BMP Performance Webcast

February 6, 2008

With:
Jonathan Jones, Wright Water Engineers
Neely Law, Center for Watershed Protection
Nikos Singelis, U.S. Environmental Protection Agency

Topics for Today's Discussion

- The Basics of BMP performance
  - National Pollutant Removal Database (CWP)
  - International BMP Database (WERF)
- Introduction to new EPA tool/website
- Other Important Factors for BMP Selection
- Comparison of (a few) BMP types
- Using BMP performance information in your stormwater program

International BMP Database

www.bmpdatabase.org

Jonathan Jones, PE – D.WRE.

Wright Water Engineers

Co-Project Team Leader for International BMP Database

Features of the International BMP Database

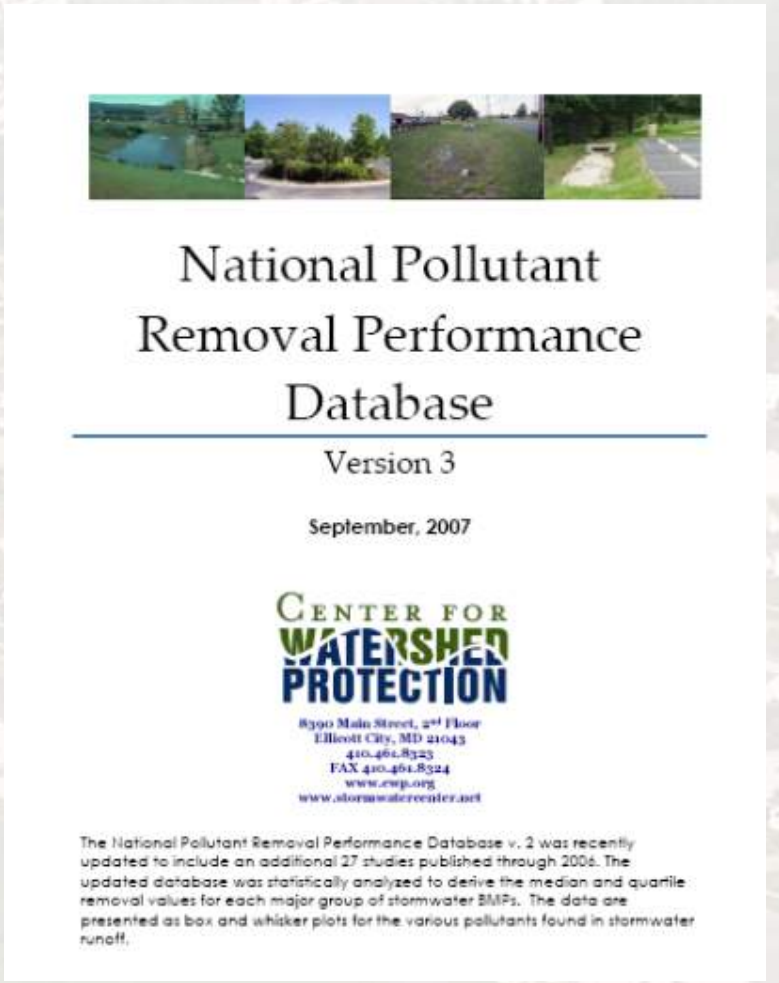
- Key resource for researchers
- Information on 300+ studies
- Summaries of BMP Performance
- Monitoring and Evaluation Guidance
- Publications and Papers
- Statistical abstracts for many studies

www.bmpdatabase.org

National Pollutant Removal Performance Database

www.cwp.org

Neely Law, PhD
Senior Research Analyst
Center for Watershed Protection



National Pollutant Removal Performance Database

- Project started in 2000
- Updated recently (NPRPD v.3, 2007)
- Now includes 166 studies published through 2006
- Visual summary of BMP performance, guidance on the use of BMP performance data
- Will continue to update and improve

www.cwp.org

Download report at:
http://www.cwp.org/PublicationStore/special.htm
(free)

Who Needs BMP Information?

Clearly someone needs BMP information! The design drawings showed the location of the straw bales as a "dashed" line… hum…

Who Needs Information on BMP Performance?

- Developers are building housing developments, big box stores, malls, industrial parks, etc. Are the stormwater controls adequate?
- 6000 MS4s are making decisions and approving plans for post-construction BMPs
- Permit writers, TMDL staff, watershed planners, etc are attempting to address stormwater impacts to meet water quality standards

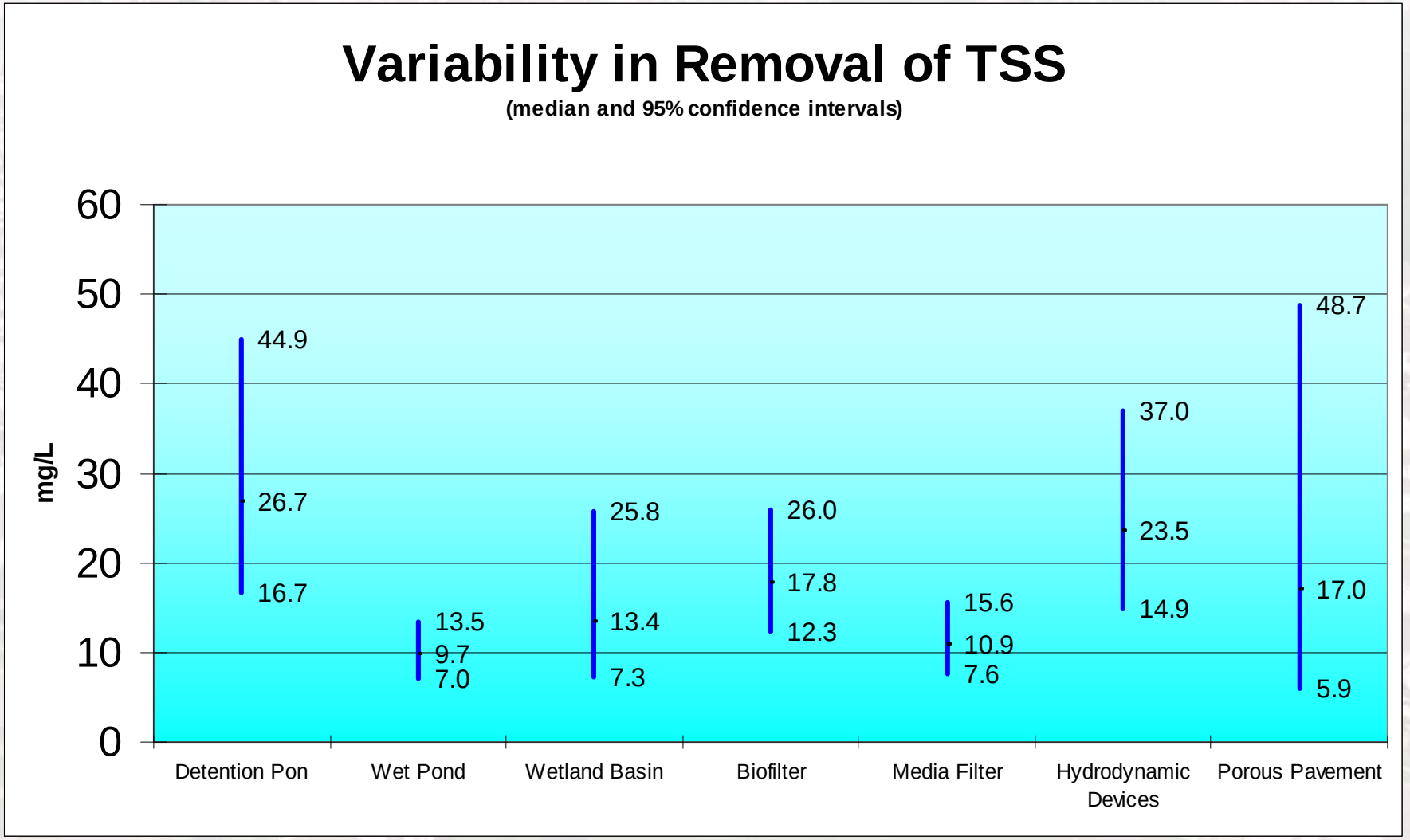
The Basics of BMP Performance

- **Understanding BMP Performance**
  - Factors influencing performance
  - Key terminology
  - Pollutant removal
    - Why “percent removal” is not a good indicator
  - The importance of volume reduction
    - Impact on stream systems
    - Relationship to pollutant removal

Factors Influencing BMP Performance

- BMPs are not static systems that deliver constant or even “predictable” results
- Performance is highly variable and impacted by:
  - Design
  - Soil type
  - Rainfall patterns
  - Land uses in the drainage area
  - Age of system
  - etc.

