Detenbeck*, Michael Borst, Kevin Oshima, Matt Hopton, Scott Jacobs, Dan Heggem, Jennifer Lin; Task 2: Richard Lowrance*, Steve Kraemer, Dale Werkema, Robert Ford, Mary Gonsoulin, Doug Beak, Chunming Su, Bill Shuster, Fran Kremer; Task 3: Joe Schubauer-Berigan*, Charles Lane, Tim Canfield, Richard Devereux (*writing team leads)

**Project Start Date:** 2016

**Project End Date:** 2019

## 1. Executive Summary

The overall goal of SSWR Topic 5 Project 5.02 is to support increased adoption of both constructed and natural green infrastructure (GI) into community stormwater management plans and watershed/sewershed sustainability goals, by providing information and guidance through community partnerships. Focus area 5.02A includes continued and new community pilot studies to determine the performance and effectiveness of GI, develop guidance and lessons learned for adaptation to other communities, as well as to enable larger watershed/sewershed analyses. Focus area 5.02B includes research and development for guidance on interactions of GI with ground water quality and quantity in the context of the overall water cycle. Focus area 5.02C includes assessment of risks posed to natural wetlands used for wastewater and stormwater management, development of guidance for managing risks and reducing potential wetland impairments, and development of guidance for monitoring wetland health and assessing the success of risk management strategies.

## 2. Research Project Description

EPA has adopted a "multi-benefit" approach to promoting the use of GI, highlighting the role of GI not only in reducing the volume of stormwater runoff and associated pollutant loadings, but also in creating "sustainable and resilient water infrastructure that supports and revitalizes urban communities…in the face of climate change" ([EPA Green Infrastructure Strategy 2013](#)). In the Agency strategy, EPA's Office

of Water highlights a research goal of providing stakeholders with data on design, siting, performance, effectiveness, costs, and benefits of GI.  Community partnerships can contribute 1) technical assistance to support implementation of GI for disaster recovery, integration of stormwater/wastewater planning, and to service underserved communities,  (2)  information (e.g., best practices for GI approaches that protect the integrity of ground water supplies, incorporation of innovative stormwater management approaches into permits, integrated water management approaches and financing of GI projects) and 3) case studies that can be more broadly applied to other communities.  Community partnerships can also motivate the academic, economic development, and business sectors to develop the curricula, trained personnel, incentives, and companies needed to install and monitor GI.

A recent survey of EPA's Regional GI Coordinators found general support for the research objectives outlined in the draft Strategic Research Action Plan (StRAP) and emphasized the need to quantify costs and benefits, as well as ancillary risks (e.g., from potential groundwater contamination and pathogens) and to provide guidance on GI maintenance and operational costs.  Some important regional differences were noted with respect to prevalence of combined sewer overflow (CSO) vs municipal separate storm sewer systems (MS4) communities (and related financing issues), surface and groundwater availability under changing climate, water rights, and specific needs of underserved communities (e.g., tribes, underserved communities, etc.).

Focus area-specific Agency Research Needs

Focus area 5.02A: Overall, we need to facilitate use, identify incentives for, and remove barriers to the adoption of GI practices for stormwater management in communities of all sizes across the United States.  This includes providing information not only on the performance and effectiveness, but also on the long-term costs and additional benefits of GI, as well as limitations on GI suitable uses.  Community needs/drivers and capacity for financing, implementing, and maintaining GI vary widely across the country due to differences in existing infrastructure and governance (e.g., CSO vs MS4), climate (positive versus negative water balance, seasonality, extreme events), existing laws and regulations (e.g., eastern vs. western water rights), access to a trained workforce and viable GI companies/providers, and vulnerability of different ecosystems and human populations.  We need to develop priorities for selecting place-based research and partnerships to support community needs, resolve technical, legal, and socioeconomic issues, and fill information and data gaps on the costs and benefits of GI practices at community and sewershed/watershed scales.  Guidance for assessing the performance and effectiveness of GI at multiple spatial and temporal scales is needed so that communities have the information needed to utilize adaptive management.  We also need to ensure that data are collected and organized in such a way that they are useful in informing decisions that are applicable to other communities in similar settings.

