CTE National Broadcast Series Presents

International Stormwater BMP Database: A Resource for BMP Selection and Design Guidance

November 29, 2006
1:00 – 3:00 p.m., EST

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Welcome and Introduction of Moderator
(1:00 – 1:05 p.m., EST)

Katie McDermott
Technology Transfer Director
Center for Transportation and the Environment
North Carolina State University
(Raleigh, NC)

Program Overview and
Introduction of Panel
(1:05 – 1:10 p.m., EST)

Jeff Moeller, P.E.
Senior Program Director
Water Environment Research Foundation
(Alexandria, VA)

International Stormwater
BMP Database:
Coalition Partners

- Water Environment Research Foundation (WERF)
- Federal Highway Administration (FHWA)
- American Society of Civil Engineers – Environmental & Water Resources Institute (ASCE-EWRI)
- American Public Works Association (APWA)
- Environmental Protection Agency (EPA)
Acknowledgements: Steering Committee Members

- Jeff Moeller, WERF
- Patricia Cazenias, FHWA
- Brian Parsons, ASCE-EWRI
- Colene Carter, APWA
- Eric Strassler, EPA

Acknowledgements: Project Subcommittee (PSC) Members

- Ben Urbonas, Urban Drainage and Flood Control District (PSC Chair)
- Richard Tveten, Washington State DOT
- Michael Barrett, University of Texas
- Bob Carr, Water Resources Modeling
- Gregory Granato, U.S. Geological Survey
- David Graves, New York State DOT
- Jesse Pritts, EPA
- Shaw Yu, University of Virginia

Acknowledgements: Project Team

Co-Principal Investigators:
- Jon Jones, Wright Water Engineers, Inc.
- Eric Strecker, GeoSyntec Consultants
- Jane Clary, Wright Water Engineers, Inc.
- Jon O’Brien, Wright Water Engineers, Inc.
- Marcus Quigley, GeoSyntec Consultants
International Stormwater BMP Database

AGENDA – Hour 1

• Program Overview/Introduction of Panel
  Jeff Moeller, WERF
• BMP Database Background
  Ben Urbonas, Urban Drainage & Flood Control District
• BMP Database Findings & Uses
  Eric Strecker, GeoSyntec Consultants
• BMP Performance Monitoring & Available Guidance
  Marcus Quigley, GeoSyntec Consultants
• DOT Case Study
  Richard Tveten, WashDOT
• Panel Discussion: Potential Uses of Database
  Entire Panel w/Audience Q&A

International Stormwater BMP Database

AGENDA – Hour 2

• Local Agency Case Study
  Ben Urbonas, Urban Drainage & Flood Control District
• Panel Discussion and Audience Q&A
  Entire Panel w/Audience
• Closing Remarks
  Jeff Moeller, WERF

WERF Stormwater Research Program

• Over 60+ ongoing and completed stormwater projects to date valued at $17+ million
• www.werf.org
WERF Subscriber Stormwater Survey

Ranking by Mean Score

<table>
<thead>
<tr>
<th>Rank</th>
<th>Stormwater Research Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stormwater Controls (BMPs)</td>
</tr>
<tr>
<td>2</td>
<td>Receiving Water Effects</td>
</tr>
<tr>
<td>3</td>
<td>TMDLs</td>
</tr>
<tr>
<td>4</td>
<td>Source Identification and Control</td>
</tr>
<tr>
<td>5</td>
<td>Monitoring</td>
</tr>
<tr>
<td>6</td>
<td>Indicators</td>
</tr>
<tr>
<td>7</td>
<td>Modeling</td>
</tr>
<tr>
<td>8</td>
<td>Program Management</td>
</tr>
<tr>
<td>9</td>
<td>Conveyance and Storage</td>
</tr>
<tr>
<td>10</td>
<td>Land Use</td>
</tr>
<tr>
<td>10</td>
<td>Communication/Public Education</td>
</tr>
</tbody>
</table>