BMP Performance is Variable



Source: International BMP Database

Terminology

- ***Concentration*** **– influent and effluent concentrations usually expressed as mg/L or ug/L**
- ***Percent Removal*** **– using an influent and effluent concentration to obtain a simple percentage**

  ****** Not Recommended! (more on that later)**
- ***Volume*** **– in liters coming into (influent) and out of (effluent) a BMP. Measurements can be conducted in different ways. We report "paired" values**

Terminology

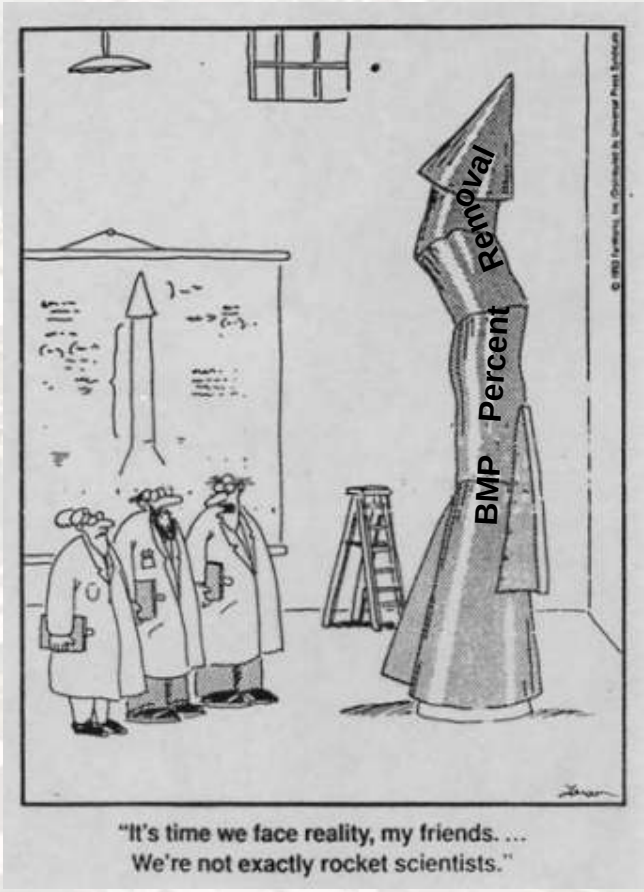
- **Total Load – a calculation of the amount of a pollutant by weight (e.g. kg or pounds) coming into and out of a BMP during a storm event or series of events**
  - **Better overall measure than just concentration**
  - **More on that in a minute…**

Terminology

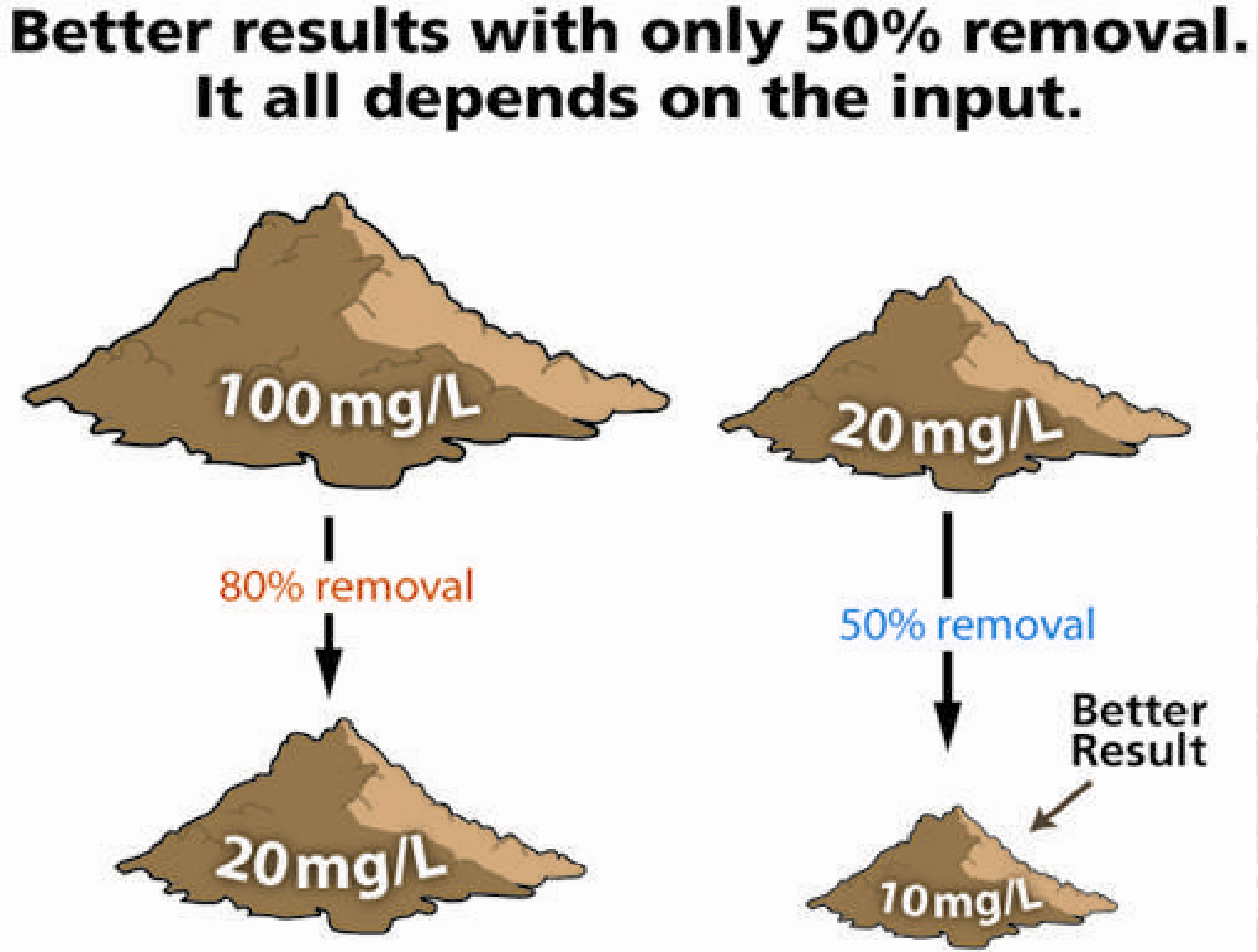
- **Event Mean Concentration (EMC)**
  - Defined as the total pollutant load in a runoff event divided by the volume of that event
  - Generally very difficult to measure, so it is estimated by using flow weighted automatic sampling
  - Units are milligrams per liter (mg/L) or micrograms per liter (ug/L)
- **Confidence Intervals and Quartiles**
  - Statistical measures that can be used to assess the variability of the samples or observations in a data set
  - Examples are the 95% confidence interval or 75% quartile

