Pennsylvania Stormwater Management Symposium
Stormwater from the Ground Up

2013 Symposium Program Guide

October 17 – 18, 2013
www.villanova.edu/vusp

Robert G. Traver, Ph.D., PE, D. WRE, F.EWRI, Symposium Chair
Director, Villanova Urban Stormwater Partnership
Thanks to Our Sponsors

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Wine and Cheese

Thursday Lunch

Friday Refreshment

Name Badges

Tour A/ VUSP

Tour D/ Western Suburbs
Thanks to Our Vendors
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Philadelphia PWD Water Department

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Obrien & Gere

Pohlig Engineering

Tetra Tech

Manko Gold Katcher Fox LLP

Van note - harvey

Geosyntec Consultants

AMEC

Gannett Fleming

CH2M Hill
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**Editor**

Ms. Sonali Joshi, MS, MA, EIT
Engineering Operations Manager
Villanova Center for the Advancement of Sustainability in Engineering
www.villanova.edu/vcase
The purpose of the symposium is to advance the knowledge and understanding of sustainable stormwater management for those dealing in all aspects of planning, design, implementation and regulatory compliance.

A workshop for non-engineers will be held in conjunction with the symposium. Participants are expected to include Engineers, Planners, Water Resource Professionals, Regional, State and Local Government Representatives, Land Development Professionals, and Watershed and Conservation Groups. This is the seventh symposium on stormwater issues that has been held at Villanova.
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<td><strong>Registration - Refreshments</strong></td>
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<tr>
<td>9:00 AM</td>
<td>Technical Session 1a: Stormwater Control Measures - The Importance of Soils and Infiltration -1</td>
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<tr>
<td>9:00 AM</td>
<td>Technical Session 1b: Stormwater Control Measures - Permeable Pavements</td>
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<td>9:00 AM</td>
<td>Technical Session 1c: Regional Approaches -1</td>
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<tr>
<td>10:30 AM</td>
<td><strong>Break - Vendor Area</strong></td>
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<td>10:50 AM</td>
<td><strong>Plenary Session</strong></td>
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<tr>
<td>10:50 AM</td>
<td>Robert G. Traver, Ph.D., PE, D.WRE: Symposium Chair; Director, VCASE and VUSP; Professor, VU</td>
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<tr>
<td>10:50 AM</td>
<td>E. Christopher Abruzzo: Secretary, Pennsylvania Department of Environmental Protection</td>
</tr>
<tr>
<td>10:50 AM</td>
<td>John Capacasa: Director, Water Protection Division, USEPA Region III</td>
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<tr>
<td>10:50 AM</td>
<td>Dominique Lueckenhoff: Associate Director, Water Protection Division</td>
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<td>11:30 AM</td>
<td><strong>PADEP Perspectives - Current Issues for Stormwater Management in Pennsylvania</strong></td>
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<td>11:30 AM</td>
<td>Lee McDonnell: Director of PADEP's Bureau of Point and Non-Point Source Management</td>
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<td>Ken Murin: Chief, Bureau of Waterways Engineering and Wetlands</td>
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<td>12:30 PM</td>
<td><strong>Lunch - Vendor Area</strong></td>
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<td>1:30 PM</td>
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<td>1:30 PM</td>
<td>Technical Session - 2b: Stormwater Control Measures - The Importance of Vegetation</td>
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<td>1:30 PM</td>
<td>Technical Session - 2c: Building Partnerships - Studies in Collaboration</td>
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<td>Technical Session - 3a: Stormwater Control Measures- Innovative Tools</td>
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<td>3:30 PM</td>
<td>Technical Session - 3b: Regional Approaches -2</td>
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<tr>
<td>3:30 PM</td>
<td>Technical Session - 3c: Innovative Site Design</td>
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<td>5:00 PM</td>
<td><strong>Poster Session / Reception</strong></td>
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<td>Time</td>
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<td>Technical Session 4a: Approaches to Municipal Stormwater Financing – What’s Old is New (at least in PA)</td>
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<td>Technical Session 4b: Building Partnerships - Studies in Collaboration - 2</td>
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<td>Technical Session 4c: Stormwater Control Measures - Water Quality</td>
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<td>Technical Session 5a: The Triple P’s of Stormwater: Policy, Planning and Procedures</td>
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<td>Technical Session 5b: Monitoring and Modeling Approaches - 2</td>
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<td>Technical Session 5c: Stormwater Control Measures - The Importance of Soils and Infiltration - 2</td>
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<tr>
<td>12:00 PM</td>
<td>Optional Tours</td>
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<tr>
<td></td>
<td>A - Villanova University SCM Research and Demonstration Park</td>
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<td></td>
<td>B - Philadelphia Water Department - Reinventing the Neighborhood</td>
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<tr>
<td></td>
<td>C - Philadelphia Water Dept. - What’s Happening in the Wissahickon Watershed?</td>
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<td>D - Good, Bad, and Ugly – A Tour of the Western Philadelphia Suburbs Stormwater Facilities</td>
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<td>4:30 PM</td>
<td>End of Tours</td>
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<td>Note: All tours do not end at the same time</td>
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## Concurrent Technical Session I – October 17th

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<tr>
<th>Abstract ID</th>
<th>Title</th>
<th>Presenter</th>
<th>Affiliation</th>
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<tr>
<td>1a</td>
<td><strong>Stormwater Control Measures - The Importance of Soils and Infiltration -1</strong></td>
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<tr>
<td>1a1</td>
<td>Stormwater Infiltration Testing at Depth</td>
<td>Clay Emerson, PhD, PE, CFM</td>
<td>Princeton Hydro</td>
<td>C 001</td>
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<tr>
<td>1a2</td>
<td>Urban Soils - One Size Does NOT Fit All</td>
<td>April M Barkasi, PE LEED AP</td>
<td>CEDARVILLE Engineering Group, LLC</td>
<td>C 001</td>
</tr>
<tr>
<td>1a3</td>
<td>The Role of Urban Trees in Managing Stormwater</td>
<td>Vincent J. Cotrone</td>
<td>Penn State University - Extension</td>
<td>C 001</td>
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<tr>
<td>1a4</td>
<td>State of the Practice of Soil Mixes used in Rain Gardens</td>
<td>Andrea Welker, Ph.D., P.E.</td>
<td>VUSP</td>
<td>C 001</td>
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<tr>
<td>1b</td>
<td><strong>Stormwater Control Measures - Permeable Pavements</strong></td>
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<tr>
<td>1b1</td>
<td>Water Quality Response from Permeable Pavement</td>
<td>Robert A. Brown, Ph.D., EIT</td>
<td>ORISE Postdoc at U.S. EPA</td>
<td>T 215</td>
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<tr>
<td>1b2</td>
<td>Surface Infiltration Monitoring of Permeable Interlocking Concrete Pavement</td>
<td>Kevin Earley, PG</td>
<td>Nicolock Paving Stones</td>
<td>T 215</td>
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<tr>
<td>1b3</td>
<td>Water Quality Improvements with Permeable Pavement</td>
<td>Glenn Herold, P.Eng.</td>
<td>Oldcastle Architectural Technical Director, Interlocking Concrete Pavement Institute</td>
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<td>1b4</td>
<td>Industry Guidelines for Permeable Interlocking Concrete Pavement</td>
<td>David R. Smith</td>
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<tr>
<td>1c</td>
<td><strong>Regional Approaches - I</strong></td>
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<tr>
<td>1c1</td>
<td>Stormwater Management: A Framework for Site Design</td>
<td>Rachel Ahern</td>
<td>CHPlanning Ltd</td>
<td>C 205</td>
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<tr>
<td>1c2</td>
<td>PWD’s systematic watershed-wide approach to Stormwater Management</td>
<td>Jeffrey Featherstone, PhD</td>
<td>Temple's Center for Sustainable Communities</td>
<td>C 205</td>
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<tr>
<td>1c3</td>
<td>Restoring the Health of Panther Hollow</td>
<td>Kate Evasic</td>
<td>Meliora Design</td>
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<tr>
<td>1c4</td>
<td>PWD Cobbs Creek Restoration &amp; Green Infrastructure</td>
<td>Thomas A. Graupensperger</td>
<td>Dewberry</td>
<td>C 205</td>
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</table>

**Moderators**

**1a** - Scott Brown, PE, D. WRE. Pennoni Associates, Inc.  
**1b** - Andrea Braga PE, CPESC. Geosyntec Consultants  
**1c** - Don Coleman, V.P. O'Brien & Gere
### Concurrent Technical Session II – October 17th

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<tr>
<td>2a- Monitoring and Modeling Approaches - 1</td>
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<tr>
<td>2a1</td>
<td>When it Rains it Stores: PWD’s SCM Monitoring</td>
<td>Stephen White</td>
<td>Philadelphia Water Department</td>
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<td>2a2</td>
<td>Mill Creek: A Long-Term Stream Study</td>
<td>Patrick Gardner</td>
<td>Lower Merion Conservancy</td>
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<tr>
<td>2a3</td>
<td>A Proposal for Measuring the Effects of Greening a 10 Acres Commercial Site</td>
<td>William Heasom PE, M.ASCE, LEED AP</td>
<td>Down to Earth Design Foundation</td>
<td>C 001</td>
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<td>2a4</td>
<td>Making Decisions in Uncertainty - Monte Carlo Analysis of Health Risk Associated with Recreational Exposure to Combined Sewer Overflow</td>
<td>Nathan Boon, M.A., PMP, GISP</td>
<td>The George Washington University</td>
<td>C 001</td>
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<td>2b- Stormwater Control Measures - The Importance of Vegetation</td>
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<td>2b1</td>
<td>A comparative analysis of evapotranspiration rates</td>
<td>Kimberly DiGiovanni, PhD, EIT</td>
<td>Drexel University</td>
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<tr>
<td>2b2</td>
<td>Rainfall Interception by Four Common Shrub Species</td>
<td>Walter Yerk</td>
<td>Drexel University</td>
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<tr>
<td>2b3</td>
<td>How Best to Take Credit for ET in Green Roofs – A Roundtable Discussion (40 Min)</td>
<td>Bridget Wadzuk, Ph.D.</td>
<td>VUSP</td>
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<td>2c- Building Partnerships - Studies in Collaboration</td>
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<td>2c1</td>
<td>P3s for Urban Stormwater Retrofits</td>
<td>Jon Capacasa, Director, Water Protection Division</td>
<td>US EPA Region 3</td>
<td>C 205</td>
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<tr>
<td>2c2</td>
<td>Building Blue Communities</td>
<td>Jenni E. Woodworth, P.E., CPSWQ</td>
<td>A.D. Marble &amp; Company</td>
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<tr>
<td>2c3</td>
<td>Door-to-Door Stormwater Management: RainScapes</td>
<td>Ann English, RLA, LEED AP BD+C</td>
<td>Montgomery County, MD DEP</td>
<td>C 205</td>
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<tr>
<td>2c4</td>
<td>Implementing LID Drainage Manual, Lessons Learned</td>
<td>James Michel</td>
<td>Town of Greenwich, CT</td>
<td>C 205</td>
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**Moderators**

- **2a** - Susan Giannantonio, PE. Gannett Fleming Inc.
- **2b** - Ken Murin, Chief, Bureau of Waterways Engineering & Wetlands,
- **2c** - Jeremy Colello, PE. Pennoni Associates
## Concurrent Technical Session III – October 17th

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<tr>
<td>3a- Stormwater Control Measures- Innovative Tools</td>
<td>VUSP Green Infrastructure Research (40 Min)</td>
<td>VUSP Faculty</td>
<td>VUSP</td>
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<td>3a1</td>
<td>VUSP Green Infrastructure Research (40 Min)</td>
<td>VUSP Faculty</td>
<td>VUSP</td>
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<td>3a3</td>
<td>Making Green Work, and Work Harder</td>
<td>Andrea Braga</td>
<td>Geosyntec Consultants</td>
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<tr>
<td>3a4</td>
<td>ALERT: AMEC Load Estimation and Reduction Tracking</td>
<td>Thomas Williams</td>
<td>AMEC Environment &amp; Infrastructure</td>
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<tr>
<td>3b- Regional Approaches -2</td>
<td>A Case Study on BMP's and LID at Shoemaker Green</td>
<td>Grant Scavello</td>
<td>University of Pennsylvania</td>
<td>T 215</td>
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<tr>
<td>3b1</td>
<td>A Case Study on BMP's and LID at Shoemaker Green</td>
<td>Grant Scavello</td>
<td>University of Pennsylvania</td>
<td>T 215</td>
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<tr>
<td>3b2</td>
<td>Regulatory Impacts to a Sites Hydrologic Balance</td>
<td>Scott A. Brown, PE, D WRE</td>
<td>Pennoni Associates, Inc.</td>
<td>T 215</td>
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<td>3b3</td>
<td>Greening of America’s First Zoo</td>
<td>Andrew Statos, PE</td>
<td>Pennoni Associates</td>
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<tr>
<td>3b4</td>
<td>Introduction to the Sustainable Sites Initiative</td>
<td>Bryan Astheimer, MS, LEED AP</td>
<td>ReVision Architecture</td>
<td>T 215</td>
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<tr>
<td>3c- Innovative Site Design</td>
<td>Performance Based Landscapes: Shoemaker Green</td>
<td>Thomas Amoroso, RLA</td>
<td>Andropogon Associates</td>
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<td>3c1</td>
<td>Performance Based Landscapes: Shoemaker Green</td>
<td>Thomas Amoroso, RLA</td>
<td>Andropogon Associates</td>
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<td>3c2</td>
<td>Van Sciver Bioretention Area-Design &amp; Construction</td>
<td>John Nystedt, RLA, LEED AP</td>
<td>Delaware Riverkeeper Network</td>
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<td>3c3</td>
<td>Large Parking Lot Stormwater Retrofit</td>
<td>James W. Pillsbury, MS, PE</td>
<td>Westmoreland Conservation District</td>
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<tr>
<td>3c4</td>
<td>Gustine Lake Interchange Improvement Project</td>
<td>Julia Rosenbloom, P.E.</td>
<td>Michael Baker Jr., Inc</td>
<td>C 205</td>
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</tbody>
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**Moderators**