Ranking by Mean Score of
Need for Information on Various Aspects of Stormwater Controls (BMPs)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Need for Information on Aspects of BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>2</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>3</td>
<td>Whole Life Costs</td>
</tr>
<tr>
<td>4</td>
<td>Performance Standards</td>
</tr>
<tr>
<td>5</td>
<td>Fate of Captured Pollutants</td>
</tr>
<tr>
<td>6</td>
<td>Mechanical vs. Natural Systems</td>
</tr>
<tr>
<td>7</td>
<td>Retrofitting</td>
</tr>
<tr>
<td>8</td>
<td>Regional vs. Smaller Systems</td>
</tr>
</tbody>
</table>

BMP Database Background
(1:10 – 1:20 p.m., EST)

Ben Urbonas, P.E., D.WRE, M.ASCE
Urban Drainage and Flood Control District
(Denver, CO)
What is the “International BMP Database”?

- Collection of BMP Field Test Data linked to site conditions and design parameters.
- Contains data from sites throughout the United States and other countries.
- All data submitted undergoes a Q&A check
- It is supported by a broad coalition of partners that include: WERF, EPA, EWRI of ASCE, APWA, FHWA, Caltrans, WSDOT.
- WERF leads/coordinates this coalition.

The Problem in ‘94 and Now

- Widespread use of BMPs without sufficient understanding of performance and factors affecting performance
- Inconsistent data collection and reporting
  - Limit objective comparisons and evaluations
  - Wide range of reported “effectiveness”

Addressing the Problem
(Efforts from 1995-2007)

- **History**: Initial funding from USEPA in 1995 of the Urban Water Resources Research Council of ASCE.
- **Goal**: To gather and distribute sufficient technical design/performance information to
  - Provide technical data for research
  - Improve BMP selection
  - Improve BMP design
  - Foster cost-effective stormwater solutions
**Key Tasks**

- Develop standardized BMP performance data reporting protocols
- Compile data of BMP performance in USA and other countries
- Develop a database and store data on BMP performance, the facility’s site conditions, and design parameters
- Analyze data using rigorous standardized statistical protocols
- Continue populating the database to help improve BMP designs and their proper applications

---

**Standardized Data Reporting Protocols**

(Software and/or Spreadsheets)

![Image of database interface](image)

**General Test Site Information**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Name</td>
<td>Test site identification</td>
</tr>
<tr>
<td>Location</td>
<td>Geographic coordinates</td>
</tr>
<tr>
<td>Date</td>
<td>Test date</td>
</tr>
<tr>
<td>Site Size</td>
<td>Area or volume</td>
</tr>
<tr>
<td>Facility Information</td>
<td>Additional site details</td>
</tr>
</tbody>
</table>

**Watershed Data**

![Image of database interface](image)

**Watershed Information**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Name</td>
<td>Watershed identification</td>
</tr>
<tr>
<td>Location</td>
<td>Geographic coordinates</td>
</tr>
<tr>
<td>Date</td>
<td>Date of data collection</td>
</tr>
<tr>
<td>Site Size</td>
<td>Area or volume</td>
</tr>
<tr>
<td>Facility Information</td>
<td>Additional watershed details</td>
</tr>
</tbody>
</table>

*Note: Fields in blue are required, those in black are not.*
General BMP Design Info

BMP-Specific Design Data for the Media Filter Example

- Permanent Pool
  - Volume of Upstream Pre-Setting Pool, If Any
  - Surface Area & Length
  - Drain (emptying) Time
- SurchARGE Detention Above Upstream Pool and Filter Media
  - Volume
  - Surface Area
  - Length & Depth
- Media Filter
  - Angle of Sloping or Vertical Filter Media
  - # of Media Layers in Filter
  - Type & Depth of Each Layer

- Cost Data (Nice to Have)
  - Excavation
  - Basin Construction
  - Filter Construction
  - Structural Control Devices
  - Engineering and Overhead
  - Land Costs or Value
  - Sediment Removal and Media Replacement Costs

Note: All fields required, except those in yellow.