Urban Myth: Percent Removal

- Calculations of percent removal are common in the stormwater world
  - Myth #1. EPA/CWA requires 80% removal for stormwater. No!
  - Myth #2. Percent removal is a good way to demonstrate BMP performance. No!
- Percent removal can be very misleading…



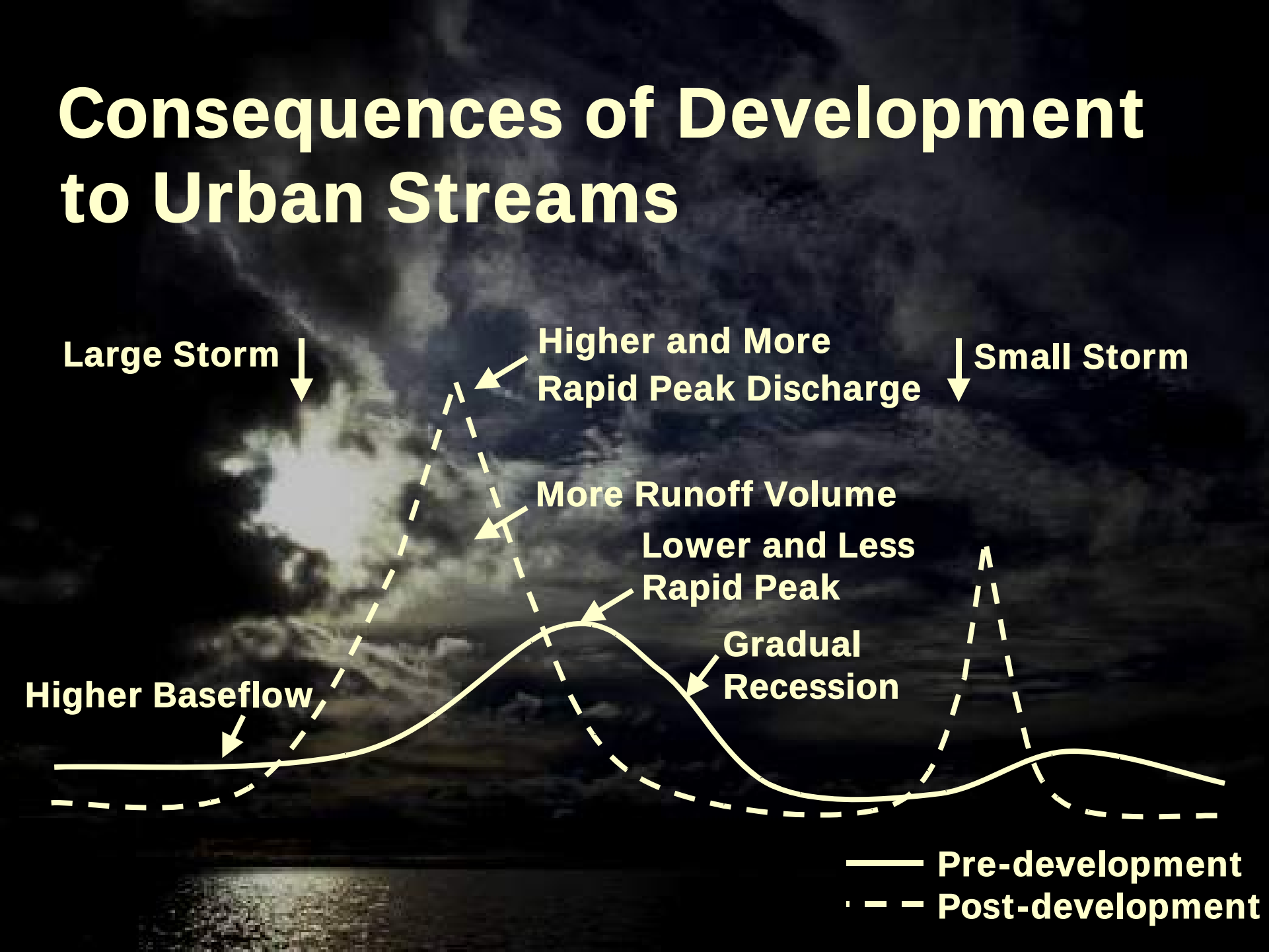
Percent Removal is Misleading



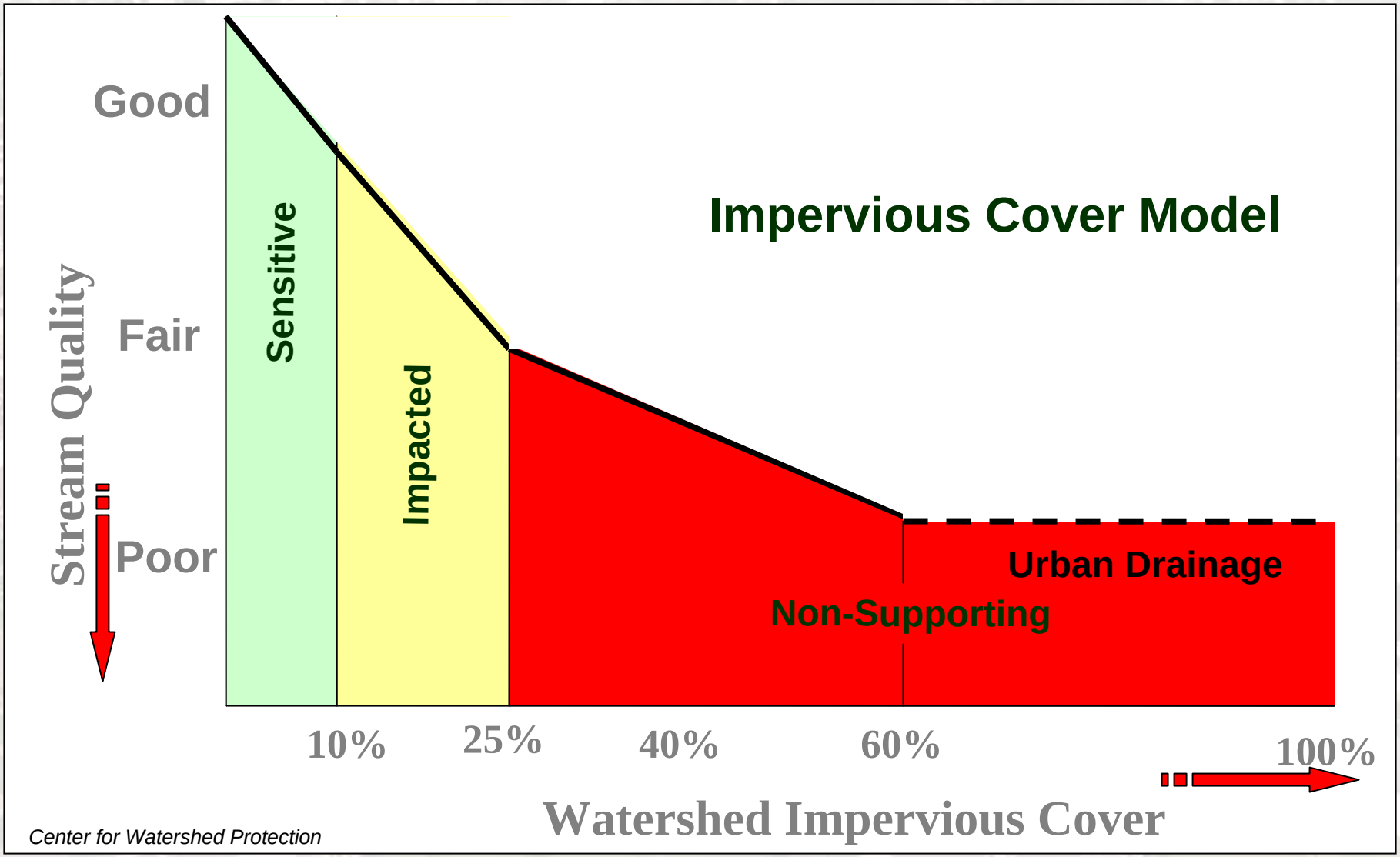
Importance of Volume Reduction

- **Urban and suburban development are driving increasing impervious surfaces in our watersheds**
  - **Changing the hydrology of systems, especially smaller and medium-sized creeks, streams, and rivers**