3a - Paul DeBarry, PE, PH, GISP, D.WRE. NTM Engineering, Inc.  
3b - Erin Dalius, Dewberry  
3c - Carolyn Paone, Langan Engineering
## Concurrent Technical Session IV – October 18th

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<tr>
<td>4a-</td>
<td>Approaches to Municipal Stormwater Financing – What’s Old is New (at least in PA)</td>
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<td>4a1</td>
<td>Stormwater Authorities - PWD's Experience (40 Min)</td>
<td>Joseph S. Clare</td>
<td>PWD</td>
<td>C 001</td>
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<td>4a3</td>
<td>Creating a Stormwater Fee in Pennsylvania</td>
<td>Brian Merritt</td>
<td>AMEC Environment &amp; Infrastructure, Inc.</td>
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<td>4a4</td>
<td>Funding Stormwater in Pennsylvania</td>
<td>Mark Derham Bowen, P.E., CFM</td>
<td>Kleinschmidt Associates</td>
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<td>4b-</td>
<td>Building Partnerships - Studies in Collaboration - 2</td>
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<td>4b1</td>
<td>Municipalities Collaborate to Clean Your Water (40 Min)</td>
<td>Meghan M. Filoromo</td>
<td>GreenTreks Network</td>
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<td>4b3</td>
<td>Highlights from the Vernon Park Community Rain Garden Project</td>
<td>Julie A. Hendrickson, PLA</td>
<td>AKRF, Inc</td>
<td>T 215</td>
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<tr>
<td>4b4</td>
<td>A Case For Collaboration</td>
<td>Jamie N. Anderson</td>
<td>Eastern Delaware County Stormwater Collaborative</td>
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<td>4c-</td>
<td>Stormwater Control Measures - Water Quality</td>
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<td>4c1</td>
<td>Meeting the Numbers with Stormwater Treatment</td>
<td>Shirley Clark</td>
<td>Penn State Harrisburg</td>
<td>C 205</td>
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<tr>
<td>4c2</td>
<td>Impact of Rainfall Calculation on Capture Volume</td>
<td>Ruth Hocker</td>
<td>Chesapeake Bay Foundation</td>
<td>C 205</td>
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<tr>
<td>4c3</td>
<td>Feasibility Study of Water Treatment Plant Residuals to Improve Pollutant Removal in SCMs</td>
<td>John Komlos, Ph.D.</td>
<td>VUSP</td>
<td>C 205</td>
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<td>4c4</td>
<td>Water Quality as a Function of Design Criteria</td>
<td>Bridget Pounds</td>
<td>Penn State Harrisburg</td>
<td>C 205</td>
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**Moderators**

- **4a** - Kim Dunn, PE, CFM, Dewberry
- **4b** - Brian Oram, PG, B.F. Environmental Consultants, Inc.
- **4c** - Michele Adams, PE, Meliora Design
## Concurrent Technical Session V – October 18th

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<tr>
<td>5a1</td>
<td>Funding Stormwater and Non-point Source Projects (40 Min)</td>
<td>Brion Johnson</td>
<td>PENNVEST</td>
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<td>5a3</td>
<td>PHRC’s Subdivision and Land Development Guidelines</td>
<td>Chris Hine</td>
<td>Pa Housing Research Center, Penn State University</td>
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<tr>
<td>5a4</td>
<td>Navigating the State and Local Stormwater Framework</td>
<td>Timothy J. Bruno</td>
<td>PADEP - Northwest Regional Office</td>
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### 5b- Monitoring and Modeling Approaches -1

| 5b1         | A karst case study: Flow and water quality analysis of 5 urban watersheds | Katie Blansett, Ph.D., P.E.          | PA Housing Research Center, Penn State University                 | T 215 |
| 5b2         | Integration of WQ data with mainstream GIS                            | Evgeny Nemirovsky, PE                | Villanova University                                              | T 215 |

### 5c- Stormwater Control Measures - The Importance of Soils and Infiltration - 2

| 5c1         | Proven Viability of a Multi-Well Gravity Drain System During 3 Years of Stormwater Injection | James L. Lolcama, P.G.               | Principal and Hydrogeologist, KCF Groundwater Inc                | C 205 |
| 5c2         | Inconsistencies and Sensitivities in Encased Borehole Soil Infiltration Procedures in Pennsylvania | Timothy B. Carlin, P.E.             | Earth Engineering Incorporated                                   | C 205 |
| 5c3         | Urban Soils & Suitability for Green Infrastructure                     | Stephen Dadio, CPSS                  | CEDARVILLE Engineering Group, LLC                                 | C 205 |
| 5c4         | Addressing Erosion with Nontraditional Techniques                      | Lichuan Chang                        | Princeton Hydro, LLC                                              | C 205 |

### Moderators

5a - Jonathan Rinde, Esq., Manko | Gold | Katcher | Fox LLP  
5b - Frank Browne, Ph.D, PE, President, F. X. Browne Inc.  
5c - Andrea Welker, Ph.D, PE, Villanova University
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Oral Presentation Abstracts
Stormwater Infiltration Testing at Depth

Clay Emerson PhD PE CFM, Princeton Hydro

The New Jersey Department of Environmental Protection (NJDEP) released the Soil Testing Criteria (Appendix E of the New Jersey Stormwater Best Management Practices Manual) in September of 2009. As a result of this guidance, stormwater infiltration tests may be required at substantial depths below the existing ground surface. To comply with OSHA regulations, adequate side slopes and stepping of test pits to these depths often result in an extremely large excavation which may be impractical. The NJDEP acknowledged this issue and requested that the Groundwater Subcommittee of the New Jersey section of the AWRA investigate and provide recommendations on techniques for conducting infiltration testing at depths where typical test pit observations are not safe or practical. The committee members have a wide variety of experience and professional backgrounds, and met routinely in 2012 in an effort to compile references and prepare recommendations for the NJDEP. This work effort included a field meeting where four different infiltration test methods were demonstrated. This presentation will summarize the committee’s findings as well as highlight the multidisciplinary collaboration effort which was fostered by the NJAWRA.

Urban Soils - One Size Does NOT Fit All

April M Barkasi, PE LEED AP, CEDARVILLE Engineering Group, LLC; Stephen Dadio, CPSS, CEDARVILLE Engineering Group, LLC

In the regional planning and urban design of stormwater management and green infrastructure in cities, the conditions of the existing soils are often assumed as a universal detriment to green infrastructure design. CEDARVILLE is part of an ongoing study conducted in 4 major cities to date, examining the both density and infiltration capacity of surface soils in cities. Tests were conducted on existing parks as well as vacant lots, which are the dominant pervious landscape in urban settings. Our results indicate that, while the density and infiltration rates are quite variable, the existing hydrologic characteristics are impacted by both vegetation and management. Already performing as a type of passive green infrastructure, the soils are infiltrating rainfall during storm events. Our research has resulted in a protocol to assess the existing condition of pervious surfaces in cities to quantify regional potential prior to planning and to integrate in site design.
The Role of Urban Trees in Managing Stormwater

Vincent J. Cotrone, Penn State University - Extension

Urban Trees play a significant role reducing stormwater and pollutant loads and can be one of the most cost effective and greenest approaches to managing stormwater. Trees reduce stormwater and associated pollutant loads, in several ways.

Trees work like large umbrellas, intercepting rainfall in their canopies. Average interception by deciduous trees ranges from 700 to 1,000 gallons per year, while an evergreen can intercept more than 4,000 gallons per year. Large canopy trees such as Planetree, Oak or Maple planted over impervious surfaces provide the most benefit.

Trees develop extensive, deep roots that increase infiltration rates. In forest soils, infiltration rates can range from 10-18 inches per hour.

Actively growing trees are natural water pumps that return water back to the atmosphere through evapotranspiration. It also serves to cool and modify surrounding summer temperatures.

Trees actively remove nutrients and contaminants from soils and water. Phytoremediation studies documented a single roadside sugar maple removed 60 mg of cadmium, 140 mg of chromium, 820 mg of nickel, and 5200 mg of lead in a single growing season (Coder, 1996). Studies at UC Davis, documented nutrient removal rates of 47-99% and 75-96% for heavy metals (Xiao M. and E. McPherson. 2008). In comparison, studies of residential lawns document an over use of chemical fertilizers and synthetic pesticides.

Lastly, trees growing along our streams are critical to stream health and pollutant removal. Riparian forests filter sediments; remove nutrients; stabilize streambanks; shade and cool streams; provide aquatic and wildlife habitat for many species; reduce stream velocity and downstream flooding.

Trees are finally being viewed by some as part of the "green infrastructure" solutions required by our communities to improve water quality and control stormwater. Urban tree planting can be used by MS4 communities to help meet their TMDL requirements and PennVest is helping to finance the planting of trees in some cities.

State of the Practice of Soil Mixes used in Rain Gardens

Andrea Welker, PhD, PE, VUSP

Rain gardens are an effective means to control volume and reduce pollutant loads to receiving waterways. In addition, rain gardens do more than just restore the hydrologic cycle through infiltration (if there is no underdrain) and evapotranspiration
(ET) – they create habitat and are aesthetically pleasing. Many states have published design guidelines for the planting and volume storage soils used in rain gardens. These guidelines were developed to ensure plant growth, allow adequate infiltration, and encourage the retention of contaminants commonly found in runoff. For example, the PA BMP Manual (2006) provides the following guidelines for these soils:

- The planting soil should be 20-30% organic material (compost) and 70-80% soil base (preferably topsoil).
- The volume storage soils should have a pH between 5.5 and 6.5, clay content less than 10%, and have 5-10% organic material.

Often, the on-site soils are excavated and replaced with bioretention media to meet the requirements of the state or township. However, this practice greatly increases the cost of the project and may not be necessary to ensure that a rain garden functions as intended. This presentation will explore the development of a performance-based cost-effective soil specification that considers infiltration, ET, and pollutant removal. Experiences of the audience members will be solicited.

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**Water Quality Response from Permeable Pavement**

Robert A. Brown, PhD, EIT, ORISE Postdoc at U.S. EPA; Michael Borst, U.S. EPA

Communities are increasingly installing infiltration-based stormwater control measures (SCMs) to restore the predevelopment hydrologic balance and reduce pollutant loads associated with stormwater runoff. Permeable pavement is a SCM that has limited research on working-scale, side-by-side performance of different permeable pavement surface types. The existing studies commonly have small, short-duration datasets and are often limited to a single permeable pavement surface making it difficult to extrapolate and compare the results between surface types.

In 2009, the U.S. Environmental Protection Agency constructed a 0.4-ha (1-ac), 110-space, parking lot in Edison, NJ that was surfaced with three different permeable pavement types [permeable interlocking concrete pavers (PICP), pervious concrete (PC), and porous asphalt (PA)]. Each permeable pavement type has four equally sized and spaced, lined sections that drain to 5.7-m³ (1,500-gal.) collection tanks that enable composite sampling for water quality analysis. Each liner (0.45 mil EPDM membrane) was installed to a depth of 0.41 m (16 in.) below the parking surface. The lined sections gravity drain through pipes under the roadway to the collection tanks; rainfall events up to 38-mm (1.5-in.) can be completely
captured. Each lined section is 55 m² (590 ft²) and has an impervious asphalt contributing drainage area of about 36 m² (390 ft²). Samples analyzed in this presentation were collected at roughly monthly intervals for more than two years.

Rainwater and asphalt runoff were also sampled to provide comparisons to the infiltrate. Some of the measured stressors that will be described include: nitrogen, phosphorus, chloride, zinc, suspended solids, and pH. For many stressors, the concentrations varied significantly by surface material. As an example, total nitrogen concentrations were significantly larger for PA compared to PICP and PC, and the PA surface had a significantly larger total nitrogen concentration compared to both rainwater and asphalt runoff samples.

