

NERRS Science Collaborative Progress Report

Reporting Period: March 1 – August 31, 2014

Project Title: Implementing Credits and Incentives for Innovative Stormwater Management

Principal Investigator(s): Keely Davidson-Bennett

Project start date: November 25, 2011

Report compiled by: Keely Davidson-Bennett

Contributing team members and their role in the project:

- *Project Coordination and Fiscal Agent:* Keely Davidson-Bennett; Chagrin River Watershed Partners, Inc.
- *Collaboration Lead:* Frank Lopez, Old Woman Creek National Estuarine Research Reserve with Ona Ferguson; Consensus Building Institute providing Collaboration Technical Assistance
- *Applied Science Investigator:* Jay D. Dorsey; ODNR, Division of Soil and Water Resources
- *Additional project team members:*
 - Heather Elmer and Kristen Buccier; Chagrin River Watershed Partners, Inc.
 - Breann M. Hohman and Crystal Dymond; Erie Soil and Water Conservation District
 - Cheryl Wolfe-Cragin; Old Woman Creek National Estuarine Research Reserve
 - Ryan Winston; North Carolina State University

A. Progress overview:

The goal of this project is to promote the implementation of Low Impact Development (LID) and other innovative stormwater systems in the Ohio Lake Erie Basin by addressing barriers to implementation, gathering data on local stormwater control measures (SCMs), building capacity of local stormwater professionals, and developing tools to effectively guide communities and consultants toward more sustainable stormwater management. This project will also highlight the role of LID in adapting to changes in rainfall volumes and intensities due to climate change. The project team includes the Chagrin River Watershed Partners (CRWP), Old Woman Creek National Estuarine Research Reserve (OWC NERR), Ohio Department of Natural Resources Division of Soil and Water Resources (ODNR-DSWR), Erie Soil and Water Conservation District (Erie SWCD), North Carolina State University (NCSU), and the Consensus Building Institute (CBI).

Installation of the bioretention cell at Ursuline College occurred this spring, and the permeable pavement parking lot at Old Woman Creek NERR was constructed this summer. We will monitor stormwater control measures at 6 sites through 2014.

We held two CLG meetings in May and August. We have received positive feedback from the project team and the Collaborative Learning Group (CLG) participants. At a recent CLG meeting, many participants stated that they found the stormwater monitoring data collected through this project very useful. Furthermore, one participant said that our project has greatly assisted a faculty member at the University of Toledo in the development of a stormwater monitoring program. Design engineers and site representatives expressed pride in the permeable pavement installations supported by this project.

A DRAINMOD model has been built and calibrated for the Perkins Township site using 2013 data. It will be validated using 2014 data. NCSU will be building, calibrating, and validating site scale DRAINMOD models for 3 other permeable pavement and 3 bioretention installations monitored through this project. In collaboration with the University of Tennessee, these models will also be used to predict future performance of bioretention and permeable pavement under climate change scenarios. The NSC team presented on monitoring results, lessons learned on design and construction of permeable pavement and bioretention cells, and SWMM modeling results at the Ohio Stormwater Conference in June 2014.

B. Working with Intended Users:

Our project team held two CLG meetings this reporting period. At the May meeting, participants toured the bioretention cell at Ursuline College during its construction. CLG feedback resulted in a last minute design modification wherein multiple curb cuts were replaced by one wider inlet point with rock protection to better account for water flow patterns coming from the existing asphalt parking lot. Project team members presented the redesign of Old Woman Creek parking lot retrofit from porous asphalt to permeable pavers and rainwater harvesting due to locally high costs associated with installation of porous asphalt at very small scales. CLG members discussed experience and regulations regarding using cistern water for non-potable indoor use. Cost information for SCMs installed through this project was shared at this meeting.

At the CLG meeting on August 20, 2014, participants toured the newly completed permeable interlocking concrete pavement and underground cistern installation at Old Woman Creek NERR. The meeting included sharing monitoring results from permeable pavement installations at Perkins Township, Willoughby Hills, and Orange Village and bioretention at Holden Arboretum and Orange Village. Additionally, ODNR-DSWR presented further analyses on peak flow reduction based on SWMM model outputs and NCSU presented on the Perkins Township pervious concrete DRAINMOD model. We asked CLG members to provide feedback on potential trainings and tools. CLG members expressed interest in trainings for designers on permeable pavement and trainings for contractors on bioretention and permeable pavement. CLG members were most interested in trainings on permeable pavement since recent workshops in northeast Ohio have focused on bioretention.