Monitoring Stations
Water Quality Data

On-line Database Search Criteria

Cumulative Data Analysis Reports Available to Public
Benefits to Date

- BMP data and analysis reports are available to the public on the project Web site (www.bmpdatabase.org)
- Database continues to grow with entry and analysis of new BMP studies—nearly 250 studies to date
- Increased recognition of analysis protocols
- Interpretive reports/data summaries
- Project team continues work on improving user access and friendliness

BMP Database Findings & Uses
(1:20 – 1:30 p.m., EST)

Eric Strecker, P.E.
GeoSyntec Consultants
(Portland, OR)

Current Studies in BMP Database

<table>
<thead>
<tr>
<th>BMP CATEGORY</th>
<th>NUMBER OF BMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>Biofilter</td>
<td>59</td>
</tr>
<tr>
<td>Detention Basin</td>
<td>26</td>
</tr>
<tr>
<td>Hydrodynamic Device</td>
<td>23</td>
</tr>
<tr>
<td>Infiltration Basin</td>
<td>1</td>
</tr>
<tr>
<td>Media Filter</td>
<td>38</td>
</tr>
<tr>
<td>Percolation Trench/Well</td>
<td>1</td>
</tr>
<tr>
<td>Porous Pavement</td>
<td>5</td>
</tr>
<tr>
<td>Retention Pond</td>
<td>37</td>
</tr>
<tr>
<td>Wetland Basin</td>
<td>15</td>
</tr>
<tr>
<td>Wetland Channel</td>
<td>14</td>
</tr>
<tr>
<td>Total Structural</td>
<td>210</td>
</tr>
<tr>
<td>Non-Structural</td>
<td></td>
</tr>
<tr>
<td>Maintenance Practices</td>
<td>26</td>
</tr>
</tbody>
</table>
Recommended Measures of BMP Performance

- How much stormwater runoff is prevented? ("hydrological source control")
- How much of the runoff that occurs is treated by the BMP or not ("hydraulic performance")?
- Of the runoff treated, what is the effluent quality? ("concentration characteristics achieved")
- Does BMP address downstream erosion impacts?

Percent Removal is Very Problematic and SHOULD NOT be used as a performance measure for BMPs.

Runoff Volume Control

- ET losses
- Infiltration

Runoff Volume Control

Consider “credit” for volume reduction in design requirements

<table>
<thead>
<tr>
<th>BMP Type</th>
<th>Mean Measured Outflow/Mean Measured Inflow for Events Where Inflow is Greater Than or Equal to 0.2 Watershed Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detention Basins</td>
<td>0.70</td>
</tr>
<tr>
<td>Biofilters</td>
<td>0.62</td>
</tr>
<tr>
<td>Media Filters</td>
<td>1.00</td>
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<tr>
<td>Hydrodynamic Devices</td>
<td>1.00</td>
</tr>
<tr>
<td>Wetland Basins</td>
<td>0.95</td>
</tr>
<tr>
<td>Retention Ponds</td>
<td>0.93</td>
</tr>
<tr>
<td>Wetland Channels</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Potential Future Volume Reduction Analyses

- Characterize based upon storm sizes (volumes and/or rates of inflow – hydraulic loading rate)
- Assess if BMPs in certain soil types and/or with amended soils/growing media perform better
- Infiltration vs. evapotranspiration as a loss mechanism

Box plots of the fractions of Total Suspended Solids (TSS) removed

Box plots of the Observed Total Suspended Solids effluent quality of selected BMP types
Box plots of effluent quality of selected BMP types for Total Phosphorus and Total Copper

BMP Effluent Quality Data Use

Box plots of effluent quality of selected BMP types for Fecal Coliform and Fecal Coliform inflow and outflow by event.
Lake George Field Study Evaluation