Surface Infiltration Monitoring of Permeable Interlocking Concrete Pavement

Kevin Earley, PG, Nicolock Paving Stones

Permeable Interlocking Concrete Pavement (PICP) is becoming a popular Low Impact Development (LID), stormwater management solution. Local municipalities and design professionals interested in confirming that design surface infiltration rates are being achieved post-construction at PICP sites can utilize ASTM C 1781 M-13, Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems.

This presentation reviews two commercial PICP projects installed in 2009 and 2010. Both were designed in conformance with the Interlocking Concrete Pavement Institute (ICPI)’s guidelines, and the local rainwater storage requirements. Both sites had granular subgrade and other site conditions ideal for direct infiltration of stormwater. Two different paver shapes were used with washed highly permeable aggregates (ASTM No. 8 and No. 9) in the surface joint openings. No vacuum maintenance or cleaning has been done at either site to date to observe and quantify the rate of clogging and the long-term impact on surface infiltration rates.

A series of post-construction pavement surface infiltration rates were measured at each site. Results demonstrated average infiltration rates decreased over time but have stabilized and are currently in the 100-300 in/hr range. ICPI and the author believe that the ASTM C 1781 method is sufficient for measuring acceptance or performance criteria of PICP systems. The field test method could also be used to establish maintenance criteria to validate a remediation or repair of a permeable interlocking concrete pavement.

Water Quality Improvements with Permeable Pavement

Glenn Herold, P.Eng., Oldcastle Architectural

Permeable Pavements are recognized by the Pennsylvania Department of Environmental Protection as an efficient Best
Management Practice for stormwater volume/peak rate reduction. However, in terms of water quality benefits, the general opinion is that the determination of “the removal efficiency of pollutants, both particulate and dissolved, from stormwater is a difficult and inefficient process” – simply put, the “evaluation process is largely a work in progress”. This is because the treatment mechanisms involved are not clearly understood.

The objective of this presentation is to summarize the available knowledge on treatment mechanisms associated with permeable pavements, specifically Permeable Interlocking Concrete Pavements (defined in the BMP Manual as Pervious Block Pavers), based on a compilation of academic research conducted at several universities around the country.

The removal of Total Suspended Solids (TSS), Polycyclic Aromatic Hydrocarbons (PAH), metals and nutrients are all discussed based on findings from the following, amongst other, reports: “Investigation of Hydraulic Capacity and Water Quality Modifications of Stormwater by Permeable Interlocking Concrete Pavement Systems” from Florida Gulf Coast University; “Evaluation of Permeable Pavements in Cold Climates” from University of Guelph and Toronto & Region Conservation Authority; and, “Final Report on Cold Climate Permeable Interlocking Concrete Pavement Test Facility at the University of New Hampshire Stormwater Center”. There will also be a review of the Best Management Practices Treatment Aid (BMPTRAINS) software development by the University of Central Florida, which is used to evaluate stormwater runoff nutrient loads and treatment efficiencies of BMPs.

**Industry Guidelines for Permeable Interlocking Concrete Pavement**

1b4

**David R. Smith, Technical Director, Interlocking Concrete Pavement Institute**

In 2011, the Interlocking Concrete Pavement Institute (ICPI) released the 4th edition of the manual, Permeable Interlocking Concrete Pavements – Design Specifications Construction Maintenance. This paper provides an overview of this 100-page book on permeable interlocking concrete pavements (PICP) which communicates industry best practices in the United States and Canada. This paper provides highlights from the publication’s five chapters; Overview; Design Contexts, Overview and Guidelines; PICP Design; Construction; and Maintenance.

Compared to previous editions, the design chapter has expanded formulas for sizing full and partial exfiltration PICP designs using perforated drain pipes. An entirely new section covers structural design for supporting vehicular traffic and includes a base/subbase thickness design chart. The construction chapter covers essentials on residential and commercial projects and includes an updated guide construction specification.
The final chapter on maintenance references research and experiential information on types and performance of vacuum sweepers for regular maintenance and remediation of neglected surfaces clogged with sediment. There is a construction and maintenance checklist, plus a model municipal ordinance to encourage PICP use by municipalities on public and private projects. Besides the numerous references, an updated glossary of terms is provided.

Key Words: permeable interlocking concrete pavement, permeable pavement design, permeable pavement hydrologic and structural design, permeable pavement construction, permeable pavement maintenance

Stormwater Management: A Framework for Site Design

Rachel Ahern, CHPlanning Ltd; Shelly Jones, Philadelphia Water Department

Stormwater management can lay the groundwork for a comprehensive site design. When site planning takes an integrated approach, green stormwater infrastructure (GSI) can serve as a stormwater control measure that creates a design framework for the site. GSI can be used to a wide variety of design goals, providing amenities to users, defining space, and supporting programming.

One example of this approach is the revitalization of one of Philadelphia’s vacant lots, located at N 16th Street and W Seybert Street. This site will be renovated into a park in Spring 2014 alongside a new housing complex. Here city agencies and private development collaborated on an integrated approach to maximize the benefits of required stormwater management associated with development. A design inspired by a native meadow and maximum capture is the foundation for the user experience, defining pedestrian circulation and setting apart spaces for reflection. In a neighborhood with little green space, the new park will provide a much needed community resource.

A second example is the George W. Nebinger School, located between the Bella Vista and Queen Village neighborhoods of Philadelphia. A green stormwater infrastructure project will be the first phase of Nebinger’s complete transformation to a “green school,” including both schoolyard greening and an increased academic focus on sustainability and environmental stewardship. This partnership effort among City agencies, the EPA, the Philadelphia School District, local community groups, and nonprofits uses GSI investments to leverage funds for future phases. The GSI project consists of a treatment train of innovative practices such as vegetated swales, rain gardens, porous play surfaces, and underground infiltration basins. These features include native Pennsylvania woodland vegetation and interactive educational components to support the school curriculum. Situated along the periphery of the site, these state-of-the-art stormwater features will serve as gateways to the soon-to-be world class green schoolyard.
PWD’s systematic watershed-wide approach to Stormwater Management

Jeffrey Featherstone, PhD, Temple's Center for Sustainable Communities; Paul A. DeBarry, PE, PH, GISP, D.WRE, NTM Engineering, Inc.; Joanne Dahme, Philadelphia Water Department

The Philadelphia Water Department is nationally recognized for their innovative LID approach to greening the city. However, less people are aware that these are part of a bigger picture, and that the PWD has also implemented a systematic watershed-wide approach to stormwater management. Through Act 167 when it was funded, and then financing on their own, the PWD has had developed comprehensive watershed management plans for the Tacony/Tookany-Frankford, Pennypack, Poquessing and Wissahickon watersheds and cooperated with Delaware County in development of the Cobbs Creek Plan. These Plans took a detailed look at flooding, problem areas, existing detention basins and obstructions in the watershed, and through hydrologic modeling evaluated timing of various tributaries to come up with a long term stormwater management approach. Recommendations are made to reduce runoff and flooding on a watershed scale along with various “green development” scenarios modeled to predict the benefits. Cooperating with surrounding Counties, model stormwater management ordinances were developed, which laid the framework for PWD’s stormwater management standards.

Restoring the Health of Panther Hollow

Kate Evasic, Meliora Design; Emily McCoy, RLA, ASLA, Andropogon Associates

The Pittsburgh Parks Conservancy has embarked on a visionary effort to restore the Panther Hollow Watershed, which encompasses part of Schenley Park, and the neighborhoods of Oakland and Squirrel Hill. Characterized by a man-made lake at the end of an urbanized watershed, the streams that feed the lake have been “beheaded”, buried, and diverted to the combined sewer system. After traversing the urban park, the remaining stream system and lake overflow back into the combined sewer system. The Parks Conservancy is using a green infrastructure approach in an effort to restore the health of Panther Hollow to a condition that keeps with its original, forested hydrology. Essentially, they are striving to restore the water balance to this urban and highly impacted watershed.

The work effort included public engagement and outreach, coordination and involvement of city agencies and adjacent universities (University of Pittsburgh and Carnegie Mellon), and the development of a longterm green infrastructure plan for the watershed. Detailed designs were also developed for pilot
projects which include measures that capture street runoff, restore urban soils, and enhance connectivity to the park. One of the critical components of the Panther Hollow Plan was the hydrologic analysis of the existing conditions and how the unexpected findings informed the plan recommendations and designs. The computer model WinSLAMM (Source Loading and Management Model for Windows) was applied, which allowed us to evaluate all rainfall events over a 47 year period using very specific land uses. A three-year record of rainfall and corresponding flow discharge from the watershed, collected by the Allegheny County Sanitary Authority (ALCOSAN), allowed us to compare the model results to actual conditions.

Through this analysis, we learned that the park itself – with a golf course, lawn areas and urban woodlands – was generating much more runoff and at a much faster rate than we had anticipated. The compacted soils of the highly used park were impacting the health of the stream system. This presentation will introduce the results of the hydrologic modeling analysis and discuss how the findings led to specific GI recommendations and practices within the park. We will explain the water quality and ecological challenges facing Panther Hollow, and share recommendations for GI implementation. GI pilot projects that have been designed in Panther Hollow will also be presented.

**PWD Cobbs Creek Restoration & Green Infrastructure**

**Thomas A. Graupensperger, Dewberry**

As part of the City of Philadelphia’s ambitious 25-year, $1.67-billion stormwater control plan, the PWD is implementing a restoration and ecosystem enhancement program in Cobbs Creek Park. The goal of the City’s integrated ecological restoration and infrastructure protection program is to use natural channel design techniques for the restoration of Cobbs Creek, combined with other advanced sustainable/green design practices—to reverse the degradation and provide a safe attractive greenway that provides flood protection through means such as: reducing sediment load; restoring/stabilizing the stream channel, stream-bank erosion features, exposed sewer manholes and parallel interceptors; increasing floodplain connectivity and stormwater wetland treatment opportunities; creating a stable and sustainable environment and stream corridor; creating Green Stormwater Infrastructure (GSI), runoff control measures and BMPs to address Combined Sewer Overflow (CSO) impacts; and creating trails, trailheads and gateways to invite and promote park use.

This restoration project is the culmination of years of coordinated planning by many individuals and groups in the watershed. Within the Cobbs Creek Park, a natural and historical interpretation of these restorations and watershed renovations will be provided through example, in a living
classroom and natural park setting where multiple generations can interact. Discussions will focus on CSO discharge reducing Green Stormwater Infrastructure (GSI) components of the overall proposed restoration plan and the integration of rain gardens, infiltration trenches, bioswales, tree trenches, bermed-bioretention basins, curb-bumpouts, pervious paver techniques, and other green design elements into the naturalized setting of Cobbs Creek Park, in concert with gateway, trailhead and other park, stream restoration and infrastructure related improvements.

When it Rains it Stores: PWD's SCM Monitoring
2a1

Stephen White, Philadelphia Water Department; Chris Bergerson, Philadelphia Water Department

The Philadelphia Water Department's (PWD) Green City, Clean Waters Program (CSO Long Term Control Plan Update (LTCPU)) outlines a vision of "large-scale implementation of green stormwater infrastructure (GSI) to manage runoff at the source on public land and reduce demands on sewer infrastructure." A GSI monitoring plan has been developed as a component of the "Comprehensive Monitoring Plan" required by Pennsylvania Department of Environmental Protection's consent order agreement with PWD. This GSI monitoring plan describes methods of monitoring performance in reducing overflows from the combined sewer system in a large scale scenario.

The implementation of this plan and the refinement of the methods therein are currently underway. Discussion of select methods currently in use, and in development by PWD to observe the response of specific stormwater control measures (SCM) during precipitation events, and during simulated events is presented. Monitoring of Multiple SCM types are discussed from the perspectives of continuous performance monitoring (ex. continuous data set from observation wells) and performance testing (ex. surface infiltration rate testing with infiltrometers and simulated runoff testing). Preliminary data sets that are part of the annual reporting from continuous monitoring and performance testing of select SCMs are presented.

Mill Creek: A Long-Term Stream Study
2a2

Patrick Gardner, Lower Merion Conservancy

Beginning behind Villanova University, Mill Creek flows six miles through Lower Merion until it reaches the Schuylkill River. Since 1996, the Lower Merion Conservancy has studied the impacts of stormwater runoff on Mill Creek through various chemical and physical tests, as well as through annual macroinvertebrate sampling. Over 17 years of data indicates that Mill Creek has become significantly impaired. It is listed as an impaired waterway by the PA DEP and was chosen in 2013 by the PA Fish & Boat Commission as one of the first
streams in the state to be removed as an approved trout water due to poor habitat quality.

By comparing our data with data collected by Stroud Water Research Center, we were able to determine that Mill Creek is in the bottom six of the twenty main tributaries of the Schuylkill River. Considering that five of the other six received combined sewage overflow or acid mine drainage, and that the only permitted discharge to Mill Creek is stormwater, this statistic is a cause for concern. In addition to the biological data, we also monitor streambank erosion. At one of our most upstream sites, we have recorded nearly 20 inches of streambank erosion on an unvegetated bank in just ten years. Partnering with Lower Merion Township, the Lower Merion Conservancy has helped in various streambank stabilization projects along Mill Creek to restore and prevent further damage to Mill Creek. Every few years, the Lower Merion Conservancy prepares the Mill Creek Report, which highlights the major concerns for Mill Creek, draws conclusions about the health of Mill Creek, and determines what actions we and the surrounding community can take to preserve Mill Creek.