The project team had intended that the August 20, 2014 CLG meeting would be the last, with the team transitioning from CLG sessions to gather input on research decisions to trainings and dissemination of project results in the final year of the project. However, CLG members expressed a desire to see project results before they were shared with a larger audience, so we will have our final CLG meeting in April 2015 to share those results. This meeting may serve as a pilot for future training related to project results targeting state and federal regulators, stormwater utilities and other stormwater professionals. Additionally some CLG members expressed interest in serving on a work group to continue discussions of what is needed in terms of additional performance and policy research to develop credits for LID runoff reduction in Ohio. More detail, including full presentations and meeting summaries will be posted online at <http://www.crowp.org/index.php/projects/research-projects/nerrs-science-collaborative>.

Attendance at CLG meetings continues to be strong with 23 participants at the May meeting and 22 at the August meeting. Of CLG and project team members responding to a survey after the May 2014 meeting:

- 100% said participating in the project is a good use of their time.
- 83% said participating has increased their knowledge of BMP performance “a lot” or “a great deal”
- 100% have learned something new that they intend to apply in their future work or decisions.

At our August meeting, all CLG participants had the opportunity to share their reflections on the project. Many expressed appreciation for the project. Participant comments included:

- “It’s my first meeting, but I’ve had some of the information in my hands for the past year, and we’re kind of doing the same thing at UT with some of our local projects, and we haven’t had to reinvent the wheel because what you guys have been doing, so it’s been a real big help to us.”
- “Just for everything to fall in place, our project at Perkins Township to come online, I know the Trustees were very supportive of doing the project, with doing alternative stormwater management, and then to line up with the monitoring, they’re really proud of that, and it’s been really good for the Township to see that

happen. Not only the elected officials, but the staff. They're really proud of what went on. . . What's coming out of this group is definitely the result of good partnerships, and being able to get the right people in the room, and get different perspectives, and agree to disagree sometimes. It's been a really good project and always interesting to come to these meetings and listen to all the perspectives."

- "So to see some of [the data] coming out, and the numbers that come out look pretty good, it gives me a better feeling that if we have to make people do some of these, and to prove out that they work, is a lot easier than saying, well, it works out on the east coast somewhere in the light soils, but what we have around here, we don't know, but you got to put it in anyway. So, hopefully this won't stop at this point. We can do this on other practices to ensure that they also work in this area. What kind of modifications do we need to do? We'll know that if we continue to do these studies. So, it's been very informative, and I appreciate being a part of it."

C. Progress on project objectives for this reporting period:

Objective 1: Engage stormwater professionals in a collaborative process to identify and remove regulatory and technical barriers to implementation of LID in Ohio.

1. Completed activities and products:
 - a. Held two collaborative learning group (CLG) meetings on May 7 and August 20, 2014.
 - b. Documented lessons learned and ideas from CLG meetings in summaries, which are widely shared, and in our private project notes on lessons learned housed on Basecamp.
 - c. Conducted survey to gather feedback on the project from CLG members, project team, contractors, and partners.
 - d. Gathered CLG input on potential trainings and tools that could result from this project.

Objective 2: Quantify BMP specific and site level hydrology for local soil and climate characteristics.

1. Completed construction and installed monitoring equipment at:
 - a. Ursuline College: Bioretention cell to treat runoff from existing parking lot on campus in Pepper Pike.
 - b. Old Woman Creek NERR: permeable interlocking concrete pavement (PICP) and rainwater harvesting system.
2. Continued monitoring hydrology at two permeable concrete applications in Perkins Township, Erie County; two permeable interlocking concrete pavement retrofits in Willoughby Hills; permeable interlocking concrete pavement and bioretention at Orange Village; two bioretention cells at the Holden Arboretum (Kirtland).
 - a. 72 storms have been monitored at Perkins Township
 - b. 58 storms have been monitored at the Holden Arboretum
 - c. 38-39 storms have been monitored at Willoughby Hills and Orange Village
 - d. 17 storms have been monitored at Ursuline College
 - e. 5 storms have been monitored at Old Woman Creek NERR
 - f. All sites have a weather station to monitor climatic parameters, internal water level sensors within each SCM (except Orange Village), and outlet weir structures to monitor outflow from each device. In all cases, inflow to each SCM is being calculated using measured rainfall and catchment characteristics.
 - g. Data analysis for all sites is underway.