Focus area 5.02B: The use of GI is largely in urban settings and built environments to reduce the flashiness of urban water flows and to allow greater infiltration of stormwater runoff.  Benefits for surface water quantity and quality may occur at the expense of ground water quality and the redistribution of groundwater quantity, which, for example, may result in return flow (or inflow-infiltration) to sewer systems.  As communities develop plans for GI, they need information on potential tradeoffs (with regard to both quantity and quality) and tools to evaluate those tradeoffs.  Potential impacts to ground water quality are of at least three general types: 1) direct contamination of ground

water by infiltrated dissolved and suspended surface contaminants (e.g. microbials, oil and gas, pesticides); 2) indirect contamination through changing aquifer conditions that allow a potential contaminant to be mobilized (e.g. arsenic mobilization due to redox changes); 3) interaction of infiltrated water with existing subsurface contaminants (in either soil, subsoil, or ground water) that could alter the spatial extent of existing contamination.

Among the unknown factors that control these potential effects are:  1) ability of soil to attenuate contaminants sourced from stormwater; 2) potential mobilization of contaminants in the soil introduced from past land use; and 3) potential mobilization of naturally-occurring elements in the soil that may be transported due to changes in water chemistry with increased infiltration; and 4) increased transport of existing ground water contaminants due to changing hydrology. The placement of GI needs to be considered in the context of existing or potential sources of contamination such as gas stations, industrial facilities, or materials management operations. The hydraulic flux resulting from the placement of GI in proximity to these contaminant sources can result in unanticipated movement of contaminants in the ground water. Additionally, the location of public and private water wells should be considered in the placement of GI to ensure protection of drinking water supplies.

In areas where ground water is used as drinking water and where increasing infiltration has the potential to increase ground water supply, designed aquifer storage and recovery (ASR) needs may be met at least partially through GI Improvements.  ASR is typically done with rural water supplies through recharge wells and into cavernous aquifers.  Because stormwater generally contains contaminants and storm water infiltration may adversely affect vadose zone soil properties as well as groundwater quality, ASR projects typically exclude stormwater, especially when sediment, bacteria, and other contaminants are high (e.g. Antioch Cave recharge facility, Edwards Aquifer, TX).  More broadly defined ASR might include urban use of spreading basins or  decentralized BMPs (best management practices) to recharge aquifers being actively used for public water supply (e.g., Los Angeles basin).  The research in this task will address critical needs in understanding the effects of GI on ground water in a range of settings.

Focus area 5.02C: Coastal and inland natural (i.e. not constructed) wetlands are important elements of the natural GI of landscapes and watersheds.  They provide key ecosystem services that are central to sustainable ecosystems and ecological communities and vital to the health and well-being of our nation. Wetland ecosystems provide critical habitat for commercial and recreational fisheries (including fin fish and shellfish), migratory and resident birds, amphibians and other wildlife. Wetlands provide key biophysical services. They protect coastal and inland areas from storm damage (through storm surge protection) and flooding (via stormwater retention); and improve water quality by removing pollutants, nutrients and sediments.  Wetlands provide key linkages to groundwater recharge and thereby help maintain stream baseflow and can be a pathway for contaminants.  Wetlands are utilized for their biophysical services, both passively (for storm protection and as part of GI stormwater management) and, to a limited extent, actively to reduce nutrient loads in wastewater.  The focus of this research is to: 1) assess the potential risks and impacts to wetlands used for wastewater and as part of stormwater management, 2) develop guidance and risk management strategies for managing these risks and impacts, 3) provide guidance for monitoring wetland health and assessing the success of risk management strategies for wetlands used to manage wastewater and as part of GI stormwater management and 4) quantify the benefits of wetlands used in stormwater management.

<u>*Coastal wetlands and wastewater treatment*</u>.