A Proposal for Measuring the Effects of Greening a 10 Acres Commercial Site

William Heasom PE, M.ASCE, LEED AP, Down to Earth Design Foundation

As part of its effort to revitalize urban neighborhoods and to mitigate the impacts of stormwater discharging into Philadelphia’s combined sewer system, the Philadelphia Water Department in partnership with the Environmental Protection Agency and the Community Design Collaborative sponsored a competition to elicit innovative design ideas. This paper discusses one contending entry: a proposed retrofit for the 10 acre Pathmark site on Grays Ferry Avenue. It includes a green roof, cisterns and rain barrels, a rain garden, tree trenches and street planters, and an innovative rock storage infiltration bed constructed under the conventional asphalt parking area surface. These elements are arranged into treatment trains that retain more than one inch of runoff from the largely impervious (> 90%) retail complex.

At present, nearly all of the rainfall excess from shopping center is collected in a simple system of pipes and inlets that discharge to the city sewer line at a single point. It is noted that this configuration provides an unusual opportunity for monitoring and research since it allows for a single flow meter to measure both pre- and post-construction whole-site discharges continuously. An accompanying weather station and
data recorder could provide continuous monitoring of the site’s response to rainfall and the treatment train performance. Benefits would include: establishing a performance baseline; facilitating adaptive adjustment of a phased design; facilitating measurement of heat island effect mitigation through extended evapotranspiration; providing an educational display with real-time weather and performance data; verifying local reduction in stormwater fees based on volume; encouraging replication of the SCMs at other large impervious sites; etc. Since the configuration of the Pathmark site is typical, both in Philadelphia and nationwide, such a research and demonstration project would deliver benefits far beyond the single site on which it might be implemented.

Making Decisions in Uncertainty - Monte Carlo Analysis of Health Risk Associated with Recreational Exposure to Combined Sewer Overflow

Nathan Boon, M.A., PMP, GISP,
The George Washington University

This study undertakes a quantitative microbial risk assessment of Giardia infection from exposure to contaminated river water during rowing activities downstream from active combined sewer overflow (CSO) discharge using a specific case study along the Schuylkill River 15km upstream of Philadelphia, PA. Different experimental scenarios are used to model risk under a variety of flow regimes and discharge scenarios, providing insight into the potential costs and benefits of achieving mandates for CSO reductions. While naturally present in surface waters at levels ranging up to hundreds of thousands of cysts per liter, concentrations of Giardia organisms in raw human sewage can range from one to three orders of magnitude higher, aggravating public health risk in combination with the growing issue of untreated sewage mixing with storm water before discharging to receiving waters.

A real world scenario was modeled where a high school boys’ team is rowing downstream of an active sewage treatment plan during a characteristic CSO discharge event. An exposure model was developed to assess rowers’ contact with Schuylkill River water contaminated with pathogen-laden CSO during a single practice session through wetting of the hands and subsequent ingestion via hand-to-mouth contact. The exposure dose is calculated from the pathogen in CSO and surface water and discharge ratio with complete mixing, frequency of hand wetting events, water volume adhered to wetted hands, frequency of hand-to-mouth contact, pathogen transfer efficiency between contaminated hands and mouth, and time between first and last possible exposure. The likelihood of infection following ingestion was calculated from published dose-response models and uncertainty for the data was modeled using fitted and estimated distributions within a Monte Carlo uncertainty analysis.

The exposure model yields an average effective volume ingested from the hands of 12.5 ml, as compared to or
combined with survey-based estimates for rowers from recent literature of 3.9 ml ingested on average, with an upper confidence limit of 11.2 (Dorevitch et al. 2011). The complete mixing scenario showed a mean dose of 0.007 cysts per rowing session, with a mean risk of 0.0001 probability of infection and a maximum risk of 0.004, as compared to results for a prospective cohort study in Chicago that showed an unadjusted increased incidence of disease of 0.0087 for recreators exposed to sewage impacted waters (Dorevitch et al. 2012). Additional scenarios taking into account aerosolized and direct exposure pathways, additional local discharges, incomplete mixing, or alternate locations 15 km downstream below Philadelphia CSO outfalls can increase mean risk to 0.0004, 0.0005, 0.001, or 0.005 respectively; and cumulatively induce risks of infection higher than one in ten.

A comparative analysis of evapotranspiration rates

Kimberly DiGiovanni, PhD, EIT, Drexel University; Stephanie Miller, Drexel University; Franco Montalto, PhD, PE, Drexel University; Stuart Gaffin, PhD, Columbia University

Vegetation and climate are both key determinants of evapotranspiration, an important hydrologic process linked to stormwater management, microclimate regulation and other valuable ecosystem services that can be obtained from reconfigured urban green spaces. This presentation presents lab and field studies that attempt to disentangle these relationships with a focus on the species used in New York City green infrastructure facilities. The field studies were performed at eight sites with different microclimates and vegetation and include green roofs, bioretention areas, airports and an urban park. Measurement and modeling of ET, suggest that micrometeorological factors can account for differences of up to 40% in cumulative annual reference evapotranspiration. Because the role of vegetation at the field sites was difficult to ascertain, a lab experiment was set up in a greenhouse. ET rates were measured directly by weighing lysimeter for sixteen exemplars of four different vegetation species subjected to identical microclimate. Over one growing season, significant differences in cumulative evapotranspiration were apparent between the four species with 61% of this difference accountable for by the vegetation. Research is ongoing to determine the mediating role of soil moisture.

Rainfall Interception by Four Common Shrub Species

Walter Yerk, Drexel University; Franco Montalto, Ph.D., PE, Drexel University

Interception loss by vegetation canopies has been long recognized as a very important factor of a watershed balance. Still only a few reports on interception by urban vegetation have been published. In 2012 we designed and conducted a field experiment where we: (a) developed a method for direct
measurement of throughfall with 5-sec sampling frequency, (b) quantified differences of throughfall between two common shrub species used in urban landscaping. August-October records demonstrated statistically significant difference of recorded throughfall (94% for Itea virginica, 86% for Cornus sericea).

An improved and expanded set-up has been installed in 2013. We have been monitoring four species (Prunus laurocerasus and Hydrangea quercifolia were added). The new results from 2013 confirm that difference between various species' interception ability exists. The observations show that throughfall intensity is a linear function of rainfall intensity and this relationship is stable on a broad range of rainfall intensity.

The measured combined intra-storm fraction of interception and stemflow was reaching 35% and more of gross precipitations, and the interception depths are several times more than traditional models based on canopy storage capacity and potential evaporation suggest. proposed in recent literature and poorly understood intra-storm evaporation mechanisms are assumed to be the key in explaining such high interception ratio.

How Best to Take Credit for ET in Green Roofs – A Roundtable Discussion (40 Min)

2b3

Bridget Wadzuk, PhD, VUSP

Through research at Villanova and elsewhere in the stormwater community we have established that evapotranspiration (ET) is a nontrivial component of a green roof's water balance, even over shorter time periods. We are at the point now where we need input from the community of designers and regulators about how best to credit this key mechanism in stormwater volume removal for green roof stormwater control measures. The roundtable will begin with a briefing on findings followed by a lively discussion on the best way to move forward.

P3s for Urban Stormwater Retrofits

2c1

Jon Capacasa, Director, Water Protection Division, US EPA Region 3; Dominique Lueckenhoff, Deputy Director, US EPA Region 3

Challenges to successful implementation of more sustainable green infrastructure practices to retrofit urban areas for improved stormwater management to restore impaired waters, meet total maximum daily load (TMDL) and CSO obligations and better manage water demand are driving the need for more innovative business models and alternative funding strategies
to offset costs and limited public funding. The reliance on LID/GI is expected to significantly increase as the economic, environmental and social benefits of LID/GI over traditional gray infrastructure practices become more widely known.

EPA Region 3 has been researching, benchmarking and evaluating the viability of using a range of innovative, GI-driven Public-Private-Partnerships (P3s) as alternative financing tools to help local governments leverage private sector resources to plan, design, construct and/or operate and maintain urban wet weather retrofit programs using Low Impact Development’s (LID) decentralized management approaches and sustainable Green Infrastructure (LID/GI) practices.

Utilizing these financing strategies, coupled with next generation, higher performing, lower cost GI designs and technologies can further reduce overall implementation costs, while improving upon sustained performance and protection. Region 3 has driven this process by conducting a number of GI National Experts Roundtables. P3s were identified as viable alternative financing strategies for encouraging private financing and using market forces to improve costs, efficiencies, and overall value.

Building Blue Communities

Jenni E. Woodworth, P.E., CPSWQ, A.D. Marble & Company

This presentation will focus on a new Best Management Practice; Community Involvement. Sustainable Stormwater Management will not succeed unless the participating community is educated on the impacts of stormwater and how they can contribute to Pollution prevention. This presentation will describe how structural BMP’s can be understood and applied at the homeowner level, how to encourage residents to be actively involved, and how township ordinances need to be modified to promote and enforce stormwater management.

Door-to-Door Stormwater Management: RainScapes

Ann English, RLA, LEED AP BD+C, Montgomery County, MD DEP; Daniel Somers, Montgomery County, MD DEP; Pamela Rowe, Montgomery County, MD DEP

Imagine part of an MS4 permit requires controlling the first inch of rain from fifty impervious acres using RainScapes (LID) practices that treat 500-3000 square feet of impervious area at a time. Further, almost all projects will be on private property, largely residential, requiring the cooperation and voluntary participation of those owners. Now imagine that
there must be enough projects installed to control that amount of water using RainScapes techniques after three years. In addition, property owners often don’t know that they are contributing to stormwater runoff problems and even if they are aware, are not sure where to start. Finally, imagine you have to develop a program that is accessible to the general public, is technically sufficient for stormwater control and reporting, is good for the environment, and is able to account for how public money is expended on private property. This is the time-space-money-knowledge-reporting puzzle that the RainScapes team is solving.

Implementation of small scale retrofits over a large area presents some interesting challenges. Puzzle solvers everywhere know that solutions to multidimensional challenges requires creative thinking and a certain amount of calculated risk taking in order to test and rapidly evaluate both technical requirements and outreach approaches in order to get to the implementation goals set out in the MS4 permit. In addition, this effort has been an evolving process, and as we have gone door-to-door, meeting-to-meeting, event-to-event, we have learned how to reach those who will be willing to actively make a difference, starting at home.

### Implementing LID Drainage Manual, Lessons Learned

James Michel, Town of Greenwich, CT

In May 2012, the Town of Greenwich, CT implemented a new Low Impact Development based Drainage Manual. This manual took over 2 years to create and was a combined effort of the DPW, a consultant, and the local engineers and developers. The manual provides incentives for using 100% LID techniques. The local engineers and developers were extremely resistant to this manual prior to implementation so we provided several educational opportunities to learn about the manual which also helped us fine tune a few items. During the first year of implementation we have determined there are a few things that still are very difficult to meet or may be perceived as unreasonable by the engineers. We have held a couple site visits to see the challenges and provide our guidance on the process.

The presentation will focus on the process we took to reach the stage of implementation, the challenges we faced and the proposed changes. In addition, we will discuss the primary Low Impact Development requirement of the manual and how it is intended to follow the new Low Impact Development principles being implemented nationwide. Greenwich is one of the first municipalities in the State of Connecticut that has implemented a LID based manual and the geography of the area presents several challenges to this process.
VUSP Green Infrastructure Research (40 Min)

VUSP Faculty, VUSP

The Professors of the Villanova Urban Stormwater Partnership will update the participants on ongoing green infrastructure research. The research is supported through the Pennsylvania Growing Greener Program, the PaDEP 319 Non Point Source Pollution Program, The William Penn Foundation, and the Partners of the VUSP. A specific focus of the presentations is lessons learned for the design community on Green Infrastructure, and what we see as the needs of the future. The researchers will be soliciting ideas for future projects from the audience.

Making Green Work, and Work Harder

Andrea Braga, Geosyntec Consultants; Marcus Quigley, Geosyntec Consultants

State and local governments as well as private enterprises have made significant investments in stormwater BMPs for flood attenuation and water quality treatment. As regulations become more stringent due to changes in NPDES permits, TMDL requirements, and numeric nutrient criteria, investment in enhancing stormwater BMPs will be needed to meet future pollutant reduction requirements. Despite these more stringent water quality regulations, many State and local governments continue to experience budget cuts that limit their ability to invest in water quality BMPs. As a result, innovative approaches are needed to optimize the effectiveness of BMPs in both retrofit and new construction scenarios to provide the maximum cost benefit.

