Project Overview

The International Stormwater BMP Database project has evolved over the last decade and includes multiple components. This fact sheet provides a brief overview of the following key aspects of the project:

- Project Background
- BMP Database
- BMP Performance Assessment
- Data Evaluation Results and Findings
- BMP Monitoring Guidance

Project Background

In the early 1990's the U.S. Environmental Protection Agency (USEPA) mandated that most municipalities in the United States with populations larger than 10,000 apply for and obtain a stormwater runoff discharge permit. One of the most significant requirements of this permit program is the use of non-structural and structural best management practices (BMPs) appropriate to local conditions to reduce pollutant discharges to the maximum extent practical. At the same time, industries were also required to obtain stormwater permits with BMPs required and in some cases numerical limits or benchmarks for water quality included. In response to this program, communities and industries need to know which types of BMPs are appropriate for them (e.g., which BMPs function best in cold climates or in areas of heavy rainfall or for what land uses and activities) and how to monitor the performance of the BMPs they select to ensure they function properly.

However, a centralized, easy-to-use, scientifically sound tool for assessing the appropriateness of BMPs under a variety of site conditions was non-existent. In addition, BMP studies in the literature had not historically followed standardized data collection, reporting and performance evaluation protocols, making a scientific and consistent evaluation of these data difficult.

In response to this problem, the International Stormwater BMP Database project began in 1996 through the efforts of a team of experts associated with the Urban Water Resources Research Council of the American Society of Civil Engineers (ASCE) under a grant from the USEPA. The original principle investigators for the project were Ben Urbonas, P.E., Urban Drainage and Flood Control District; Eric Strecker, P.E., Geosyntec Consultants; and Jonathon Jones, P.E., Wright Water Engineers. The project's original long-term goal, which remains the central focus of the project today, is to gather sufficient technical design and performance monitoring and reporting information to improve BMP selection and design so that local stormwater problems can be effectively addressed. Original project tasks included:

1) Develop scientifically-based BMP performance monitoring and reporting protocols

2) Collect and evaluate existing BMP design and performance data for meeting the monitoring and reporting protocols,

3) Design, create, and populate a national stormwater BMP database with studies that meet the protocols,

4) Develop BMP performance evaluation protocols, and

5) Evaluate the data collected and report initial findings.

A companion project to develop a detailed stormwater BMP monitoring guidance document emerged when it became apparent that much of the available BMP data was of limited or reduced value due to inconsistent BMP monitoring and reporting protocols and to assist BMP researchers in more consistently meeting the protocols. The results of all of these tasks are contained on the project website.

In 2004, the project transitioned to a broader coalition of supporting partners including the Water Environment Research Foundation (WERF), ASCE Environmental and Water Resources Institute (EWRI), USEPA, Federal Highway Administration (FHWA) and the American Public Works Association (APWA). Wright Water Engineers, Inc. and Geosyntec Consultants are the partnering entities maintaining and operating the database clearinghouse and web page, answering questions, conducting analyses of newly submitted BMP data, conducting updated performance evaluations of the overall data set, disseminating project findings, and expanding the database to include other approaches such as Low Impact Development (LID) techniques. The overall project is being managed by WERF's Jeff Moeller with the support of an expert advisory committee as well as the supporting partners' representatives.

As of 2007, the Project Team continues to actively pursue new BMP data for inclusion in the database, continues to conduct statistical analysis of new BMP data sets, and is laying initial framework to expand the database to include LID techniques. The remainder of this fact sheet provides an overview of four key components of the project: 1) the BMP

database itself, 2) BMP performance assessment measures, 3) initial data evaluation results and findings and 4) BMP monitoring guidance.

BMP Database

The cornerstone of the project is the BMP Database itself, which was developed based on the input and intensive review of many experts for the purpose of developing standardized reporting parameters necessary for more accurate BMP design and resulting performance analyses. The database encompasses a broad range of parameters including test site location information, watershed characteristics, climate data, BMP design characteristics, monitoring instrumentation, and monitoring data for precipitation, flow and water quality. The database consists of two components: 1) data entry software for those monitoring BMP performance and 2) a master database "loaded" with BMP studies for those researching BMP performance. The database was initially release on a CD in 1999 including these two components and 71 BMP studies, which were selected from an initial bibliography of over 800 reports. A User's Guide was developed in tandem with the database. Although the original CD is no longer being distributed, the most up-to-date version of the database with roughly 300 BMPs can be searched on-line or downloaded from the project website (www.bmpdatabase.org). The on-line version of the database also contains statistical analyses of the BMP data, including both analyses of each individual BMP study as well as by BMP types. The Clearinghouse conducts quality assurance review of the BMPs prior to posting them to the site and conducts data analysis using statistical techniques developed during the course of the project. The data entry component of the database can also be downloaded from the project website and is now based on easy-to-use Excel spreadsheets.

BMP Performance Assessment

As part of evaluation of over 800 literature sources, the Project Team identified a wide variety of measures that have been used historically to assess BMP performance, resulting in wide variations in reported BMP effectiveness. Additionally, the commonly used simplistic approach of assessing BMP performance based only on the percent difference between mean concentrations (i.e., percent pollutant removal) was determined to be misleading under many conditions, as were other percent difference approaches based upon other methods. As a result of the literature review and the input of an expert advisory committee, the Project Team selected a BMP performance assessment approach that fully accounts for the statistical characteristics inherent to stormwater quality data, as well as includes measures that are better tied to receiving water goals. For example, the Project Team determined that the lognormal distribution was most representative for describing the majority of water quality data examined. Using the log-transformed data as a starting point, the Project Team selected a variety of statistical plots to describe the data based on their ability to quickly and accurately depict BMP efficiency and convey information that is statistically relevant (e.g., central tendency, confidence in mean values, and variability). Methods were selected for application to individual BMP studies, as well as for application to groups of BMPs. The results were summarized in

two technical reports downloadable from the project website: *Development of BMP Performance Measures* (1999) and *Data Evaluation Report* (2000). Periodic updates to the data evaluation report have been completed since this time including *Analysis of Treatment System Performance: International Stormwater Best Management Practices (BMP) Database (1999-2007)* and *Analysis of Treatment System Performance: International Stormwater Best Management Practices (BMP) Database (1999-2005).* A brief description of the statistical analysis approaches used to evaluate the data follows.