Gulf coast natural wetlands are actively used to treat wastewater primarily for excess nutrient (nitrogen) management.  This practice has been argued to benefit natural wetlands by accelerating the productivity of the receiving wetlands and accelerating the accretion of soil organic matter that promotes soil building.   Ultimately it is thought that adding wastewater will help stabilize wetland losses from subsidence and erosion and also provide protection to wetlands and coastal areas from sea level rise.  An economic benefit of this practice is inexpensively removing excess nitrogen from wastewaters. Coastal hypoxia caused by excess nutrients and subsidence and fragmentation of wetlands is a major problem on the Gulf coast.

It is unclear if there is sufficient science to support the expected benefits from this management practice.  Some recent published studies have indicated that adding nutrients at too high a level may have the opposite effect and reduce below-ground production (e.g., plant root growth) leading to increased wetland erosion and subsidence.  Also, it is unclear if additional risks from this management practice have been evaluated, such as altering the species composition of wetlands or the possible human and wildlife health impacts from other contaminants associated with waste water (e.g. bacteria, pharmaceuticals, metals or organics).  Oyster reefs and fish associated with the wetlands could potentially pose health risks when consumed by humans.

<u>*Inland wetlands*</u>

Natural inland wetlands (including floodplain wetlands) are part of the natural green infrastructure of watersheds and are passively used to manage stormwater throughout the US.  As EPA encourages widespread use of GI in the management of stormwater, science is needed to assure that the health and quality of wetlands used passively to manage stormwater is maintained.   Phosphorous, organic contaminants, and metals that accumulate or are transformed to more toxic forms (e.g. methyl mercury) in wetland soils may be of particular concern. Connections and impacts to groundwater must also be assessed for hydrologic and contaminant considerations.

<u>Research Approaches</u>

Focus area 5.02A. A classification framework will be developed to inform both selection of new place-based studies and extrapolation of results from existing place-based studies (e.g.,  Austin, TX; Boston, MA; Camden, NJ; Cincinnati, OH; Clarksburg, MD; Cleveland, OH; Detroit, MI; Edison, NJ; Fort Riley, KS, Louisville, KY; Omaha, NE; Philadelphia, PA; Santa Monica, CA) to new communities and watersheds.  This will take into account community-, watershed- and regional-scale differences in constraints, costs, and valuation of potential benefits of green infrastructure.  In addition to considering biophysical differences among regions, this effort will leverage ongoing work in SHC (e.g., incorporate information on community typologies and GI-related indicators incorporated in the Urban Atlas) and SSWR (e.g., STAR grants program).  Regional and community-scale variations in incentives for GI use will also take into account Regional community support prioritization efforts (Gina McCarthy, Oct 28, 2014 memo "Making a Visible Difference in Communities").  In collaboration with Project 5.01, existing and new place-based research will be used to test and refine GI tools and models to screen for positive and negative associations with GI approaches, and to evaluate financial strategies, economic costs, effectiveness, and performance of GI with respect to water quantity, water and air quality, human health (e.g., chemical  and pathogen exposures, asthma, heat island effects) and other goals (e.g., drinking water, flooding risk, green space) at multiple spatial scales.  Where possible, place-based research will simultaneously evaluate issues related to impacts on and protection of wetlands and

groundwater resources. The use of GI to augment existing water resources in arid and semi-arid regions will also be considered.

Focus area 5.02B research will be closely coordinated with research in 5.02A and with Project 5.01, Green Infrastructure Models and Tools.  The research will proceed in multiple phases.  The first phase will be a comprehensive literature review and literature interpretation.  This will be used to develop draft guidance for OW (and OSWER, if necessary) on GI and ground water quantity and quality.  The second phase will proceed through identification of ongoing GI projects where GW data are available and where ancillary and/or additional ground water measurements may be made.  Priority will be given to projects where a limited increment of research effort will lead to a large expansion in interpretable results relative to GI and ground water.  The third phase will be to coordinate with new demonstrations to assure that research components on both ground water impacts and aquifer storage and recovery are possible.   The fourth phase will be to provide a framework to integrate results and new understanding of the effects of GI on ground water into planning and design tools for GI developed in SSWR Project 5.01.  In using either existing information or developing new data, particular attention will be given to projects that represent the range of conditions where GI will substantially affect ground water.  This range of conditions would ideally represent at least the following areas:  a setting where the performance of a sewer system may be affected; a setting where municipal and/or private water supply wells may be affected; a setting where changes in ground water may affect urban streams with impairments; a setting where ASR is a goal of GI; and a setting where potential effects on contaminated sites exist.  Interactions of ground water affected by GI and contaminants is of special concern in many areas.   Communities are faced with an array of potential sources of contamination that can affect their water supplies. These can result from individual or aggregate effects of releases stemming from sources such as local gas stations, dry cleaners, materials management operations, or contaminated sites. The distribution of the contaminants in ground water can be altered by a number of factors including extreme weather events (droughts or excessive precipitation) and increased water well pumping to meet public/private water demands.  In addition, hydraulic flux resulting from the placement of GI in proximity to these contaminant sources can result in unanticipated movement of contaminants in the ground water.