  - **Increased streambank erosion, down cutting, channelization, loss of habitat, temperature**
  - **Decreases in baseflow and groundwater recharge (in many areas)**

Consequences of Development to Urban Streams



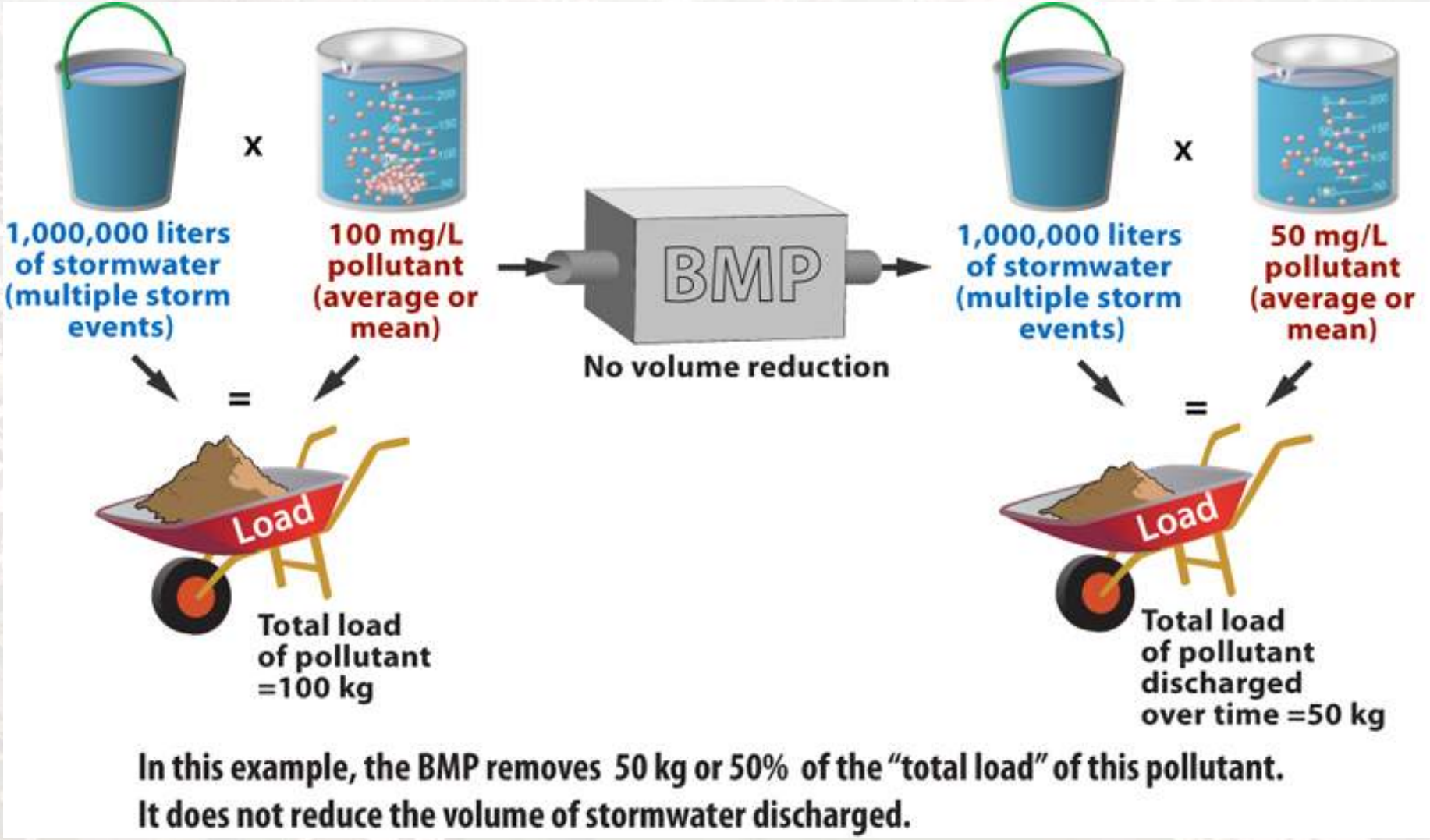
Generalized Relationship Between Impervious Cover and Stream Quality



Volume Reduction (con't)

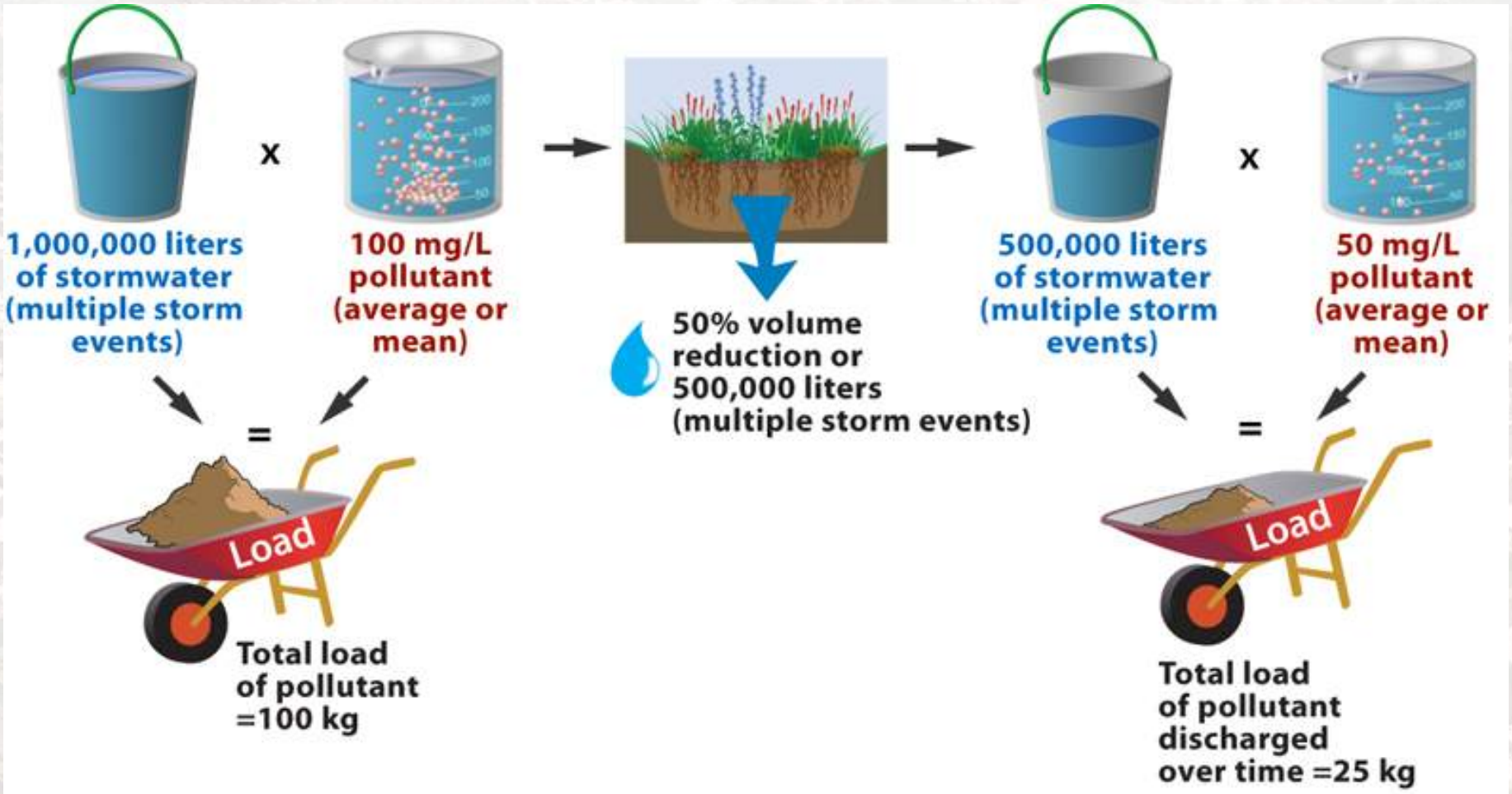
- Volume (and velocity) reduction is important for its impact on the physical and biological aspects of streams
- Volume reduction also plays an important part in pollutant reduction…