Hydrodynamic BMP

<table>
<thead>
<tr>
<th>Event#</th>
<th>Interpolated TSS in (mg/L)</th>
<th>Arithmetic TSS in (mg/L)</th>
<th>Interpolated TSS out (mg/L)</th>
<th>Arithmetic TSS out (mg/L)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>128.14</td>
<td>88.10</td>
<td>263.18</td>
<td>205.98</td>
<td>73%</td>
</tr>
<tr>
<td>2</td>
<td>128.73</td>
<td>88.20</td>
<td>59.23</td>
<td>59.18</td>
<td>54%</td>
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<tr>
<td>3</td>
<td>1040.04</td>
<td>882.13</td>
<td>337.87</td>
<td>486.75</td>
<td>68%</td>
</tr>
<tr>
<td>4</td>
<td>213.73</td>
<td>225.42</td>
<td>359.14</td>
<td>388.08</td>
<td>-68%</td>
</tr>
<tr>
<td>5</td>
<td>1673.57</td>
<td>1217.53</td>
<td>71.39</td>
<td>102.84</td>
<td>96%</td>
</tr>
<tr>
<td>6</td>
<td>535.16</td>
<td>603.54</td>
<td>70.14</td>
<td>85.23</td>
<td>87%</td>
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<tr>
<td>7</td>
<td>180.81</td>
<td>132.22</td>
<td>29.76</td>
<td>34.88</td>
<td>84%</td>
</tr>
<tr>
<td>8</td>
<td>2491.55</td>
<td>2202.78</td>
<td>35.41</td>
<td>35.47</td>
<td>99%</td>
</tr>
<tr>
<td>9</td>
<td>99.99</td>
<td>76.60</td>
<td>31.98</td>
<td>33.14</td>
<td>64%</td>
</tr>
<tr>
<td>10</td>
<td>1047.02</td>
<td>2257.46</td>
<td>37.08</td>
<td>31.22</td>
<td>96%</td>
</tr>
<tr>
<td>11</td>
<td>439.45</td>
<td>344.86</td>
<td>16.57</td>
<td>13.83</td>
<td>96%</td>
</tr>
<tr>
<td>12</td>
<td>445.19</td>
<td>291.58</td>
<td>17.36</td>
<td>14.91</td>
<td>95%</td>
</tr>
<tr>
<td>13</td>
<td>1156.16</td>
<td>674.94</td>
<td>44.72</td>
<td>37.91</td>
<td>94%</td>
</tr>
</tbody>
</table>

Averages: 802.22/15 745.49/54 105.67/92 117.64/77 87% 84%

(Winkler and Gussa 2002)

- Is an average of 100+ mg/l TSS acceptable performance?

Percent Removal Use Results

- BMPs improperly "rejected"
- BMPs improperly "accepted"
- "Daisy-Chaining" BMPs and applied % removals at each step that highly over predicts performance
- Improper use of TSS as the sole indicator of performance
- Etc. Etc.

Recommended Measures of BMP Performance

- How much stormwater runoff is prevented? ("hydrological source control")
- How much of the runoff that occurs is treated by the BMP or not ("hydraulic performance")?
- Of the runoff treated, what is the effluent quality? ("concentration characteristics achieved")
- Does BMP address downstream erosion impacts?

Percent Removal is Very Problematic and SHOULD NOT be used as a performance measure for BMPs.
Analysis Findings Cont.

- These basic BMP performance description elements can be utilized to more accurately:
  - assess the concentrations that BMPs are able to achieve (concentration TMDLs),
  - assess BMP effects on total loadings (TMDLs),
  - estimate the frequency of potential exceedances of water quality criteria or other targets, and

Example BMP Database Use

- Design of BMPs and Urban Drainage Water Quality Facilities
- California Expert Panel on Feasibility of Numeric Effluent Limits
- Lake Tahoe TMDL Development (what is achievable for setting of TMDLs)
- Los Angeles BMP Performance Tool
- WERF and NCHRP Research Reports on Unit Processes and Observational Data for BMP Selection and Design

Database Web Site:
BMP Performance-Fact Sheets
Database Website: Articles, Reports, and Presentations