Over the monitoring period, the permeable pavement applications at Perkins Township, Willoughby Hills, and Orange Village have reduced runoff by 20 - 50%. Data from water table wells indicate that 7.5 - 14% of rainfall volumes are infiltrating into the subgrade. At all three sites, permeable pavement effectively reduces median peak flow rate by at least 70%. Observations of drainage rates suggest that underdrains limit outflow to 0.1 - 0.15 cfs, which is the main

factor that causes peak flow mitigation. For infrequent return interval storms, peak inflow was nearly equal to that of peak outflow.

The monitored bioretention cells are also effectively reducing peak flow and outflow volume. The curve numbers for the bioretention cells at Holden are 83 and 87. These compare well against the expected curve number of 90.5 for the untreated watersheds. After normalizing for watershed area, there was no difference in volume reduction between the cell planted with woody vegetation and the one with herbaceous vegetation after the first nine months of growth.

3. Investigated permeable pavement maintenance needs by conducting quarterly surface infiltration testing.
 - a. PICP at Willoughby Hills clogged in July to the point where surface runoff occurred into the catch basin. In August, the parking lot was vacuumed which successfully restored its infiltration capacity.
 - b. Infiltration tests at Orange Village and Perkins Township indicate that maintenance is not yet needed at these sites.
4. Monitored water quality from PICP at Willoughby Hills and Old Woman Creek and bioretention at Ursuline College.
 - a. Twelve paired water quality samples have been collected from the Willoughby Hills permeable pavement applications (large and small bays) as well as a control, untreated asphalt location. To this point, metals, nutrient, and sediment data appear to not follow previously published water quality improvements for permeable pavement. We have run sample duplicates at this site to ensure that laboratory data are reliable.
 - b. Three paired samples have been collected at Ursuline College. Only one sample event's data has been received back from the lab, so data will be presented during the next project update.
 - c. Two water quality sampling events have occurred at Old Woman Creek. Data have not yet been received from the laboratory at this time.

Objective 3: Simultaneously model treatment of water quality and quantity volumes to meet local and state requirements.

During this semi-annual period CRWP and ODNR continued to work with modeling subcontractor Cardno JFNew on USEPA Storm Water Management Model (SWMM) models and contracted with NCSU for DRAINMOD modeling of bioretention and permeable pavement. DRAINMOD is an agricultural drainage model that has already been used to successfully model the performance of one permeable pavement application in North Carolina as well as that in Perkins Township, OH. In addition, NCSU will coordinate with University of Tennessee (UT) Civil Engineering Department and the Oak Ridge Laboratory on development of projected climate change scenarios for the two Lake Erie subwatersheds of interest.

To date, Cardno JFNew has completed the following:

- a. Developed climate input files for SWMM from Cleveland Hopkins Airport data.
- b. Using SWMM, completed event-based sensitivity analyses for bioretention, dry detention, filter strips, grass swales, green roofs, permeable pavement, soil renovation, and underground storage, documenting the impact of key design parameters on runoff volume reduction.
- c. Used SWMM to model annual performance of bioretention, dry detention, filter strips, grass swales, green roofs, permeable pavement, and underground storage using continuous time series climate data for an

average year (1979) and a wet year (2011), evaluating the sensitivity of key design parameters on annual volume reduction.

- d. Drafted a technical memorandum summarizing model inputs and results. This document is currently being revised and a final version is expected September 2.

ODNR has begun using the volume reduction data generated by Cardno JFNew to develop and evaluate a crediting mechanism for the Critical Storm Method (CSM) peak discharge control guidance. To date, ODNR has quantified and evaluated peak discharge credits for permeable pavement, underground detention, and grass filter strips. An overview of this analysis was presented at the recent CLG meeting. Over the next six months, ODNR will complete quantification and evaluation of the remaining practices, and begin to develop the framework through which LID practices can receive appropriate credit toward meeting water quality volume (WQv) and CSM requirements. This should allow us to have the crediting guidance and tools drafted by project completion.

Objective 4: Adapt models to include rainfall runoff scenarios anticipated as a result of climate change and characterize climate change adaptation functions of LID BMPs.

Modeling subcontractor NCSU has established a relationship with UT professors Dr. Joshua Fu and Dr. Jon Hathaway through which UT will provide dynamically downscaled climate data projections for mid-century (2050s). UT will provide continuous precipitation data sets for both moderate and intensive climate change scenarios. Future climate scenarios are based on representative concentration pathways (RCPs) for greenhouse gas emission over the next century. The UT data include both moderate (RCP 4.5) and severe (RCP 8.5) climate change scenarios. These data are currently being reformatted to allow for input into DRAINMOD and SWMM models. This will help in quantifying climate change adaptation functions of bioretention and permeable pavement. Climate change data sets will be delivered to the project team by end of 2014, and modeling with projected data will be completed once the permeable pavement and bioretention models have been calibrated with monitored data.