Both traditional BMPs and green infrastructure systems have almost entirely been designed as passive systems governed by a fixed control structure designed to achieve a target water quality and/or quantity objective (i.e., treatment volume, attenuation). Passive systems however, rarely represent optimal solutions. For example, a typical wet detention pond detains then discharges a fixed amount of runoff downstream through a static control structure regardless of storage volume remaining within the pond at any given time. Runoff that could be retained during inter-event periods to increase residence time (for treatment) or used as a resource for irrigation (harvesting), is discharged. As a result, the full pollutant load reduction and stormwater harvesting potential of the capital investment in on-site storage is not fully realized.

Due to the advances in low cost, internet accessible controller systems and wired and wireless communications, real-time and dynamic controls of BMPs are now viable, cost-effective options for new construction as well as retrofits. These technologies allow these BMPs to be monitored and controlled in real time via the internet.
The presentation will focus on the engineering aspects and outcomes of recent research, modeling, and case studies performed by the authors where dynamic real time controls of stormwater BMPs have been implemented for optimized BMP performance. The pollutant reduction, flood control, and hydrologic and hydraulic, and hydromodification benefits of utilizing real time controls to optimize the use of available storage to extend detention time, harvest stormwater, and optimize volume recovery in otherwise traditional BMPs and conventional green infrastructure will be presented. The promise of real time controls to maximize the cost benefit of several types of BMPs will also be presented.

**ALERT: AMEC Load Estimation and Reduction Tracking**

Thomas Williams, AMEC Environment & Infrastructure

AMEC originally developed the ALERT toolset to help its local MS4 clients plan for the Chesapeake Bay TMDL. Since then, the ALERT tools have been updated and expanded to help stormwater planners everywhere evaluate and assess mitigation strategies associated with a variety of water quality issues and impairments. The ALERT toolset consists of two independent, but related components: a spatial analysis component built on ArcGIS, and a non-spatial dashboard implemented in Microsoft Silverlight. The GIS-based ALERT tools enable users to experiment with different landuse and treatment scenarios to evaluate pollutant loads, while also providing geographic visualizations of pollutant loads as well as a footprint of a stormwater capital improvement plan.

Results from this GIS-based analysis feed into the non-spatial ALERT dashboard, which helps the user quickly gauge any remaining long-term effort needed to meet TMDL requirements, in terms of treatment needs and total implementation and maintenance costs. The dashboard effectively serves as a starting point for more detailed planning with the aforementioned GIS tools. ALERT was designed for flexibility, and allow adjustments to pollutant loading rates (lbs/ac/yr) and/or event mean concentrations (mg/L), removal efficiencies, implementation and maintenance costs, and other parameters. Multiple pollutants can be evaluated simultaneously, allowing the user to efficiently manage compliance against several distinct targets. Additionally, results from the ALERT components have proven to be effective communication tools for public servants positioning for stormwater funding from Boards of Supervisors or City Councils. The ALERT tools are helping AMEC’s clients efficiently plan, prioritize, and implement stormwater projects to achieve pollution reduction goals.
A Case Study on BMP's and LID at Shoemaker Green

Grant Scavello, University of Pennsylvania

‘Green’ stormwater infrastructure is installed with the best of intentions: to remediate and manage polluted water, improve drainage, and ‘naturalize’ urban spaces in ways that maximize ecosystem services. However many green infrastructure projects lack funding, manpower, or other resources that help monitor whether the infrastructure is truly impactful in diverting water from the sewer, filtering pollutants, and providing worthwhile areas for urban recreation. Enter: Shoemaker Green. At first glance, the site appears to be much like a typical urban park or collegiate quad space. But Shoemaker Green was designed to mimic a large sponge or kidney that absorbs, cleanses, and stores stormwater. The Shoemaker Green system is designed to capture the first inch of any storm by utilizing a series of trench drains and inlets that release the water (via gravity) into several feet of designed soils under the main green space. Additional stormwater is moved to a rain garden which retains and helps cleanse the water of pollutants. All stormwater is eventually collected at the bottom layer of the system by an innovative under-drainage system called a Smartdrain. The Smartdrain wicks water up via capillary action, further removing particulate matter from the water. Finally, the system conveys water to a centrally-located cistern for storage and eventual reuse as irrigation for a large lawn and surrounding vegetation.

A five-year monitoring plan is currently in its second full season at Shoemaker Green. The plan is designed to allow a student-led project team at the University of Pennsylvania, system architects Andropogon Associates, and the public to interact with and measure the effectiveness of a ‘living’ urban system. The plan uses various instrumentation to monitor stormwater, soil, vegetation, and social behavior, and was funded earlier this year via a student-led application to the University of Pennsylvania’s Green Fund grant program. Shoemaker Green has the opportunity to become what green infrastructure seldom is: an effectively monitored space that captures, filters, and delivers clean water back to the environment. The results gathered from Shoemaker’s monitoring plan will help provide a realistic determination of whether the integrated Best Management Practices (BMP’s) and Low Impact Development (LID) at the site effectively filter stormwater. This data can be translated and disseminated worldwide in an effort to help design future green infrastructure for optimal capture, filtration, and delivery of stormwater back to the watershed.

Regulatory Impacts to a Sites Hydrologic Balance

Scott A. Brown, PE, D WRE, Pennoni Associates, Inc.

The results of an investigation to quantify changes in site hydrologic balance for a development site resulting from the implementation of Pennsylvania’s runoff volume control
standard are presented. This case study developed around a 350 acre commercial development that will create over 300 acres of impervious and other significantly disturbed landscapes. The site is currently a mix of forest and lawn areas. Pennsylvania regulatory standards require that excess runoff generated by development activities be controlled through implementation of stormwater Best Management Practices (BMP’s). These BMP’s are to be designed in accordance with the Pennsylvania Stormwater Best Management Practices Manual (BMP Manual).

As stated in the BMP Manual, the goal of the regulatory standards and design guidance is to mimic pre-development hydrologic conditions (runoff and ground water recharge) to the maximum extent practicable. Pennsylvania’s runoff volume standard, often referred to as Control Guidance 1 (CG-1), uses the increase in runoff resulting from a 2-year, 24-hour storm event as a measure for demonstrating compliance. The pre-development hydrologic balance for the site was evaluated through analysis of annual rainfall and stream flow data from nearby gages. The hydrologic balance for the developed condition was analyzed using the existing historic rainfall record coupled with the average annual runoff capture resulting from construction of surface and subsurface stormwater infiltration BMP’s. Site BMP’s were designed to capture the increased runoff volume from the 2-year, 24-hour design rainfall as required by CG-1. The study results indicate that achieving compliance with Pennsylvania’s storm runoff volume control standards at this site will resulted in a significant shift in the sites hydrologic balance, particularly as it relates to annual surface runoff and recharge volumes.

Greening of America’s First Zoo

Andrew Stathos, PE, Pennoni Associates

The Philadelphia Zoo Green Streets and Intermodal Transportation Improvements Project was a high profile venture with an ideal opportunity to incorporate Green Stormwater Infrastructure (GSI) into one of the region’s top attractions. The overall project included a new 683-car parking garage; traffic and roadway improvements; streetscape, landscaping, and wayfinding signage all aimed at enhancing the Zoo experience. Portions of the project site are within an existing combined sewer overflow (CSO) area which allowed for the utilization of GSI as a tool to help manage stormwater. This presentation will provide pertinent background information, challenges encountered, and the successful incorporation of GSI within a CSO area. The project includes rain gardens, subsurface stone infiltration trenches, stormwater planters, and porous pavement design elements which “green” over one acre of directly connected impervious area. As we progressed through the high paced design and construction project, there were many challenges to overcome, including existing utilities; high vehicular, transit, and pedestrian traffic; and coordination of numerous stakeholders, approval agencies, and community groups. From conceptual planning to design,
bidding to construction, and final acceptance, the project was a success and has resulted in added educational value for patrons who visit the Zoo. This presentation will highlight the challenges and summarize the social, economic, and environmental benefits for the community.

To view a video summary about the project, use this link: http://bit.ly/1514uFT

**Introduction to the Sustainable Sites Initiative**

Bryan Astheimer, MS, LEED AP, ReVision Architecture

The Sustainable Sites Initiative (SSI) has developed a sustainability rating system for landscapes called SITES that will serve as a driver to the landscape design and construction industry. The rating system evaluates landscapes using a broad set of indicators resulting in the need of consulting expertise from a diverse set of professionals, including contractors, engineers, architects, landscape architects, soils scientists, ecologists, and planners in order to design and document performance to meet credit thresholds. This 20 minute session will deliver information and insight into SITES using a power point presentation, the Chicago Navy Pier (CNP) case study, and a question and answer session. Given the recent release of the SITES rating tool this topic will be of interest to all levels (entry, intermediate, advanced) of attendees.

Key learning objectives for this session:
- Learn the history of the SSI and what its goals and objectives are;
- Understand the SITES certification rating system framework including its current state of development, credit and point structure;
- Know the process for taking a project from registration though to certification;
- Participants will gain project specific insight using the CNP project as a case study - including lessons learned and tricks for success.

**Performance Based Landscapes: Shoemaker Green**

Thomas Amoroso, RLA, Andropogon Associates; Emily McCoy, Andropogon Associates; Molly Julian, Meliora Design

Shouldn’t our landscapes do more than simply look good? Is it possible for interstitial, remnant exterior spaces in our cities to have meaningful contributions aesthetically, ecologically and socially? What are the necessary constituents to ensure successfulness of such spaces? This lecture will delve into the realm of performance-based landscapes within an urban and institutional context and demonstrate how these landscapes can become an integral, contributing player in the urban fabric of our cities -- from large-scale planning, to individual projects.
and implementation, and finally to landscape maintenance and monitoring.

As part of the Penn Connects master plan, the Shoemaker Green project revived one of the most underutilized spaces on the University of Pennsylvania campus. What were previously aging tennis courts, concrete walkways and a few trees is now the “front door” to the surrounding historic athletic structures and the recently completed Penn Park. This site, Shoemaker Green, is now a model for sustainable campus design; specifically, in urban spaces where the built environment competes for limited space and dollars. Through the innovative use of a variety of strategies and technologies, the design of Shoemaker Green was optimized to not only provide vibrant social spaces; but to also provide ecosystem services for the City of Philadelphia, a canvas for future curricula and scientific study, and serve as an impetus for the development of sustainable design and maintenance strategies for the entire University.

**Van Sciver Bioretention Area-Design & Construction**

**3c2**

**John Nystedt, RLA, LEED AP, Delaware Riverkeeper Network; Altje Hoekstra, PE, Meliora Design; Peter Johnson, RLA, Think Green LLC**

A bioretention system, commonly known as a rain garden, can provide stormwater cleaning, infiltration, evapotranspiration and stormwater flow reduction; native habitat can be enhanced and the aesthetics of an area can be improved. Properly installed, they can help improve the stormwater flowing towards receiving streams, and help recharge the baseflow of streams. However, this all takes careful planning, design and construction. The presenters will discuss how to successfully establish a beautiful and functional bioretention system, using the Van Sciver School Bioretention Area as a case study to discuss the issues. Specifics of design and construction will be discussed including watershed analysis and site grading; soil & infiltration testing; soil mixes; stormwater flow controls; native planting design; erosion control fabrics; construction sequence and methods; maintenance; community involvement and lessons learned.

**Large Parking Lot Stormwater Retrofit**

**3c3**

**James W. Pillsbury MS PE, Westmoreland Conservation District; Kathryn D. Hamilton RLA, Westmoreland Conservation District; ,**

The Westmoreland County Community College has a four + acre parking lot at their main campus. Built with no stormwater management, this large asphalt area came within 15 feet of a stream. Working cooperatively with the College and the Sewickley Creek Watershed Association, the Westmoreland Conservation District removed pavement, created a riparian buffer, and installed bio-infiltration swales to
control stormwater. Funding was provided by a Growing Greener grant.

**Gustine Lake Interchange Improvement Project**

*Julia Rosenbloom, P.E., Michael Baker Jr., Inc; John Hohenstein, P.E., Michael Baker Jr., Inc*

PennDOT’s Gustine Lake Interchange is a series of six structures at the confluence of City Avenue, Lincoln Drive, Kelly Drive and Ridge Avenue located adjacent to the Wissahickon Creek and the Schuylkill River. Although originally scoped as a bridge replacement project for five bridges, coordination with the East Falls, Manayunk and Roxborough communities resulted in an enhancement of the entire interchange. The community outreach effort resulted in the replacement of one bridge with an ADA compliant signalized intersection and the reconfiguration of four ramps. The proposed roadway improvements reduced the overall impervious cover within the disturbance area by approximately 0.23 acres or 8.17% over the existing condition. By planting street trees and grading sidewalks to drain to grassed areas, the directly connected impervious area within the project area was reduced by 20%.

To reduce peak runoff volume and flow rate, improve water quality, and mitigate thermal impacts, the project incorporated six vegetated bioretention sites, two vegetated swales and 66 street trees as part of the post construction stormwater management design. The BMPs were located adjacent to the roadway and in former ramp areas. The project also incorporated traffic calming measures, aesthetic stone finishes on the bridges, and improvements to the popular Schuylkill River Trail.