Total Load Reduction



In this example, the BMP removes 50 kg or 50% of the "total load" of this pollutant.
It does not reduce the volume of stormwater discharged.

Impact of Volume Reduction on Total Load



In this example, the BMP removes 75 kg or 75% of the "total load" of this pollutant. The "true" performance of this BMP is only apparent when we factor in the impact of volume reduction and calculate the total load of the pollutant.

Monitoring and Assessing BMP Performance

What makes for a successful approach…

Overall Goals

A "good" assessment of any BMP's performance should examine:

- **Pollutant Reduction (water quality performance)**
- **Volume Reduction (hydrological source control performance)**
- **Treatment Capacity (hydraulic performance)**

- **Downstream biological impacts**
- **Downstream physical impacts (bank erosion, channelization, etc.)**

Basic Elements

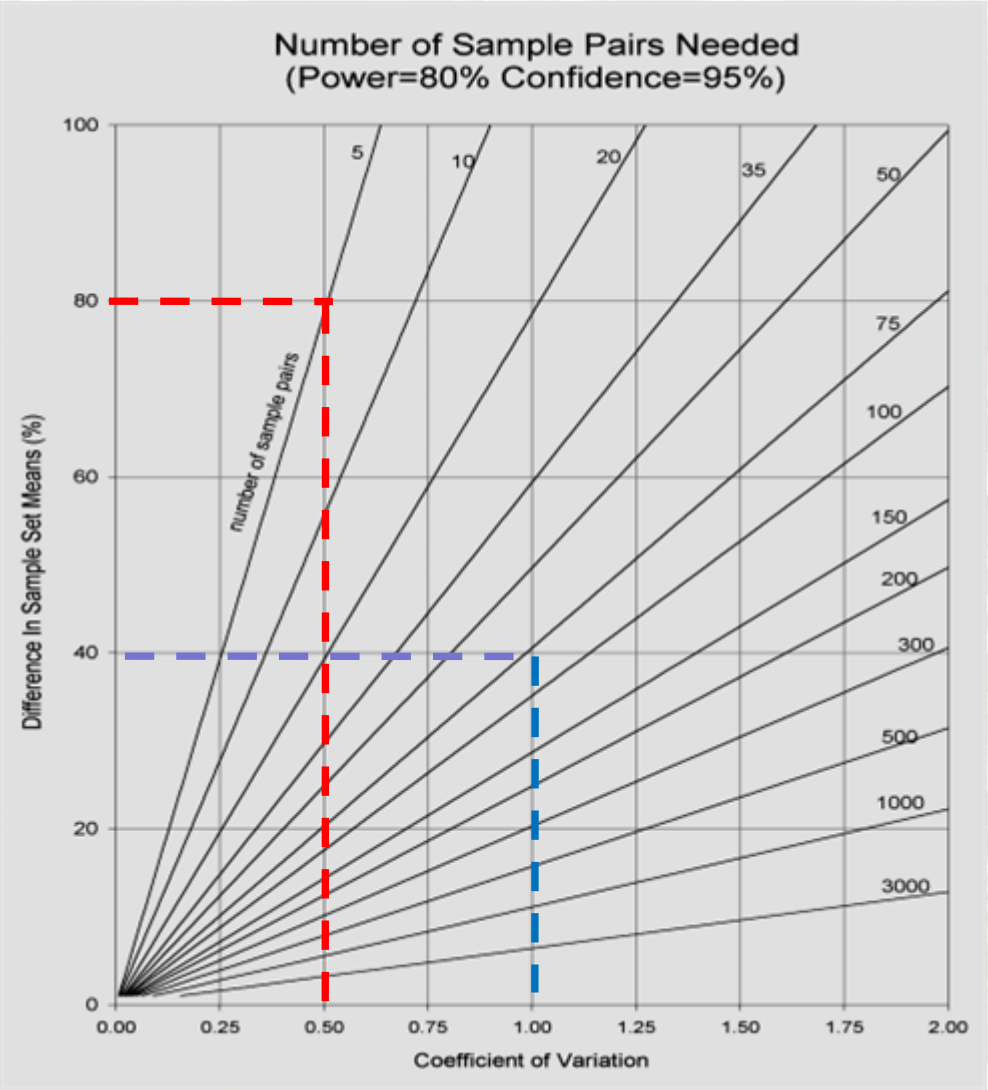
- **Sampling**
  - Number of storm events sampled
  - Number of samples per event
  - Paired samples (influent and effluent)
- **Parameters**
  - Minimum recommended pollutant parameters

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
- Generally speaking, “More variability in a water quality parameter = higher number of samples you will need”

Sampling Basics

- Sample 10 or more storms. One to three years would be even better
- 16 samples for each storm event (could be reduced in some conditions)
- Use flow weighted automatic sampling
- Sample in pairs, inflow and outflow



Common Pollutants To Monitor

- **Common Parameters**
  - Total Suspended Solids (TSS)
  - Total Phosphorus and Various Forms of Phosphorus
  - Total Nitrogen and Various Forms of Nitrogen
  - Total Copper
  - Total Zinc
  - Oil and Grease
  - E-coli
  - Temperature
  - pH
- **EPA will work on developing a standardized "minimum" recommended list**

Monitoring Guidance

- **EPA/WERF Monitoring Guidance**

  www.bmpdatabase.org/MonitoringEval.htm

- **TARP Protocol**

  www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

- **TAPE Protocol**

  www.ecy.wa.gov/biblio/0210037.html

Advanced Monitoring Considerations

- **Biological monitoring**
  - **Bioassessment protocols**
- **Physical**
  - **Impact on stream channel**

Questions

Introduction to EPA's Urban BMP Performance Tool

Background

- Many studies on stormwater BMP effectiveness have been conducted.
  - Some published in various journals, websites
  - Some unpublished
  - No easy way to access this all this information
- BMP performance information is a natural compliment to EPA's National Menu of BMPs

Objectives

- Create a system to provide easy, simple access to stormwater BMP performance studies
- Provide educational information on BMP performance