Objective 5: Develop and provide training and technical assistance materials to build capacity of stormwater professionals and communities to implement LID approaches.

1. Provide informal training to the CLG:
 - a. We presented information on SCM costs, performance, and maintenance to the CLG at the May and August meetings.
 - b. A report entitled *Case Studies of LID Implementation and Performance* featuring design, construction and performance information for four project sites developed by University of New Hampshire TIDES intern Will Brown and the project team was circulated for CLG comment and a final first edition of the report distributed at the August CLG meeting. TIDES intern Rebecca Jacobson is developing additional case studies focused on Ursuline College and Old Woman Creek NERR and will update the report with 2014 data.
2. Provide formal training and technical assistance to stormwater professionals: Project team members participated in planning training sessions sponsored by Old Woman Creek and presented at a professional conference.
 - a. Project team members presented project findings at the Ohio Stormwater Conference held in Akron in June 2014.
 - b. Old Woman Creek is supporting two inspection and maintenance workshops on stormwater control measures presented by Bill Hunt and Bill Lord of NCSU in October.
3. Model regulations that remove regulatory barriers to LID:
 - a. CRWP continues working with Cleveland State University and Lake County Planning and Community Development to update its model Conservation Development code.
 - b. Once the municipal separate storm sewer system (MS4) permit is issued (comments on draft were due January 29, 2014), CRWP will update model codes for erosion and sediment control and stormwater management. This permit may include requirements to:

- Update to Stormwater and Erosion and Sediment Control codes to current Construction General Permit standards within 2 years.
- Update Storm Water Management Program within 2 years.
- Use of TMDL recommendations in BMP selection.

CRWP has been working with NOACA and Ohio EPA to develop an approach to assist communities in updating their local codes and Stormwater Management Plans to include TMDL recommendations.

4. Provide technical assistance on the adoption and implementation of local codes and project recommendations.
 - a. Currently Erie County's Phase II Communities are working with the Erie SWCD to update and revise the County's Stormwater Regulations to include enforcement and regulation language for compliance under the OEPA Small MS4 permit. Erie SWCD staff members are working with the County Prosecutor's office to determine enforcement procedures and have secured a draft that is under review. Once the draft is more substantial it will be presented to the local township trustees and zoning officials during a comment period to ensure local acceptance and practicality.
 - b. The City of Sandusky adopted stormwater management and erosion and sediment control codes on July 14, 2014.
 - c. Both CRWP and Erie SWCD have assisted in increasing the prevalence of LID stormwater practices by helping communities apply for Ohio EPA Storm Water Improvement Fund (SWIF) grants. The following projects were funded this project period:
 - i. In Erie County, the City of Sandusky will install pervious concrete at Jackson St. public parking lot and the City of Vermilion will install pervious pavers at the Showe Park parking lot.
 - ii. Among CRWP Member communities, Mentor will install a bioretention cell and permeable pavers at Wildwood Cultural Center, Woodmere will install a rainwater harvesting system for vehicle washing and permeable pavers at its service facility, and Mayfield Village will install permeable pavement at its civic center.

5. Support development of Ohio specific guidance on design, construction, cost, operation and maintenance of BMPs:
 - a. Informed by NSC project activities and results, ODNR updated (10-21-13) bioretention guidance in the Rainwater and Land Development (RLD) Manual. Subsequent to this update, the project team has – through design and construction of the Ursuline bioretention cell and feedback from presentations on the new specification - identified a few minor tweaks to further improve the RLD guidance.

What data did you collect?

- Water quantity monitoring data at Perkins Township, Willoughby Hills, Orange Village, Holden Arboretum, Ursuline College, and Old Woman Creek
- Water quality data at Willoughby Hills, Ursuline College, and Old Woman Creek
- Permeable pavement maintenance data at Willoughby Hills, Orange Village, Old Woman Creek, and Perkins Township
- CLG input on potential trainings and tools

Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?

Water quality results at Willoughby Hills have been confusing and inconsistent with other research on pollutant removal by permeable pavement. Control samples have had lower pollutant concentrations than treated samples. We thought that this disparity could be because control samples were not representative. We noticed sediment was settling on the asphalt before it reached the catch basin. We filled a depression in the asphalt to try to get a more

representative sample, but this has appeared to have no effect. We also are running a duplicate set of samples at another lab to compare results.