Focus area 5.02C will also be closely coordinated with other research across Project 5.02. This research is split into two subareas.

*Coastal wetlands use in wastewater management*:  1) Perform an initial state of the science review to assess the extent of the current practices and the possible impact of these practices on coastal wetlands. The review will focus primarily on the risk from excess nutrients but also include an analysis of the potential impacts from other contaminants associated with wastewater (e.g. bacteria, pharmaceuticals, metals, or organics), the constituents of which are to be determined in cooperation with regional and program office partners. 2) Conduct additional retrospective and prospective place-based case studies, focusing on at-risk estuaries and coastal systems.

*Inland wetlands used in stormwater management:*  1) Perform an initial state of the science review to assess the current understanding of the extent and best management practices on inland wetlands. The review will focus on the impacts from phosphorous, organic chemicals and metals that accumulate or are transformed to more toxic forms in wetland soils; and quantifying the benefits of natural GI used in stormwater management. Connections and possible impacts to groundwater must be assessed.  2)

Conduct additional retrospective and prospective place based case studies targeting priority watersheds.

**3. Project Impact**

The Program Office, Regions, States, and other stakeholders need the following information to promote the implementation of GI solutions where appropriate:

- What issues do communities face that GI may help resolve? What type(s) of GI do communities need for various purposes (flood control, cost-effective augmentation of existing infrastructure with sustainable solutions, groundwater recharge) and at what scale?
- What are the barriers to implementation of GI and how can these be addressed?
- What incentives do communities have/need to implement GI?

From a scientific perspective, we expect Focus area 5.02A to provide 1) an understanding of socio-economic drivers for GI implementation, 2) data and demonstration of methods to quantify the performance evolution and long-term costs, benefits, longevity, and effectiveness of GI, 3) information on how to avoid or mitigate potential risks associated with GI implementation, and 4) the potential contribution of GI to community resilience.  Focus area 5.02B will provide new information and knowledge that will be applied by the relevant offices, state partners, tribes, cities, and others to provide the widest possible net environmental benefit from GI.  Focus area 5.02C will provide an analysis of the state of the science and provide a knowledge gap assessment needed to evaluate the potential risks and impacts to wetlands, support monitoring, and improve management guidance to sustain natural wetland systems used for waste- and stormwater efforts, and quantify the benefits of wetlands used in stormwater management.

4. **Project Scope**

The scope for Focus area 5.02A will include the following elements:

a) Framework for selecting study sites by considering types of GI, partner communities and other selection parameters to enable the generalization of results (in coordination with social scientists and modelers) for utilization by a wide range of communities.  We need a balanced portfolio based on community size and development stage (expansion versus retrofits), capacity and funding structures for GI implementation, climate regime, legal frameworks, biophysical characteristics, and surrounding land-use matrices
b) Collection and analysis of performance data, effectiveness, costs, community involvement, social benefits, and lessons learned from study sites, and
c) Framework for community and watershed organization decision-making about GI – what types, where, benefits and costs, economic valuation or trading, business development potential, and consideration of environmental justice (EJ)

Focus area 5.02B will provide scientific synthesis for formulation of guidelines on ground water impacts and interactions; enhanced scientific information on ground water impacts and interactions from existing field sites; and new scientific information on ground water impacts and interactions from new field sites.  In addition, the effort will provide the basis for long-term research on the efficacy of GI as a suite of BMPs for water resources enhancement particularly in arid and semi-arid regions.