Key Steps

- Gathered results and key supporting data from studies that either meet EPA's published criteria or have been published in a peer-reviewed journal or website
- Designed easy to use search and sort options
- Developed format to report pollutant removal and volume reduction information
- Provided linkages to studies, statistical abstracts, and design briefs, where available

Elements of the Tool

- **Educational essays on:**
  - **Understanding BMP performance**
  - **The importance of volume reduction**
  - **The problems with “percent removal”**
- **Currently info on 220 studies and over 275 BMPs**
  - **In first phase, studies are from International BMP Database or from State of California collection**
- **Easy to use search options:**
  - **Pollutant – 12 pollutant groups, hundreds of subgroups**
  - **BMP Type – 14 BMP types**
  - **Volume Reduction – Key to Low Impact Development/Green Infrastructure**
  - **Key Words**

Urban BMP Performance Tool Home

Key Topics About BMP Performance

Frequent Questions & Glossary

BMP Study Search

Stormwater Home

NPDES Topics | Alphabetical Index | Stormwater Home | Comment on the Urban BMP Tool

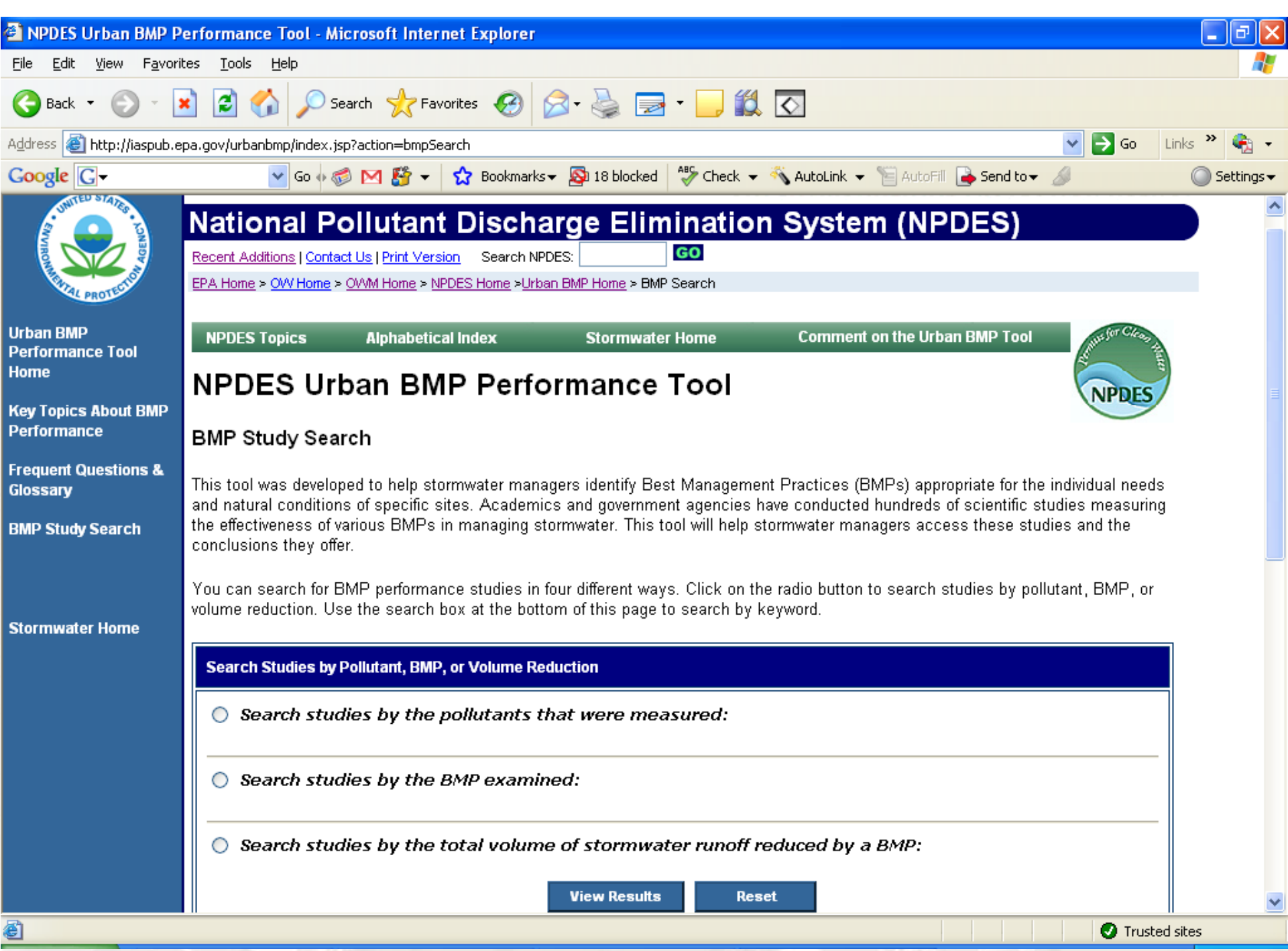
Urban BMP Performance Tool

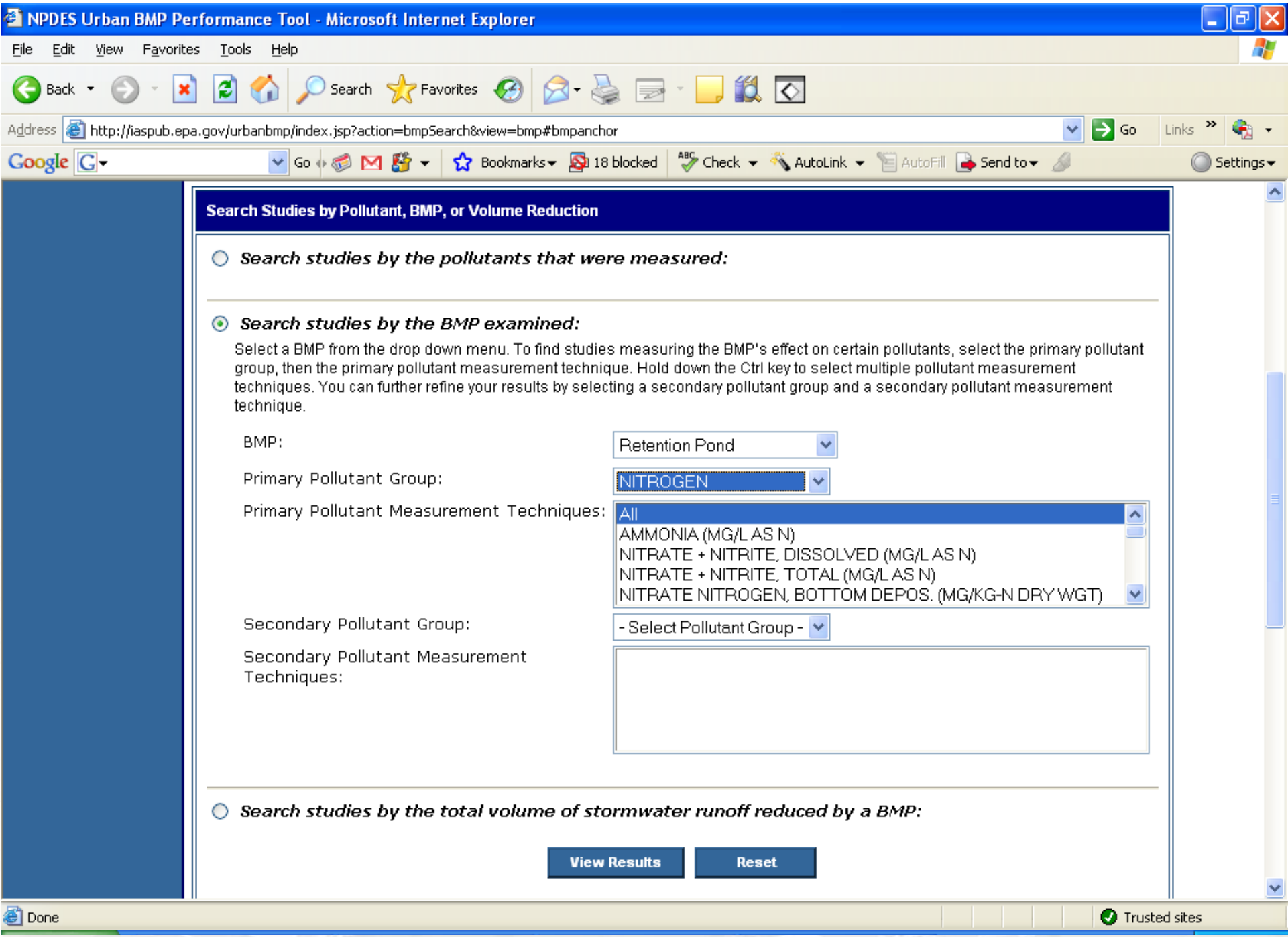
This Urban Stormwater BMP Performance Tool has been developed to provide stormwater professionals with easy access to approximately 220 studies assessing the performance of over 275 BMPs. Additional studies will be added to this collection periodically. This Tool presents information previously compiled by the International Stormwater BMP Database EXIT Disclaimer and by the State of California in an easy to use search and sort format. In the future, EPA hopes to add more studies to this collection, particularly ones that evaluate the performance of "green infrastructure" or "low impact development" BMPs.