Meeting the accelerated construction schedule proved difficult within the small construction zones in this highly urbanized area. Field changes, delays, and difficulty obtaining the amended soils all had a negative impact on the proposed BMPs. This challenged the team to find solutions to these issues and provided valuable lessons learned. These stormwater features are not only functional, but they improved an existing urban interchange into a friendly gateway to the community center, residential homes, Schuylkill River Trail and SEPTA bus transfer station located within the interchange. Construction was completed in December 2011.

**Stormwater Authorities - PWD's Experience (40 Min)**

*Joseph S. Clare, PWD; Jaclyn Rogers, PWD*

The session will discuss Philadelphia's experience in its recent effort to move from a meter based stormwater service charge to an area based stormwater charge based on gross and impervious area. The session will cover the problems and resistance encountered, the upfront analysis, discussion and
data gathering and the numerous accommodations and assistance programs that were developed to ease in the transition.

**Creating a Stormwater Fee in Pennsylvania**

*Brian Merritt, AMEC Environment & Infrastructure, Inc.; Steve Norcini, Radnor Township Director of Public Works*

A stormwater “user fee” often referred to as a utility or authority, if done right, can provide a stable, adequate, flexible, and equitable way to fund needed maintenance, regulatory compliance, and stormwater infrastructure improvements. This presentation will walk participants through the nuts and bolts of stormwater utility development based on experience with Pennsylvania and other EPA Region III localities. Key elements include developing a stormwater business plan, assessing data requirements (aerial photographs and parcel information) and potential billing systems, establishing a rate structure and master account file, and effective public education and outreach. Radnor Township will be highlighted in the presentation along with case studies from two other Pennsylvania municipalities that have adopted a dedicated stormwater user fee. Other locations highlighted will include Mt. Lebanon Township (Adopted in 2011) and the City of Meadville (Adopted in 2012). Each of these communities face unique challenges in addressing their stormwater management needs; however there are many common themes among them such as aging infrastructure, the need for a more pro-active asset management, concerns of elected officials and the public about new fees, MS4 Compliance requirements, as well as meeting the expectations of the public with regard to health and public safety which must all be balanced to create a sustainable stormwater program. Participants will learn: Key elements/steps in developing a sustainably funded stormwater program; Potential challenges/hurdles in program and fee development; Importance of public education and stakeholders in implementation; Perspective and up to date progress from City/Municipal Staff where a stormwater fee has been enacted.

**Funding Stormwater in Pennsylvania**

*Mark Derham Bowen, P.E., CFM, Kleinschmidt Associates; Peter A. Angelides, PhD, Econsult Solutions; Ian Derham Bowen, Econsult Solutions*

Pennsylvania is facing a significant rise in the cost of handling stormwater. TMDLs, MS4 Permits, CSO Long Term Improvement Plans, Chesapeake Bay Watershed Improvement Plans, National Stormwater Standards, BMP Maintenance, Erosion and Sediment Discharge Monitoring are all on the horizon and all will cost townships money. Currently those PA Townships that have assessed the impact of MS4 regulations have estimated $300,000 to $700,000 in expenses over the next 5-years. Based on a review of national averages this may actually be about ¼ of the real cost. Some townships will raise
taxes, some townships will increase fees to developers, but there are other alternatives.

This presentation will explore the costs, the consequences of raising taxes and the legality of imposing user fees. One potential solution to this funding problem is forming a Stormwater Authority since this is now legal in PA thanks to the passage of long awaited legislation. Finally, private investment may become a viable solution in the near future. This presentation will provide municipal officials and engineers with a thorough understanding of what their real stormwater costs may be, and what they need to do to fund stormwater in Pennsylvania. Case studies from Pennsylvania and around the nation will help us put the problem in perspective. The presentation provides education on the limitations of Pennsylvania laws and codes, and provides an update on current legislation.

**Municipalities Collaborate to Clean Your Water (40 Min)**

*Meghan M. Filoromo, GreenTreks Network*

An important component of successful financing is saving money wherever you can. There’s no need to reinvent the wheel (and waste valuable time and funding) for public education and outreach. Collaboration across municipal borders allows for cost-effective, yet meaningful, education. During this presentation, learn about the benefits of forming an educational partnership. Meghan Filoromo of GreenTrek Network’s StormwaterPA.org project will highlight the new Clean Your Water platform as a case study in the benefits of municipal cooperation. StormwaterPA.org is Pennsylvania’s leading source of information and education for understanding the issues and impacts of stormwater runoff as well as effective ways to manage it. StormwaterPA’s Clean Your Water platform establishes multimedia websites that are localized for watersheds in Pennsylvania. Water advocates and local governments often struggle to make their messages and missions relevant to their communities. To create behavior change, you must connect with key audiences of different backgrounds, concerns, and priorities. Drawing upon our experiences as multimedia communicators, the Clean Your Water platform boasts teamwork across municipal boundaries, innovative technology, and targeted educational outreach. This presentation will share tips for building thriving partnerships and maximizing the results of outreach efforts.

**Highlights from the Vernon Park Community Rain Garden Project**

*Julie A. Hendrickson, PLA, AKRF, Inc; Rod Ritchie, PE, AKRF, Inc; Ruth Seeley, Friends of Vernon Park*

Building citywide partnerships, implementing low maintenance features, and garnering ongoing community enthusiasm and stewardship around green infrastructure are key components to
successful stormwater projects. The Vernon Park rain garden within the Germantown neighborhood of Philadelphia involved extensive public outreach efforts with community members and stakeholders. The project culminated in the collaboration of more than 50 local businesses and community groups. Landscape architect, Julie Hendrickson and Professional Engineer, Rod Ritchie, from AKRF, Inc., along with Ruth Seeley, Volunteer Coordinator for the Friends of Vernon Park group, will discuss highlights from the design, construction, and volunteer maintenance of the Vernon Park rain garden.

**A Case For Collaboration**

*Jamie N. Anderson, Eastern Delaware County Stormwater Collaborative; Karen Holm, Delaware County Planning Department*

The Eastern Delaware County Stormwater Collaborative is a partnership that grew out of an effort by the Southeastern PA RC&D Council to identify a potential mechanism to increase MS4 compliance and save money through a multi-municipal cooperative program. It was formalized in 2011 by four forward thinking municipalities. The goal of the Collaborative is to help municipal partners meet permit requirements in a coordinated and cost-effective manner by pooling resources, eliminating redundancy, and maximizing stormwater benefits and impact. The Collaborative is governed by an Intergovernmental Agreement that provides a legal and functional framework for operations. Over the first 2 years of existence, the Collaborative has grown to seven municipal members and hired a coordinator that develops and manages community education, outreach and training projects as well as handles the overall management of the Collaborative. The Collaborative’s focus is on fulfilling the requirements of MCMs 1, 2 and 6. In the past 2 years the Collaborative has successfully developed a school education program, a homeowner stormwater education seminar and rainbarrel workshop program as well as been able to offer education at community fairs, events, and meetings. Members are working on developing cohesive plans for each MCM as required under the new permits.

The joint efforts coupled with a dedicated coordinator have seen great success in garnering community involvement and engaging residents and municipal officials. The Collaborative framework has also enabled the municipalities the ability to work with outside environmental organizations on projects as well as seek funding for on the ground projects that they would not have had the ability to undertake if working individually. Additionally, the regular meetings held by the Collaborative serve as a great platform for information sharing. Overall, the Collaborative serves as a great framework to meet and exceed permit requirements while realizing a cost savings.
Meeting the Numbers with Stormwater Treatment

Shirley Clark, Penn State Harrisburg;
Robert Pitt, Penn State Harrisburg

Stormwater treatment in some locations in the U.S. now is required to meet specific numeric objectives as part of the permit requirements. These requirements may address flow rate, volume, and effluent pollutant concentration. Historically, stormwater treatment has focused on flow and/or volume reduction with water quality treatment as an afterthought. Guidance manuals, such as those created by the State of Pennsylvania, provided an estimated percentage reduction in influent concentrations based on a standard design and assumed that this percent removal applied across all influent conditions. The need to meet numeric permit limits cannot be guaranteed if water quality calculations and treatment device selection use these generic percent reductions. It will require designers to better understand and apply the physical, chemical, and biological processes underpinning these treatment technologies. This presentation will use an example of an industrial site with a numeric discharge permit to illustrate how this theoretical information can be translated into the design of a treatment system for not only conventional pollutants of solids, oil and grease, and metals, but also emerging contaminants such as dioxin, mercury, and radionuclides.

Impact of Rainfall Calculation on Capture Volume

Ruth Hocker, Chesapeake Bay Foundation;
Shirley Clark, Penn State Harrisburg

The new federal facilities’ guidance for stormwater management “Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act” set the goal of retaining the 95th percentile storm event on site and managing it through low impact development techniques. The procedure outlined in this technical guidance describes that the 95th percentile rain event can be calculated based on daily rainfall records, typically records based on rain from midnight to midnight. Other researchers and guidance documents have defined a storm event as the total depth of rainfall measured with any time period where there has not been a break in rainfall of a pre-specified time. Typically, this inter-event period between defining separate rain events has been 6 hours. Using this definition, multiple rain events can occur within one day or single rain event may occur over several days. Finally, the state of Pennsylvania uses the difference in pre- and post-development runoff for a site typically calculated using TR-55. Using rain data from approximately 20 National Weather Service rain gauges (minimum of 23 years of record), the 95th percentile calculation was performed using all 3 methods. As expected, the 95th percentile event was larger when the storm
event was calculated using a 6-hour interevent size since many storms, such as Tropical Storm Agnes, occur over several days.

The results show that calculating the 95th percentile storm event using the EISA guidance is approximately equivalent to a 2-year pre-post calculation starting with a C or D soil. These early results show that designed systems using these various methods capture equivalent runoff volume. Therefore, it may be simpler to define the design runoff peak rate and volume based on a rainfall event size that can be readily extracted from NOAA data. This will eliminate the subjectivity of defining pre-development conditions. This paper will focus on the differences in calculating the 95th percentile rain event.

**Feasibility Study of Water Treatment Plant Residuals to Improve Pollutant Removal in SCMs**

*John Komlos, PhD, VUSP; Andrea Welker, PhD, PE, VUSP; Vito Punzi, PhD, VU*

Use of water treatment plant residuals (WTRs) in stormwater control measures (SCMs) is an attractive alternative to landfill disposal of WTRs. WTRs have been shown to be effective at removing phosphate and some metals from stormwater runoff. However, additional research is needed to determine the effectiveness of WTR-amended SCMs in field-scale applications and what modifications can be implemented to improve the performance of WTRs in SCMs. This presentation will discuss how modifications to alum-based WTRs (post filter press) affected hydraulic conductivity, metals leaching and phosphate/metals removal. The as-received WTRs were modified by either oven drying (105°C) or baking (1000°C).

Both modifications resulted in a two order of magnitude increase in hydraulic conductivity compared to post-filter press (as-received) residuals. Drying did not affect the ability of WTRs to remove phosphate, but baking resulted in a decrease in phosphate removal efficiency. Manganese was the only one of the six metals tested (aluminum, iron, manganese, lead, zinc and copper) that showed signs of significant leaching in the as-received and dried WTRs. Baking the WTRs, however, provided a means to prevent Mn leaching. The as-received WTRs and both modifications removed copper, lead and zinc present in stormwater runoff to levels below each metal’s detection limit. Taken together, this research suggests that amending SCMs with modified WTRs has the potential to enhance the water quality improvement processes of SCMs while maintaining the infiltration capacity required for water quantity control.

**Water Quality as a Function of Design Criteria**

*Bridget Pounds, Penn State Harrisburg; Shirley Clark, Penn State Harrisburg*

There are many challenges associated with choosing the most
effective stormwater management device/treatment train for contaminant removal at a particular site, including determining the appropriate treatment technology and sizing the device. Current guidance documents provide estimated percent removals for a select group of pollutants (usually nutrients and total suspended solids [TSS]) and a set of design criteria, usually based on the size of either the drainage area or the impervious area.

The objective of this study is to determine the design criteria that will improve the prediction of removal performance and develop a more effective way to design appropriate treatment technologies to eliminate the problematic contaminants in runoff water at a specific site. The evaluation will be performed using performance analysis results and site design criteria for BMP performance studies contained in the International Stormwater BMP Database. Starting with correlation analyses, the pollutant removal and effluent quality of specific studies in each BMP category with sufficient data is being analyzed with respect to the potential relationship between storm-specific event mean concentrations (EMCs) and site design parameters (impervious area, total drainage area, device size, etc.) and storm characteristics (total runoff volume, etc.).