Have there been any unanticipated challenges, opportunities, or lessons learned?

This project has generated significant information needed to credit LID stormwater control measures towards the state-level WQv requirement and local peak discharge requirements in Ohio. Our monitoring and modeling data demonstrate that bioretention and permeable pavement significantly reduce runoff volumes and peak flows. The monitoring and modeling results for our BMPs located in clayey soils enhances an already robust national database on bioretention and permeable pavement performance. We concentrated our monitoring efforts on these two SCMs for several reasons: (1) they already were the most commonly used LID SCMs in Ohio; (2) several new installations of bioretention and permeable pavement were in the planning stages at the time our team was looking for SCMs to monitor; (3) the CLG expressed interest in them; (4) the performance of these SCMs on poor soils like those that predominate through coastal Ohio was very limited; and (5) if performance results were consistent with studies from other states it would facilitate using those results in Ohio. However, focusing the monitoring on permeable pavement and bioretention means we have a much bigger challenge validating model results for dry extended detention basins, grass filter strips, and grass swales, the other SCMs considered high priority by the CLG. We have begun discussions with partners within and outside of the CLG on where and how to monitor these other commonly used (and largely uncredited) SCMs, and are looking for funding to continue our monitoring efforts. Through the end of the NSC grant period we will be reviewing the limited volume reduction research available on these practices to help verify their comparatively limited volume reduction performance.

Because of the limited calibration and validation data, initial engineering guidance and tools for several practices will be conservative. However, the guidance and tools will be updated as additional data become available. Additionally, translating our project results into local stormwater regulations will require investigating policy as well as scientific processes and implications and will likely be a process that continues beyond the end of this grant.

The affiliation of our lead modeling consultant with Cardno JFNew has changed. Cardno JFNew is subcontracting with the new employer, GEI consultants, for completion of a SWMM modeling report and development of site based models. CRWP has requested a copy of this agreement.

What are your plans for meeting project objectives for the next six months?

Objective 1:

1. Final CLG results meeting – April 2014
2. Produce a project update to CLG members and others interested in the project between meetings.
3. Update project case studies for Perkins, Willoughby Hills, Holden Arboretum, and Orange Village with additional monitoring data.
4. Continue to mentor a University of New Hampshire TIDES intern.
5. Produce Ursuline College and Old Woman Creek NERR case studies with input from CLG members, the project team, and others.
6. Provide informal training on stormwater monitoring equipment, protocols, and data management for CLG members, project partners and others.

Objective 2:

1. Continue monitoring hydrology at all six sites through November 2014.
2. Analysis of monitoring data from all sites will be completed January 2015.

Objective 3:

1. Validate Perkins Township DRAINMOD model using 2014 data.
2. Build, calibrate, and validate DRAINMOD models of Willoughby Hills, Ursuline, and Holden Arboretum.
3. Develop and calibrate SWMM models of Perkins, Willoughby Hills, OWC NERR, Ursuline, and Holden Arboretum.
4. Complete analysis of Critical Storm Method credits for nine LID SCMs based on monitoring data and completed SWMM volume reduction estimates.

Objective 4:

1. Format future climate data for Ohio from University of Tennessee for use in models.
2. Begin using future climate data in DRAINMOD and SWMM to predict future performance of these stormwater control measures.

Objective 5:

1. Begin developing training on permeable pavement for designers and/or installers.
2. Prepare to share results with Ohio stormwater professionals.
3. Update CRWP model codes for Conservation Development, Erosion and Sediment Control, Comprehensive Stormwater Management.
4. Provide technical assistance on the adoption and implementation of local codes and project recommendations.
5. Begin developing and pilot testing training content and materials based on project results.
6. Present project results at 2015 International LID Conference in Houston, TX and other national and Ohio-based conferences.

- D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.**

The case study document produced with assistance from Will Brown, the TIDES intern who worked with our project last year, may be useful to other NERRS. The City of Cleveland intends to use this document as part of a stormwater operation and maintenance training series for its employees. This document is available at our project website.

CLG presentations, meeting summaries, articles, and other project information are available online:

- CRWP website at <http://www.crw.org/index.php/projects/research-projects/nerrs-science-collaborative>
- SWCD Summer 2014 Newsletter at <http://www.eriecounty.oh.gov/departments-and-agencies/environmental-resources/erie-soil-and-water-conservation-district/general-information/newsletters/>

- E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.**

None