Choosing effective stormwater BMPs is one of the key challenges facing anyone interested in improving or protecting the quality of our rivers, lakes, and coastal waters. Having access to studies of BMP performance that have been conducted by public agencies, academic researchers, non-profit groups, and others will help make better decisions. This tool provides access to summary information on studies that have been published in recognized journals or that have met detailed criteria EXIT Disclaimer established by EPA. This tool is not a statistical analysis of the data and, as such, the numbers presented should not be the sole basis for selecting BMPs. The purpose of this tool is to give users an easy to use website to access, read, and explore the literature on BMP performance. EPA hopes that this information will be used to conduct more thorough considerations of BMP selection and placement.

Bioretention area treating runoff from a parking lot

Anyone involved in the process of selecting BMPs to manage stormwater should consider a wide variety of factors, including pollutant removal potential, stormwater volume reduction, installation considerations (soils, slopes, and climate and rainfall patterns), capital costs, maintenance costs, and other factors. These studies can help provide some of this information so that BMPs are appropriate for the site and will contribute to meet


NPDES Urban BMP Performance Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://iaspub.epa.gov/urbanbmp/index.jsp?action=bmpSearch
Go Links
Google Go Bookmarks 18 blocked Check AutoLink AutoFill Send to Settings
National Pollutant Discharge Elimination System (NPDES)
Recent Additions | Contact Us | Print Version Search NPDES: GO
EPA Home > OW Home > OWM Home > NPDES Home >Urban BMP Home > BMP Search
Urban BMP Performance Tool Home
Key Topics About BMP Performance
Frequent Questions & Glossary
BMP Study Search
Stormwater Home
NPDES Topics
Alphabetical Index
Stormwater Home
Comment on the Urban BMP Tool
NPDES Urban BMP Performance Tool
BMP Study Search
This tool was developed to help stormwater managers identify Best Management Practices (BMPs) appropriate for the individual needs and natural conditions of specific sites. Academics and government agencies have conducted hundreds of scientific studies measuring the effectiveness of various BMPs in managing stormwater. This tool will help stormwater managers access these studies and the conclusions they offer.
You can search for BMP performance studies in four different ways. Click on the radio button to search studies by pollutant, BMP, or volume reduction. Use the search box at the bottom of this page to search by keyword.
Search Studies by Pollutant, BMP, or Volume Reduction
Search studies by the pollutants that were measured:
Search studies by the BMP examined:
Search studies by the total volume of stormwater runoff reduced by a BMP:
View Results
Reset
Trusted sites


NPDES Urban BMP Performance Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://iaspub.epa.gov/urbanbmp/index.jsp?action=bmpSearch&view=bmp#bmpanchor
Go Links
Google Go Bookmarks 18 blocked Check AutoLink AutoFill Send to Settings
Search Studies by Pollutant, BMP, or Volume Reduction
Search studies by the pollutants that were measured:
Search studies by the BMP examined:
Select a BMP from the drop down menu. To find studies measuring the BMP's effect on certain pollutants, select the primary pollutant group, then the primary pollutant measurement technique. Hold down the Ctrl key to select multiple pollutant measurement techniques. You can further refine your results by selecting a secondary pollutant group and a secondary pollutant measurement technique.
BMP:
Retention Pond
Primary Pollutant Group:
NITROGEN
Primary Pollutant Measurement Techniques:
All
AMMONIA (MG/L AS N)
NITRATE + NITRITE, DISSOLVED (MG/L AS N)
NITRATE + NITRITE, TOTAL (MG/L AS N)
NITRATE NITROGEN, BOTTOM DEPOS. (MG/KG-N DRY WGT)
Secondary Pollutant Group:
- Select Pollutant Group -
Secondary Pollutant Measurement Techniques:
Search studies by the total volume of stormwater runoff reduced by a BMP:
View Results
Reset
Done
Trusted sites

NITROGEN, TOTAL (MG/L AS N)

Reference Title	BMP Comment	Influent Concentration	Effluent Concentration	Other Reported Measures of Performance	Percent Volume Reduction	Quality of Study
St. Johns River Water Management District: DeBary Detention with Filtration Pond	DeBary Detention with Filtration Pond	0.81	0.7		-91%	✔ ✔ ✔
Maristany, A. and R. Bartel. 1989. Wetlands and Stormwater Management: A Case Study of Lake Munson, Part I: Long-Term Treatment Efficiencies., Proceedings of the Symposium on Wetlands: Concerns and Successes, AWRA, Tampa, FL, pp. 215-229: Lake Munson System	Lake Munson	1.61	0.88		29%	✔ ✔ ✔
Martin, E. and J. Smoot. 1986. Constituent-Load Changes in Urban Stormwater Runoff Routed Through a Detention Pond-Wetlands System in Central Florida, USGS Report 85-4310	Silver Star Rd Detention Pond	1.38	1.22			✔ ✔ ✔
Legislative Commission on Minnesota Resources: McKnight Basin Detention Pond	McKnight Basin Detention Pond	2.09	1.56		-11%	✔ ✔ ✔
Oberts, G. and Osgood, R. 1988. The effectiveness of a detention/wetland treatment system and its effect on an	Lake McCarrons					

Maristany, A. and R. Bartel. 1989. Wetlands and Stormwater Management: A Case Study of Lake Munson, Part I: Long-Term Treatment Efficiencies., Proceedings of the Symposium on Wetlands: Concerns and Successes, AWRA, Tampa, FL, pp. 215-229: Lake Munson System

General Information

Primary Author: Not Available

Co- Author: Maristany, A.E. and Bartel, R.L.