**Funding Stormwater and Non-point Source Projects (40 Min)**

*5a1*

**Brion Johnson, PENNVEST**

Over the past several years, PENNVEST has provided funding for the design and construction of non-point source pollution projects, including agricultural BMPs, stormwater basin retrofits, and tree plantings (in-stream work is not funded). Recently a change in the law permits PENNVEST to provide funding directly to landowners, rather than requiring private property owners to seek a government project sponsor. Additionally, PENNVEST is working with the PADEP to define a greater role for PENNVEST funding within the structure of municipal stormwater authorities, which have recently been explicitly permitted by recent changes in the law. PENNVEST will present what is known about the implications of these recent changes and explore options for the future role that PENNVEST design and construction funding may be able to play in municipal urban stormwater infrastructure in the future.
PHRC’s Subdivision and Land Development Guidelines

Chris Hine, Pa Housing Research Center, Penn State University; Katie Blansett, Ph.D., P.E., Pa Housing Research Center, Penn State University

PHRC’s Subdivision and Land Development Guidelines: A tool for better design in Pennsylvania Local regulations that haven’t kept pace with DEP regulations and vary greatly between neighboring municipalities can often be a major hurdle to the implementation innovative design and Low Impact Development (LID) techniques. The Pennsylvania Housing Research Center (PHRC) at Penn State University developed the “Subdivision and Land Development Guidelines for Pennsylvania” as a tool that can be used by both local governments and the design community to update local regulations or codes and provide alternative design options.

The Guidelines can be used as a resource by design professionals in requesting waivers of municipalities when existing ordinances are in conflict with other regulations or design goals. The process of developing the guidelines started with an extensive review of existing Subdivision and Land Development Ordinances (SALDOs) in Pennsylvania. Existing standards were complied and research was conducted to determine scientific or engineering justification or basis for current guidelines. A committee of stakeholders provided feedback and met regularly to discuss issues until a consensus was reached. The final document is laid out with two panels: the code and commentary. The code portion of the page presents the guidelines in typical ordinance language. The commentary portion of the page explains in plain English the basis for the guidelines and also provides additional alternatives and options that might be more appropriate under different conditions. Illustrations, photographs and case studies provide further explanation of the code and alternative approaches.

The Guidelines puts science and engineering into code while making it understandable to both technical and nontechnical audiences. The Guidelines cover design standards/criteria for all major areas of land development including, streets, sidewalks, parking, stormwater management, wastewater, potable water and other utilities.

The “Subdivision and Land Development Guidelines for Pennsylvania” are available for download from the PHRC website at www.engr.psu.edu/phrc

Navigating the State and Local Stormwater Framework

Timothy J. Bruno, PADEP - Northwest Regional Office

Stormwater management in Pennsylvania is a complicated web of laws and regulations involving multiple layers of government and permitting. This session will provide a clear
overview of these complex interactions between NPDES Post Construction Stormwater Management and Act 167 Stormwater Management County Plans and Municipal Ordinances. Specific examples from DEP Northwest Region will be presented to show the varying implementation frameworks that counties and municipalities are using to meet their statutory land development and stormwater management responsibilities. Additionally, this presentation will seek to examine where stormwater management may be heading in the coming years, with a brief discussion on multi-municipal service sharing, implementation of low impact development techniques, and future municipal impervious surface fees.

A Karst Case Study: Flow and Water Quality Analysis of Five Urban Watersheds

Katie Blansett, Ph.D., P.E., PA Housing Research Center, Penn State University; James Hamlett, Ph.D., P.E.

Stormwater runoff data for flow and water quality were collected for three years from seven locations in five urban karst watersheds in the limestone Nittany Valley in Centre County. The watersheds ranged in size from 93.5 to 231.7 hectares and total impervious area ranged from 23.4% to 67.3%. The hydrologic response and water quality characteristics were compared among the study watersheds with different land uses and percentages of impervious areas and then the response from the karst watersheds were compared to values from non-karst watersheds.

Median runoff ratios (RR, runoff volume/rainfall volume), based on more than 60 events for these urban karst watersheds (0.02 to 0.28) were found to be less than regional values (0.4 to 0.5) and less than values from the EPA National Urban Runoff Program (NURP) studies (0.5 to 0.62) for watersheds with similar imperviousness. Using the RR based on percentage of impervious area from the NURP data to predict runoff would result in overestimating the volume of runoff in these watersheds by 164% to 1,400%. Water quality samples were collected during 13 events and the event mean concentration was calculated based on the time-based sampling for each event. For total suspended solids (% difference: 45 – 353%), copper (% difference: 115 – 490%), lead (% difference: 1,720 – 4,330%), and zinc (% difference: 26 – 296%), the measured concentration data from this study were less than the data from the NURP studies. Annual nitrogen and phosphorus loads for these study watersheds as calculated by the Simple Method were much less than what would be expected for other non-karst watersheds with similar imperviousness. Based on impervious area, the Simple Method over-estimates the annual loads of phosphorus by 171% to 514% and nitrogen by 831% to 3,157% for these karst watersheds. This study shows that standard reference values for design of stormwater management facilities are not appropriate in the study karst watersheds.
Integration of WQ Data with Mainstream GIS

Evgeny Nemirovsky, PE, Villanova University; Andrea Welker, PhD, PE, Villanova University

Integration of environmental quality data in general, and water quality data in particular, with mainstream geographical information systems (GIS) is essential for effective strategic planning, monitoring and maintenance, public awareness, etc. Despite this need, water quality information is not readily available for general public. Even among professionals the large-scale state of affairs picture is often missing.

Although stormwater control measures (SCMs) have been identified as a tool of choice for water quality improvement, their downstream effects, and thus, their cost-effectiveness, are extremely difficult to assess. The proper design, installation, and maintenance of SCMs are critical for ensuring their effectiveness, longevity and, ultimately, acceptance. Lack of a “one-stop-shop” for water quality might be due to limited availability of the data, de-centralization, funding, monitoring difficulties, ambiguity with interpretation, complexity of the analysis, potential sensitivity of the findings, etc. To advance water quality field by aggregating and interpreting all available data, the need for a robust data integration platform is evident.

The authors propose a ground-up approach to integrate all existing data using main-stream GIS platforms, cloud-computing, and crowd-sourcing potential of the general public connected to the WWW. The proposed framework is inherently recursive, which makes it suitable for data input and presentation at any scale. The framework would include modules such as water quality assessment, SCM inventory and monitoring, citizen-scientist recruitment, and R & D. The platform would enable, in real-time, holistic assessment and visualization of water quality status, cost-benefit analysis of current SCMs, trends analysis, identification of the impacted zones, relative comparison, and many other capabilities for decision-making and strategic planning.

Panel - Pennsylvania's Next SCM Manual (40 Min)

Pennsylvania Stormwater Technical Workgroup - 2013 VUSP Discussion Group

The purpose of PaSTW is to install good science into stormwater implementation. Our current mission is updating the Pennsylvania Stormwater Best Management Practices Manual, and providing scientific and ecological guidance to assist designers and reviewers in implementing state of the art stormwater technology. This project is a Public/Private partnership with the Pennsylvania Department of Environmental Protection. The discussion session will examine the need for an updated manual, and the floor will be open for suggestions from the stormwater community now, when input counts. PaSTW is comprised of regulators,
Proven Viability of a Multi-Well Gravity Drain System During 3 Years of Stormwater Injection


This presentation describes the operation and performance during the 3-year post installation period of a first-of-its-kind stormwater management system consisting of gravity drains to transfer stormwater to below grade aquifers. The project location is a 130-acre planned development site in karst limestone terrain in the greater Philadelphia area. During this 3-year period of operation, slightly more than 230 million gallons of pre-treated stormwater have been managed and transferred to the karstic aquifer beneath the site. A gravity drain system is most productive in a geologic environment with comparatively large interconnected permeability, such as found in karstic limestone and dolomite, or coarse sand and gravel deposits, both above and below the water table. The system that is described here is a distributed array of 19 large-diameter, low pressure injection wells which encounter karstic permeability between 75 feet and 135 feet below grade. The initial concept was described in 2008 by Lolcama and Gauffreau in ASCE Geotechnical Special Publication 178, and the engineering, construction, and start-up of the system was described by Lolcama, Gauffreau and others in the 2011 Philadelphia Low Impact Development Symposium Proceedings.

The gravity drain system integrates institutional pollution controls above ground, Vortechs water pre-treatment technology, a stormwater retention basin, a flow-control valve, water-tight underground piping, and injection wells located in manholes. The flow rate to the injection well field is monitored remotely using automated sensors to collect and convey information to a secure data center. Similarly, the water table and groundwater temperature conditions beneath the injection well field are automatically monitored and uploaded to a data center, and reported to the project hydrogeologist who directs the operation of the well field. The water quality within the aquifer is monitored at up-gradient and down-gradient locations to confirm net zero impacts from the injection well field use.

The gravity drain system is exceeding the goals as specified in the NPDES permit for the site, which are: to manage more than a 2-year 24 hour storm event, without sinkhole formation.
or other ground disturbance, while demonstrating sustainable high capacity stormwater disposal. Furthermore, the engineered system has demonstrated that it can accommodate the demands of additional stormwater from the phased build-out of the planned development.

Inconsistencies and Sensitivities in Encased Borehole Soil Infiltration Procedures in Pennsylvania

Timothy B. Carlin, P.E., Earth Engineering Incorporated; John M. Caccese, P.E., Earth Engineering Incorporated

Field measurements of infiltration rates of soils in Pennsylvania via the encased borehole method are not specifically governed by the Pennsylvania Department of Environmental Protection’s (PADEP) Pennsylvania Stormwater Best Management Practices Manual. Protocols are based on the Maryland Stormwater Manual and supplemental information provided by the PADEP. The supplemental information contains an algebraic error and do not provide guidance for implementation of the test apparatus which could lead to inaccurate estimations of hydraulic conductivity. The method of measuring hydraulic conductivity of soils by encased borehole method is subject to sensitivities caused by the implementation of the test apparatus. Standardization of the test procedure within the Pennsylvania Stormwater Best Management Practices Manual would minimize variation in test results statewide due to these sensitivities.

Urban Soils & Suitability for Green Infrastructure

Stephen Dadio, CPSS, CEDARVILLE Engineering Group, LLC; April Barkasi, PE, CEDARVILLE Engineering Group, LLC; Russell Losco, PG, Lanchester Soil Consultants

Infiltration-based green infrastructure and engineered retrofits for stormwater capture (e.g., cisterns) are increasingly seen as management options to reduce stormwater volume contribution to overstressed combined systems. The objectives of this study were to use standard soil taxonomic and hydrologic assessment methods to describe urban surface- and sub-soil hydraulic properties within a set of sites selected for their potential to contribute to mitigation of sewer overflows. Soils were generally silt- to silty- clay loams with low permeability. Subsoil permeability was highly-variable, with generally slow drainage in most sites, with the exception of managed areas that had a high proportion of buried debris or intentional gravel bedding around an existing pipe-based stormwater detention system. However, our field data can be used for sizing green infrastructure and otherwise adjust expectations for its performance.
Addressing Erosion with Nontraditional Techniques

Lichuan Chang, Princeton Hydro, LLC

Traditional stormwater features such as basins, inlets, and their associated conveyance systems have been designed for decades throughout the United States. These have been proven to be an effective means to convey stormwater runoff away from our properties and roadways, but what happens to that water downstream? The practice of “out of sight, out of mind” comes back to haunt us when the poorly designed stormwater features floods out our neighbors’ properties or creates erosion and water quality problems in our parks and neighboring communities.

New Jersey has long been known to have stringent standards set by the regulatory agencies with the intent to protect offsite properties from erosion and reduce impacts associated with flooding and water quality.

In 2012, Conservation Resources, Inc. contracted Princeton Hydro to provide design, permitting, and construction services for a demonstration restoration project within the Borough of Emerson, Bergen County, New Jersey. For this project, Princeton Hydro was tasked with addressing a chronic erosion problem in an intermittent stream channel discharging into Oradell Reservoir. Princeton Hydro studied the hydrologic and hydraulics of the channel to identify shear stresses and velocities in the existing channel and to design measures to ensure that the channel erosion would not persist. Various channel design techniques were incorporated including the use of soil bioengineering, boulder toe, live stakes, and step-pools. A comprehensive landscape restoration plan was also incorporated into the design. Design plans and permits were completed in the winter and early spring of 2013. RiverLogic Solutions, LLC is constructing the project planned to be completed by the fall of 2013.
Poster Presentation Abstracts
Getting the Water Right: Stroud Water Research Center

Michele Adams, PE, Meliora Environmental Design; Molly Julian, Meliora Environmental Design

At Stroud Water Research Center’s new environmental education building, “getting the water right” became the guiding principal. Water is fully integrated as a resource, with rainwater that falls on the roof serving to flush toilets and support science research before being treated in a wetland wastewater treatment system. Water that is returned to the groundwater is cleaner than the water withdrawn. The green roof absorbs rainfall, while the site is designed with over a dozen rain gardens throughout the landscape. The result is a site where less water and pollutants leave the site after the building has been constructed. Combined with the native landscape, the result is a new building that begins to behave – from a water perspective- more like a forest than a new development. But living up to Mother Nature’s standard is not always easy. This presentation will discuss the design goals, regulatory limitations, and construction challenges in “getting the water right”. Discussion will include lessons learned, as well as successes achieved, including the creation of a building that is beautiful, functional, and a place for research and education to learn how more buildings can “get the water right”.