Focus area 5.02C will 1) assess the potential risks and impacts to wetlands used for wastewater and as part of stormwater management, 2) develop guidance and risk management strategies for managing these risks and impacts, 3) provide guidance for monitoring wetland health and assessing the success of risk management strategies for wetlands used to manage wastewater and as part of GI stormwater management and 4) quantify the benefits of wetlands used in stormwater management.

5. **Project Structure and Rationale**

Research in Project 5.02 is structured to address the defined objectives of the project and will have the general format including these sub-focus areas:

- 5.02A.1. Classification frameworks for prioritizing selection of and extrapolating results from case studies
- 5.02A.2.  Place-based research and information synthesis to support pre-implementation community and watershed organization decision-making
- 5.02A.3.  Place-based research and information synthesis to predict and assess optimization of natural and constructed GI performance, effectiveness, costs and benefits for communities and watershed organizations to support adaptive management at multiple scales through integration with 3.1 (GI modeling and tools) as applicable
- 5.02A.4. Region 3 RARE project with objective to study the function, efficacy, and appropriate use of  regenerative stormwater conveyance systems as a GI approach to stormwater management
- 5.02A.5. White paper/summary report on the current status of GI for augmenting water resources in arid and semi-arid regions
- 5.02B.1. Comprehensive literature review and interpretation.  In addition to providing a state of the science document, this will provide the basis for draft guidance for OW and OSWER.  The report could be modeled on the Center for Watershed Protection 2001 document on *The Practice of Watershed Protection* which is still being cited for its guidance on GI relative to stormwater management.
- 5.02B.2A. Capitalize on existing GI projects with incomplete ground water data by strategic enhancement of monitoring sites, equipment, sampling regimes, etc.  (With Focus area 3.2.1)
- 5.02B.2B.  Capitalize on new GI projects to demonstrate safe ground water recharge, aquifer storage and recovery, and a systems approach to stormwater management.  (With Focus area 3.2.1)
- 5.02B.3. Integrate new knowledge into the functional attributes of planning and design tools. Test planning and design tools with new groundwater quality and quantity data. (With Project 3.1)
- 5.02C.1A. Perform an initial state of the science review to assess the current practices and impact of wastewater management practices on coastal wetlands.
- 5.02C.1B. Perform an initial state of the science review to assess the current understanding of impact of stormwater management practices on inland wetlands.
- 5.02C.2.  Conduct retrospective and prospective place based case studies.

Focus area 5.02A. Linkages to SSWR 5.01, SHC, CSS, ACE - Coordinate with SHC Theme 2 to inform final ecosystem goods and services (FEGS) for GI.  Coordinate with SHC Theme 4 for assessment of sustainable practices on GI sites.   Demonstrate inventory and calculation of FEGS for GI site-specific research projects. Coordinate with SSWR 4 on water-reuse issues.

Focus area 5.02B will have linkages to: 1) SSWR Topic 3, Watershed Sustainability; SHC Project 3.61, Contaminated Sites; and SHC Project 4.61, Integrated Solutions for Sustainable Communities.

Focus area 5.02C. SSWR Topic 1) Watersheds - wetlands and water quality in a watershed landscape context; SSWR Topic 2) Nutrients – Nutrient management; SHC Theme 3 for assessment of GI sites and consideration of contaminated sites and other environmental releases and their impact on ground water;  SHC 4.61 Integrated Solutions for Sustainable Communities Measure of Success Nitrogen management

## 6. Measure of Success

Under Focus area 5.02A, in an effort to increase adoption of GI when appropriate, we expect to provide guidance on the design and implementation of GI at multiple scales, case studies that can be used as templates for other communities, and an improved understanding of the potential ancillary benefits and human health risks and benefits provided by GI as an alternative to gray infrastructure.  We hope to demonstrate the integration of local GI site monitoring into analysis of performance and function at larger spatial scales.  We also hope to achieve an improved understanding of the potential for negative consequences of GI use, for example, the concentration and retention of PAHs in GI, exposure to pathogens, invasive species, remobilization of soil-bound contamination where GI is considered as an alternative practice, and groundwater contamination.  We hope to understand the differences in how GI should be implemented in areas with water deficits as opposed to water surpluses.