Recommended statistical analysis of individual BMP performance includes:

1) Descriptive statistics of the influent and effluent Event Mean Concentrations (EMCs), both log-transformed and in arithmetic space, including determination of the mean, median, standard deviation, coefficient of variation, and upper and lower confidence limits (CLs) for the mean and median;

2) Parametric and non-parametric analyses of variance; and

3) Graphical analysis.

The graphical analysis includes:

1) Time-series scatter plots of influent and effluent EMCs;

2) Graphical non-parametric analysis of variance utilizing box-and-whisker plots showing influent and effluent EMCs on the same plot; and

3) Normal probability plots of log-transformed water quality data showing overlays of the influent and effluent EMCs.

All of these analyses are included in PDF summaries posted on the project website for studies meeting criteria for analysis.

The analysis techniques recommended for groups of BMPs (e.g., wet ponds) are primarily graphical and include:

1) Box-and-whisker plots of influent and effluent EMCs for each water quality constituent showing all BMPs of that type on one plot;

2) Normal probability plots showing mean influent and effluent concentrations by BMP type;

3) Box-and-whisker plots showing the distribution of effluent quality for a variety of BMP types on one plot; and

4) Scatter plots showing measures of efficiency (e.g., effluent quality) as a function of design parameters (e.g., the ratio between mean runoff volume and storage volume).

See the *Analysis of Treatment System Performance: International Stormwater Best Management Practices (BMP) Database (1999-2007)* and the *Data Evaluation Report* (2000) for application of these techniques.

Data Evaluation Results and Findings

In order to draw scientifically defensible conclusions regarding BMP performance, statistically valid sample populations are needed. As a result, conclusions drawn to date from analysis of the database have been carefully limited. Key preliminary findings regarding BMP performance including:

- BMP performance is best described by the following four measures: 1) the degree to which BMPs reduce runoff volumes; 2) the degree to which they treat runoff (e.g., how much runoff bypasses the BMP); 3) the quality of effluent achieved; and 4) the degree to which the BMP helps to reduce downstream hydromodification-related (erosion) impacts. BMP performance should not be based on comparisons using percent removals because it can be highly misleading.

- The BMP performance descriptions in the database can be used to assess the effluent concentrations and distributions that BMPs are able to achieve; assess effects of BMPs on total loadings (TMDLs); and identify the frequency of potential exceedances of water quality criteria or other targets. Effluent quality is useful for characterizing the effectiveness of the BMP; however, it is still important to determine if the BMP had a statistically significant effect on water quality for each parameter at each test site.

- Reported pollutant removal efficiencies vary considerably amongst the methods employed as well as based upon influent quality. For example, it appears that some BMP types may have been historically mischaracterized as less effective because of cleaner influent. Most BMPs unit processes will exhibit lower percent removals when the concentrations are low in the influent.

- Retention (wet) ponds and wetland basins are not well represented by storm-by-storm comparisons because paired inflow and outflow samples often are not necessarily from flows from the same event (or only part of the flows are). For example, in a wet pond that is equal in volume to the average storm runoff, there will be many smaller storms where none of the influent during the storm exits the basin during the storm.

- The analysis results show that the effluent quality of various BMP types can be statistically characterized as being different from one another.

- Some design parameters (e.g., sizing relative to incoming measured storm volumes) may be statistically significant with regard to their effect on the performance of BMPs. Additional data and work is needed to link more BMP selection and design differences to resulting differences in performance.

- Additional work is needed to link BMP performance to their effect on the physical, chemical and biological impacts of stormwater on receiving waters. Downstream response and biological/habitat assessment may be a better gauge of long-term BMP effectiveness for an area than pollutant effluent quality and especially removal efficiencies alone. However, there is insufficient information at this time to suggest which BMPs provide the best mitigation of urbanization effects on the downstream receiving waters.

- More data are needed for sound statistical analyses, particularly for BMPs other than ponds and wetlands.

- Additional monitoring of BMPs located in cold regions is needed. The majority of the database studies are in "Warm" Climates, rather than in "Cold" Climates. Even for the cold climate data sets, there are no or very few winter storms that have been monitored.

Monitoring Guidance

As a result of the reviewing over 800 literature sources on BMP performance and working with existing data sets and submitted new datasets, the Project Team identified the need for better guidance on proper monitoring and reporting of stormwater BMPs and developed the guidance document *Urban Stormwater BMP Performance Monitoring*. The manual is intended to help achieve stormwater BMP monitoring project goals through the collection of more useful and representative rainfall, flow, and water quality information. Many of the monitoring recommendations (particularly those for reporting monitoring, watershed, and design information) were directly intended to improve how studies reporting information meet the protocols of the Stormwater BMP Database project. The manual presents the recommended set of protocols for BMP monitoring and reporting and then provide guidance for collecting, storing, analyzing, and reporting BMP monitoring data that will lead to better understanding of the function, efficiency, and design of urban stormwater BMPs. The manual is also useful for BMP performance study researchers even if the study is not intended to meet the Database projects protocols.