Website

- Download spreadsheets with data and/or statistical summaries
- Download specific BMP study information

www.bmpdatabase.org

Summary

- Database and follow-on efforts provide a much improved basis for BMP Design
- We recommend conservative Design Criteria:
  - Additional treatment capacity is better
  - Target BMPs to Pollutants of Concern
  - BMP in series that include unit processes needed to address pollutants of concern
BMP Performance Monitoring and Available Guidance  
(1:30 – 1:40 p.m., EST)  

Marcus Quigley, P.E.  
GeoSyntec Consultants  
(Acton, MA)

- Available for download  
- Over 25,000 downloads to date from Web site  
- Guidance is highly relevant for various levels of BMP monitoring  

www.bmpdatabase.org

Related FHWA Manual  
- Manual specifically focused on monitoring in highway environment and runoff  
- Provides specific equipment selection guidance
Key Guidance Recommendations

- Flow monitoring must be rigorous
- Water quality performance should ultimately be assessed by hydrology/hydraulic as well as effluent quality performance
- Statistically sound approaches must be used to assess water quality performance and should be an integral component of BMP monitoring plan development and implementation as well as data analyses

Understanding Water Quality Variability

- Many sampling programs do not yield useful results – yet they are reported as valid assessments of performance
- Number of samples to obtain a statistically valid result from monitoring program often not considered

Number of Sample Pairs Needed

Adapted from Pitt and Parmer
Flow Measurement Errors

- Propagate throughout monitoring study (Loads and EMCs)
- Often little or no opportunity for calibration under actual field conditions
- Field conditions problematic (unsteady flow conditions)
- Upstream conditions required for operation of weirs and flumes are often not satisfied
- Many types of devices are not well suited for flows which may vary by three or more orders of magnitude

FHWA/USGS Study Demonstrates the Large Variability in Flow Measurements

-25% to +100% on Average!

Results From Analysis of Flow-Weighted Composite Sampling

- USGS Monitoring Data Set Used
- Initial Set of 80 sub-samples

What Number of Sub-Samples are Required?

- A minimum of between 12 and 16 sub-samples should be collected during an event
Monitoring Equipment Selection

- Monitoring Location
  - Watershed Type
  - Specific Site Characteristics
  - Location Within a Watershed
    - On the surface (gutter flow, typically grab sample)
    - At inlets (typically grab sample)
    - Mid-conveyance (manhole, in-pipe or open channel)
    - Outfall
- Monitoring Frequency
- Range of Flows to be Monitored

Flow Measurement Equipment

Selection Factors

- Site location
- Site condition
- Expected discharge rates
- Allowable loss of capacity
- Accuracy
- Expense
- Installation requirements
- Operations and maintenance requirements
- Special considerations for small watersheds

Sampling Equipment

- Grab Versus Composite Samples
- Manual Versus Automated Sampling Methods
  - Cost
  - Study Objectives
  - Sampling issues with regards to larger particles/debris
- Composite Sampling Approaches
  - Constant volume - time proportional to flow volume increment
  - Constant time - constant volume
  - Constant time - volume proportional to flow increment
  - Constant time - volume proportional to flow rate
Recommended Measures of BMP Performance

- How much stormwater runoff is prevented? ("hydrological source control")
- How much of the runoff that occurs is treated by the BMP or not ("hydraulic performance")?
- Of the runoff treated, what is the effluent quality? ("concentration characteristics achieved")
- Does BMP address downstream erosion impacts?

Percent Removal is Very Problematic and SHOULD NOT be used as a performance measure for BMPs.

Measures of Performance Cont.

- Recommended approach for water quality
  - Effluent Probability Method
  - Statistically determine that the BMP removes pollutants or not
  - Focus on EFFLUENT QUALITY

Guidance Manual Appendices

- Data Evaluation and Statistical Hypothesis Testing
- Generic Health and Safety Plan for Monitoring
  - Specific to the Near-Highway Environment
- Example Standard Operating Procedures for Field Sampling
  - Plan Used for Monitoring Work for Field Studies
Data Evaluation and Statistical Hypothesis Testing

- Understanding Detection Limits and Effects on Analysis
- Descriptive Statistics for Log-Normal Data
- Hypothesis Testing
  - Are Two Data Sets Statistically Different from One Another?
  - Are Changes in Water Quality Statistically Significant?
  - Upstream/Downstream or Temporal Comparisons

Summary

- BMP Database has good data on rain event BMP performance
- Effluent data on numerous BMPs for rain events and established differences in effluent quality for BMP types
- Better overall description of performance has been developed
- Hydrology source control of some BMPs found
- People don’t like to sample during snow melt events: Real need to sponsor BMP performance studies to include snow melt runoff/treatment

International Stormwater Best Management Practices (BMP) Database

www.bmpdatabase.org
What challenges face Washington State DOT?