If things go very, very well, we will develop a comprehensive approach for assessing potential costs and benefits of GI implementation built upon a classification framework  that recognizes regional differences in community drivers, capacity and governance structures, and workforce/business development issues, regulations, climate, soils and geology, and human and ecosystem vulnerabilities.  We will also provide a transferable process for communities to routinely assess the effectiveness of GI at multiple scales as part of adaptive approach to integrated watershed management.

Under Focus area 5.02B we expect to work with the Office of Water, Office of Solid Waste and Emergency Response, Regions, and State/Local partners to publish detailed guidelines for application of GI in the settings described above.  These guidelines will include a decision tree or structured decision making as to whether ground water monitoring would be recommended and general recommendations for how to monitor.  Successful implementation of these guidelines will allow for implementation of GI to achieve surface water benefits with either neutral or beneficial effects on groundwater.  Successful implementation of groundwater considerations in the planning and design tools done under Project 5.01 and use of these tools will also be seen as a success for this portion of the project.

Under focus area 5.02C, we expect to support sustainable management and protection of wetland resources while utilizing the biophysical benefits they provide for economical solutions to problems associated with waste- and stormwater management.

## 7.  Stakeholders (outside ORD)

a.  Office of Water (OW),  Office of Wastewater Management (OWM), Office of Solid Waste and Emergency Response (OSWER), Regions

b.   Federal Agencies (United States (US) Geological Survey, US Department of Agriculture Natural Resources Conservation Service, US Department of Interior, US Department of Housing and Urban Development, US Department of Transportation, US Army Corp of Engineers)
c.   State, local, tribal governments
d.   Private consultants, engineering professionals, and companies
e.   Utilities (water supply districts, sewerage districts)
f.   Academic community
g.   Non-governmental Organizations
h.   Economic and business development organizations (e.g., Chambers of Commerce, trade associations, water technology clusters)

Research in this area will meet needs of the OW and OSWER.  OW needs guidelines for avoiding the impact on ground water quality of enhanced infiltration through GI.  OW also needs guidance on the costs and benefits of incorporating GI into aquifer storage and recovery.  OSWER needs guidelines and strategies for avoiding GI impacts on subsurface contamination sites.  Both Offices need guidelines for planning, siting, and managing GI to achieve surface water quality improvements, reduce peak flows, and contribute to landscape diversity without creating unintended consequences for ground water.

## 8.  Output(s)

- *Title:* Advancing the ability of communities and watershed organizations to make informed decisions on whether and how to implement GI
- *Brief Description:* Stakeholders will be provided with guidance and examples demonstrating the effectiveness, costs, benefits, and risks/constraints on use of green infrastructure to treat stormwater and wastewater and recharge aquifers at multiple scales.
- *Delivery Date:* FY19
- *Intended user and audience:* Communities and watershed organizations, utilities, state and tribal governments, Regions, Program Offices, NGOs, private consultants, academia

## 9. Key Products Identified

The key products listed below are examples of potential products.  These will be finalized as specific tasks are developed and delivery dates will adjust accordingly.

- *Title:* Classification frameworks for prioritizing selection of and extrapolating results from case studies
- *Brief Description:* This product develops a tool that allows a systematic method to rank select sites where additional research is to be undertaken and help assure that the projects can be combined with other locations to develop generalized conclusions.  The ranking criteria will include technical elements (e.g., SCM types, soil properties), socioeconomic elements (e.g., governance structure), and pragmatic considerations (e.g., community ability to provide funding, previous EPA investments).  The second product will provide a framework for organizing information from pilot projects.
- *Delivery Date:* FY16

- *Intended user and audience:* An initial product related to prioritization of pilot projects would be developed by ORD in coordination with EPA Regions and Program Offices for internal EPA use in focusing research. This would be used as a starting point for a second product: an organizing framework for consolidating information from pilot projects and community/watershed organization partnerships to show how stakeholders could extrapolate results to other settings.