Wetland Restoration: Undoing the Damage

Kristina M. Peacock-Jones, P.E., Princeton Hydro, LLC

A five-acre portion of floodplain wetland complex downstream of two community lakes was targeted for enhancement by The Hideout, a large lake-oriented community in the Poconos, PA. Ariel Creek, a High Quality Cold Water Fishery (HQ-CWF) stream in the Lackawaxen Basin which drains to the Delaware River, runs adjacent to the existing undeveloped floodplain. A review of historical and recent aerial photos revealed that, prior to 1969, the stream channel meandered sinuously across the wetland, in contrast to its current straight alignment along the eastern edge of the channel corridor. The channel appears to have been straightened and portions of the floodplain filled to “reclaim” the land for agricultural use.

While realignment of the stream to its original meandering path was considered, disturbance to the surrounding wetland would have created regulatory conflicts. Instead, a compromise design included two large, shallow emergent wetland backflow areas, limited floodplain benches along the stream, and extensive riparian plantings. The regraded floodplain wetland will be replanted with native trees, shrubs (live stakes and pots), and herbs according to the anticipated hydrologic conditions. Also, large woody debris was incorporated in key areas to protect sensitive bank areas and provide habitat. As such, proposed conditions will serve as a naturally functioning
sustaining wetland system with greater flood storage and stormwater pollutant removal capacity than existing conditions. At the client’s request, the project was designed in two phases. The second phase of the project will include invasive species control over the areas not mitigated through excavation and the establishment of a forested wetland system.

This floodplain wetland enhancement will provide a number of benefits: improve floodplain connection, increase flood storage, increase habitat values by controlling monoculture of non-native invasives (reed canary grass), and reestablish a native floodplain wetland community with a variety of native plants. This enhancement will also increase the removal and processing of nutrients, sediment and other pollutants from Ariel Creek prior to reaching Roamingwood Lake downstream.

Site Sustainability and Stormwater Management

Brian R. Perry, P.E., LEED AP (BD+C), Thomas E. O’Shea, P.E., Christine E. Yeatman, P.E.
Van Note-Harvey Associates, P.C.

Princeton University, in partnership with American Campus Communities, is proposing a two-phased development of an expanded rental community for the University’s staff in Princeton, Mercer County, New Jersey consisting of a total of 326 dwelling units including townhomes, stacked flats, and multi-family units on a 25-acre site. Other site improvements include the construction of a Community Building, parking lots, and internal roads with parallel on-street parking. Two key design elements of this project are limiting land disturbance and tree clearing to the maximum extent practicable and the incorporation of low impact development (LID) techniques. Under the first phase of development (approximately 9-acre site), paved areas will be constructed primarily of porous asphalt paving. Under the second phase of development (approximately 16-acre site), existing buildings will be demolished and new units will be constructed within the existing building footprints and the existing roadway horizontal geometry will be held to minimize the removal of trees.

Stormwater management for the proposed development will be provided for the development, described above, through an integrated combination of non-structural and structural Best Management Practices (BMPs). Such measures include use of the porous asphalt pavement areas within the first development phase, underground storage systems proposed below roadways and adjacent lawn areas, vegetated swales, and low-maintenance and native landscaping. The proposed stormwater management systems on-site have been designed to meet governing local and state stormwater management criteria. The applicant is applying for LEED Certification for Homes for the proposed development and will gain credits through the use of maintaining a “permeable lot” with the integration of porous pavement, compact development strategies, and the use
of Manufactured Treatment Devices to provide additional water quality treatment.

The exhibit focuses on the integration of the proposed stormwater management system within a residential University development.

**Reduced Flows Through Integrated SWM BMPs**

*Ralph A. Petrella, PE, Van Note-Harvey Associates, P.C.*

Princeton University finished the construction of the first phase of development for a High-Performance Computer Research Center (HPCRC) on the James Forrestal Campus of the Princeton Forrestal Center in Plainsboro Township, Middlesex County, New Jersey. Construction of the initial phase consisted of a computing plant, administration office, mechanical area, access drive and on-site parking. The final, future phase will expand the computing plant portion of the new building. Stormwater management will be provided for the development, described above, through an integrated combination of non-structural and structural Best Management Practices (BMPs). The primary measure of stormwater management is the use of the porous asphalt pavement areas within all new vehicular pavement parking and driveway areas with underground stone storage and a perforated underdrain system designed to allow runoff to infiltrate on-site. The proposed underground stone storage system was constructed into four separate “bays” to maximize efficiency of the storage provided in the stone and limit excavation. The “bays” were designed to temporarily store runoff and promote groundwater recharge before overflowing into the next “bay.” Additional BMPs that have been incorporated into the site design include a rain garden, vegetated swales and low-maintenance/native landscaping.

The proposed stormwater management systems on-site were designed to meet governing local and state stormwater management criteria. The applicant received Gold LEED Certification for the proposed development, being one of only nine data centers in the world to receive this level of certification as of February 2013. Site measures implemented into the design to obtain gold certification included the reduction of peak runoff rates leaving the site, providing water quality through the use of porous pavement and rain garden, and reducing lighting pollution. The exhibit focuses on the integration of the proposed stormwater management system within this Project site.

**Aramingo Ave Shopping District GSI Master Planning**

*Gil Rodriguez, MSSD, LEED AP, AKRF*

*Ashley DiCaro, LEED AP, Interface Studio LLC*

The Aramingo Ave Shopping District is an important commercial corridor located in the Port Richmond section of
Philadelphia. The District includes a variety of major retailers, smaller specialty shops, and chain restaurants. The nearly 70 acres of highly impervious area within the corridor generate large volumes of unmanaged stormwater runoff that feed into the city’s already taxed combined sewer system (CSO). Additionally, the lack of trees and attractive landscape features in the public right-of-way and within private commercial properties create an unwelcoming environment for pedestrians and shoppers, which may be detracting from the level of economic activity within the corridor.

Impact Services, a community development corporation that manages the Aramingo Business Improvement District, in collaboration with Interface Studio and AKRF, is developing a green infrastructure master plan for the shopping district. The plan, which was funded through the Philadelphia Water Department’s (PWD’s) Stormwater Management Incentives Program, outlines investments in green stormwater infrastructure within the public right-of-way and private commercial properties.

The plan will have both city-wide benefits and benefits for local property owners. On a city-wide scale, the plan will outline strategies to reduce stormwater runoff to CSOs, helping to implement Green City: Clean Waters, PWD’s long term plan to reduce CSOs. Locally, the plan will develop a number of site-specific green infrastructure concept designs that, once implemented, will allow property owners to reduce their stormwater management service (SWMS) charge through PWD’s stormwater credit program. This program rewards non-residential property owners who manage stormwater using green infrastructure.

Finally, the plan’s implementation will attract more visitors to the corridor and enhance the shopping experience by creating a more pedestrian-friendly environment and an aesthetically attractive landscape. These improvements will increase the level of sustained economic activity, provide a more stable customer base for existing businesses, and create new opportunities for future businesses.

**Recycled Materials for Green Roof Media**

Katherine Baker, Yen-Chih Chen, Shirley Clark
Penn State Harrisburg

This research examined the potential to use shredded waste tires as the inorganic component of the medium and agricultural/municipal compost as the organic component, replacing expanded shale or slate and peat moss. The initial hydraulic studies focused on developing a mixture that could retain sufficient water for the growth of plants while not retaining excess water. In addition to hydraulics, we also examined water quality from the media. One concern raised with the use of composts in green roof media is the release of pathogenic microorganisms and chemical contaminants, particularly inorganic nutrients. We examined the leaching of
E. coli and selected chemicals of concern from systems containing commercially available media (peat/expanded shale) as well as two recycled media (compost/rubber, biosolids/rubber). There were no significant differences between the media and no coliform concentrations exceeded the USEPA Recreational Water Standards. The addition of microorganisms also had a positive benefit – the release of inorganic nitrogen was reduced as the microbial community incorporated it into the biomass. The final laboratory-scale studies involved establishing replicate planted (grass) microcosm systems to compare commercial and recycled media. Over the course of the study, the recycled media performed at least as well as, and for several parameters better than, the conventional medium. Furthermore, there were substantial differences in the release of inorganic nutrients in leachate when planted (grass) and non-planted systems were compared. There was no significant release of inorganic nutrients in the leachate from planted systems. These results demonstrate that the impact of organisms on the biogeochemical cycling of nutrients and other materials.

**Raising the Bar on Nutrient Removal**

**P7**

**Derek Berg, CONTECH Engineered Solutions**

As the regulatory framework that drives our stormwater management decisions has become increasingly stringent in recent years we have collectively strived to identify more effective stormwater best management practices (BMPs). Instead of focusing predominantly on the removal of suspended solids and attenuating peak flows, we are now tasked with deploying BMPs that are able to remove significant fractions of the nutrients, metals and other common pollutants in stormwater runoff. Recognizing that to consistently achieve high levels of phosphorus removal it is often necessary to effectively sequester and retain both particulate and dissolved phosphorus, CONTECH Engineered Solutions (CONTECH) devoted several years of research to develop a unique filtration media known as PhosphoSorb for applications targeting high levels of phosphorus removals. After successfully completing an extensive suite of laboratory evaluations CONTECH began exploring opportunities to evaluate the effectiveness of PhosphoSorb in actual field installations.

In the fall of 2010 CONTECH agreed to participate in an extensive 3rd party field evaluation of PhosphoSorb media deployed in the Stormwater Management StormFilter (StormFilter) at a parking lot site owned by Mitchell Community College in Mooresville, NC. Independent oversight of all aspects of the project was provided by representatives of North Carolina State University. During the 20 month monitoring period 13 qualifying storm events representing 23.73 inches of precipitation were successfully sampled and analyzed for a suite of stormwater pollutants.

The results demonstrate that the StormFilter with PhosphoSorb media was highly effective at removing stormwater solids and
Applying the efficiency ratio method to the entire dataset the system reduced TSS by 90.4%, SSC by 98.3%, TP by 86.1%, Diss. P by 74.2%, Ortho P by 82.5% and TN by 55.9%.

This presentation will provide an overview of PhosphoSorb media as well as a detailed discussion of the independent field evaluation of the StormFilter with PhosphoSorb media that was recently completed in Mooresville, NC. System configuration, monitoring methods and subsequent results will be presented and discussed.

Demolition & Impacts on Urban Soils and Hydrology P8

Stephen Dadio, CPSS, CEDARVILLE Engineering Group, LLC; Russell Losco, PG, Lanchester Soil Consultants; April Barkasi, PE LEED AP, CEDARVILLE Engineering Group, LLC

One often overlooked area in urban redevelopment is the role of demolition. One of the first steps in urban renewal projects for blighted neighborhoods is to demolish abandoned properties. However, there is very little information known about the existing soil conditions prior to demolition, the practice of the demolition itself, and then the subsequent backfilling of soil into the former building envelope. With good planning, these soils can be used as a basis for green infrastructure, which can provide source control for stormwater runoff volume, add greenspace to urban areas, and create land value through rendering these human services. A thorough accounting of pre-demolition soils must be conducted prior to demolition to ensure a consistency of soils and their quality with regard to supporting GI, and throughout the urban landscape.

Desktop Screening of Outfalls to Identify Candidate Retrofit Sites – A Case Study for the Philadelphia Water Department P9

Brett Long, Biohabitats; Ted Brown, PE, Biohabitats; Joe Knieriem, McCormick Taylor

The Philadelphia Water Department (PWD) has a well-established history of pursuing and implementing meaningful retrofit treatment practices at stormwater outfalls. These controls provide a range of ecosystem services including: cleaning water, providing habitat, enhancing public open space, and providing local flood mitigation. Until recently, the projects pursued have been primarily opportunistic, being driven by committed stakeholders and staff or to address local nuisance and maintenance issues. PWD recognized the need to develop a more proactive and science-based planning process to identify a broader inventory of opportunities for restoration at outfalls. A priority was placed on establishing a rapid, repeatable, and effective desktop method to screen stormwater
outfalls for retrofit potential before devoting resources to detailed field assessments.

PWD developed a set of ten screening factors to evaluate outfall suitability for retrofitting, including: hydraulics, utilities, property ownership, impervious cover treated, earthwork (excavation), accessibility, clearing & grubbing, historical / cultural, practice area to drainage area ratio, and watershed health. In addition, weighting schemes were established to allow sites to be ranked for retrofit feasibility.

The screening approach is intended more to remove infeasible sites from further consideration as opposed to identifying the top retrofitting candidates. A geodatabase was developed to store all spatial and tabular information associated with the desktop outfall assessments. This geodatabase structure is scalable. If there is a need to track new information, it’s easy to add new related tables or new fields to existing tables. The initial phase was tested and refined on 23 outfalls. Field verification occurred on a subset of these. Phase 2 scaled the effort up to the remaining 400 outfalls in PWD’s separate sewer area.

This presentation will review the key elements of the screening process, the underlying data structure of the geodatabase, and the findings based on statistical and qualitative analysis of the assessments performed on the full suite of 400 outfalls in the city’s separate sewer area. Finally, the presentation will discuss how the screening tool has influenced PWD’s planning process and streamlined their efforts to develop an inventory of candidate capital project.