• Limited data
• Limited credibility
• Need better ways to analyze and present data
• Need to change BMP performance perceptions

What attracts us to the Database?

• Large data set
• Thoughtful analysis and reporting
• Enhanced data comparability
• Broad support of credible organizations
• Free tools for housing and analyzing data
How do we contribute?

- Submitted existing data
- Will submit future data
- Participate in technical committee

How does WSDOT benefit?

- Better data
- More benefit from our data
  - Increased understanding
  - Increased credibility
  - Wider audience
- More time - no internal database hassles

First success: Changed ESA-related expectations

Regulators currently base performance goals on percent removal or hopeful desires

- Basic treatment = 80% reduction in TSS (influent range 100-200 mg/L)
- Phosphorus = 50% reduction (influent range 0.1-0.5 mg/L)
- Dissolved metals treatment = “a higher rate of removal than Basic Treatment”
  - Basic treatment efficiency for dissolved metals not defined.
  - Triggers based on traffic levels of 7,500, 15,000 and 30,000 ADT
Example: Benefits of Focusing on Effluent

- Impacts quantified
- Design standards based on discharge
- Better BMP triggers
- Identify when source control is imperative

TSS Removal Per Storm

Panel Discussion with Audience Q & A (1:50 – 2:00 p.m., EST)

- Jeff Moeller, WERF
- Ben Urbonas, UDPCD
- Eric Strecker, GeoSyntec
- Marcus Quigley, GeoSyntec
- Richard Tveten, WashDOT
BREAK!
We’ll be back in 10 minutes
(2:00 – 2:10 p.m., EST)

Recap of Hour One;
Overview of Hour Two
(2:10 – 2:15 p.m., EST)

Jeff Moeller, P.E.
Senior Program Director
Water Environment Research Foundation
(Alexandria, VA)

Public Agency Case Study
(2:15 – 2:25 p.m., EST)

Ben Urbonas, P.E., D.WRE, M.ASCE
Urban Drainage and Flood Control District
(Denver, CO)
Urban Drainage & Flood Control District’s BMP Testing

- Since 1990 District tested:
  - Undersized sand filter with pre-settlement
  - Vertical geotextile filter
  - Baffle vault with permanent pool and surcharge 1-hr drain time
  - Bigger sand filter without a pre-settlement
  - StormCeptor™
  - Extended detention basin
  - Porous pavement

UDFCD BMP Testing (con’t)

- So far we entered six of these testing activities into the database
- Waiting to complete our analysis and Q&A before entering others
  - Initially used forms
  - Lately use spreadsheets to facilitate data entries

Panel Discussion with Audience Q & A (2:25 – 2:55 p.m., EST)

Featuring:
- Jeff Moeller, WERF
- Ben Urbonas, UDFCD
- Eric Strecker, GeoSyntec
- Marcus Quigley, GeoSyntec
- Richard Tveten, WashDOT
Closing Remarks:
Additional Resources, Next Steps
(2:55 – 2:58 p.m., EST)

Jeff Moeller, P.E.
Senior Program Director
Water Environment Research Foundation
(Alexandria, VA)

What’s Next for the International BMP Database?
• ADD more data!
• Add LID Techniques
• Website and database enhancements
• Data analysis tools
• Additional partners

CTE Wrap-Up
(2:58 – 3:00 p.m., EST)

Katie McDermott
Technology Transfer Director
Center for Transportation and the Environment
North Carolina State University
(Raleigh, NC)