- *Title:* Place-based case studies and information synthesis to support pre-implementation community and watershed organization decision-making regarding natural and constructed GI implementation/restoration and maintenance/conservation including incentives, economic, financial and legal strategies
- *Brief Description:* This product will support pre-implementation planning efforts for GI and help to address barriers and incentives for GI acceptance. Ongoing related efforts include case studies with communities to test the Watershed Management Optimization Support Tool, and neighborhood partnerships developed as part of the NCER cooperative agreements supporting work in the Philadelphia area. There also may be opportunities to mine information from existing grant programs relevant to incentives for GI implementation.
- *Delivery Date:* FY18
- *Intended user and audience:* External: Municipalities, Watershed organizations and associated NGOs, with outreach through EPA Regions, Program Offices, States and Tribes, and NGOs; Internal: ORD tool developers requiring opportunities to test decision-support tools

- *Title:* Place-based research and information synthesis to predict and assess optimization of natural and constructed GI performance, effectiveness, costs and benefits for communities and watershed organizations to support adaptive management at multiple scales
- *Brief Description:* There are opportunities to build upon existing community partnerships as well as create new ones in consultation with the Regions and Program Offices. Existing community partnerships include work with Austin, TX; Boston, MA; Camden, NJ; Cincinnati, OH; Clarksburg, MD; Cleveland, OH; Detroit, MI; Edison, NJ; Louisville, KY; Omaha, NE; Philadelphia, PA; Santa Monica, CA; and the Sustainable Knowledge Corridor (Chicopee, Holyoke, Springfield, MA + Hartford, CT) - a federal partnership priority area. Watershed-scale benefits of existing natural and constructed GI are being evaluated in EPA Region 1 (including Regional/community partnerships in the Taunton River, MA watershed), the Delaware River watershed (R2/R3, including the Philadelphia area), Chesapeake Bay watershed (R3), Austin, TX metropolitan area, and the state of California. In addition, extramural funding has already been allocated to support work with Philadelphia through the NCER grant program and in cooperation with the DoD through the Net Zero program.
- *Delivery Date:* FY19
- *Intended user and audience:* External: Municipalities, Watershed organizations and associated NGOs, with outreach through EPA Regions, Program Offices, States and Tribes, and NGOs; Internal: ORD modelers, tool developers requiring opportunities to refine and test tools/models in partnership with communities and watershed organization

- *Title:* State of the Science for Groundwater Management in Green Infrastructure Projects
- *Brief Description:* Based on current state of knowledge and modeled after The Practice of Watershed Protection
- *Delivery Date*: FY17
- *Intended user and audience: Office of Water, Sta*tes, Municipalities

- *Title:*  Effects of Green Infrastructure on ground water
- *Brief Description:*  Results of new research focused on demonstration projects where GI has the potential for effects on Municipal water supply
- *Delivery Date*: FY19
- *Intended user and audience:*  Office of Water, States, Municipalities

- *Title*:  Impact of wastewater management practices on coastal and inland wetlands.
- *Brief Description*: State of the science review to assess the current practices and impact of wastewater management practices on coastal wetlands.
- *Delivery Date:* FY19
- *Intended user and audience*:  Office of Water, States, Municipalities

- *Title*:  Guidance for monitoring the impact of wastewater/stormwater management practices on coastal wetlands and inland wetlands.
- *Brief Description*: Regional focused place based studies to evaluate key metrics and develop guidance for monitoring impacts of wastewater/stormwater management practices on coastal and inland wetlands.
- *Delivery Date:* FY19
- *Intended user and audience*:  Office of Water, States, Municipalities

## 13. Assumptions and Constraints

Constraints include the lag time associated with developing community partnerships prior to implementation of GI and (for new field-based work), the need to work with communities before they start installing GI.  We assume that the work under Project 3.2 will be coordinated with SHC projects including 3.61 and 4.61 to foster community involvement.