Primary Data Provider: International Stormwater BMP Database 1999; Extracted from Literature

Year of Publication: 1989

Citation: Maristany, A.E. and Bartel, R.L.. 01/01/1989 "Maristany, A. and R. Bartel. 1989. Wetlands and Stormwater Management: A Case Study of Lake Munson, Part I: Long-Term Treatment Efficiencies., Proceedings of the Symposium on Wetlands: Concerns and Successes, AWRA, Tampa, FL, pp. 215-229: Lake Munson System" International Stormwater BMP Database 1999; Extracted from Literature

Authoring Organization:

Sponsoring Agency(s): Northwest Florida Water Management District

Quality of Study: ✔ ✔ ✔

Abstract: The study examines the long term performance of a wetland/lake system for stormwater discharge and wastewater effluent discharge. This paper studies a 255-acre wetland/lake system which has received wastewater effluent and stormwater discharges for over 30 years. Six storms were sampled upstream and three storms downstream of the lake. The study documents the constituent removal efficiency for 25 parameters.

Lake Munson displays removal rates that would be commonly expected from relatively new wet detention ponds having similar dimensions and stormwater loading rates. The lake system was effective at retaining particulate material from incoming stormwaters (turbidity 87% removal, suspended solids 95% removal, total P 64% removal, total N 31% removal, BOD 20% removal, TOC 24% removal, total Cr 78% removal, total Cu 72% removal, total Pb 91% removal). Dissolved organic nitrogen and orthophosphate had negative removal rates of -15% and -50%, respectively.

BMP Information

BMP Site Name: Lake Munson
BMP Comment: Lake Munson
BMP also known as: Not Available
Description: Retention Pond (Wet) - Surface Pond With a Permanent Pool
Link to BMP Summary: http://nswbmp.geosyntec.com/pdfs/-1204551109.pdf EXIT Disclaimer
Link to Statistical Summary: http://nswbmp.geosyntec.com/pdfs/-1204551109d.pdf EXIT Disclaimer
Link to Menu of BMPs: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

Study BMP Specification

Name	Value
Permanent Pool Surface Area	103.2 Hectares
Volume of Permanent Pool	1258151.5 Cubic Meters

Click on the linked column headings in the table to view the definition on the FAQ and Glossary page.

Pollutants

Name	Inflow Concentration	Outflow Concentration
ALKALINITY, FIXED ENDPOINT (MG/L)	37.05	26.31
BOD-5 (MG/L)	10.15	5.87
CARBON, TOTAL ORGANIC (MG/L AS C)	29.92	16.73
CHLORIDE, TOTAL (MG/L)	8.96	9.8
CHROMIUM, TOTAL (UG/L AS CR)	4.77	0.43
COD (MG/L)	51.19	31.37

Next Steps for Urban BMP Tool

- Add more studies, particularly more on Low Impact Development (LID)/Green Infrastructure BMPs
- Develop input page so researchers can enter their studies
- Identify other information gaps
- Outreach and marketing

Features of These Databases

- **EPA Urban BMP Performance Tool**
  - Easy access to information from studies, including abstracts, concentrations, and volume information
- **International BMP Database**
  - Key resources for researchers
  - Useful summary table
- **National Pollutant Removal Database**
  - Easy to understand summary information

Other Important Factors for BMP Selection

Other Considerations for BMP Selection

Beyond pollutant and volume reduction potential, we need to consider:

- **Costs**
  - **Capital costs**
  - **Costs per acre treated**
  - **Maintenance costs**
- **Maintenance**
  - **Frequency of needed maintenance**
  - **Ease of maintenance, access**
- **Function in regional drainage/flood mgt.**
- **Secondary benefits, such as habitat, carbon sequestration, water conservation, etc.**
- **Safety**
- **Aesthetics**
- **Longevity/useful life**

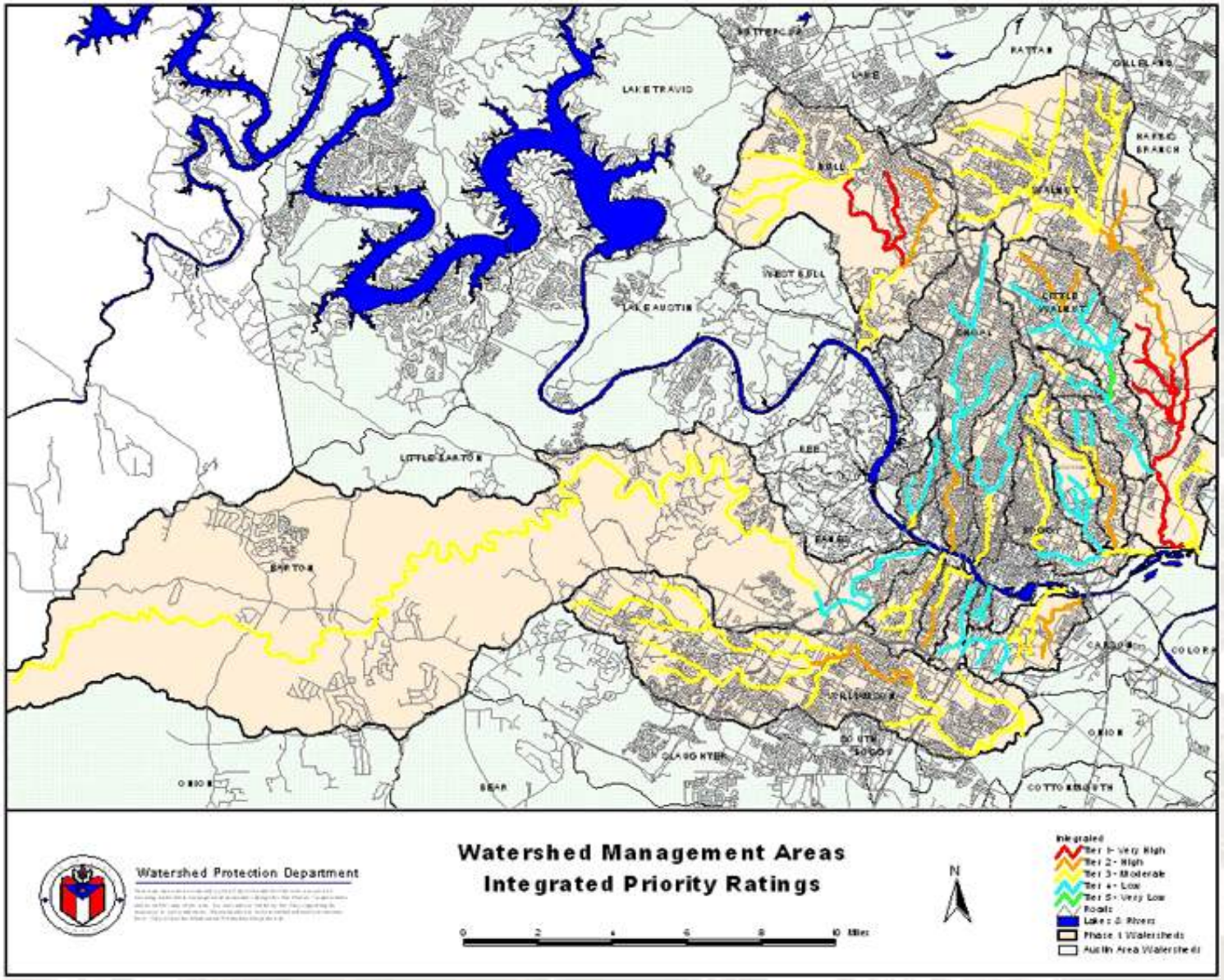
When evaluating BMPs, know your watershed

- Water Quality Standards/Designated Uses
- Existing impacts (impairments and TMDLs)
- Social setting (public acceptance)
- Ordinances/regulations
  - Required practices
  - Enforcement mechanism
- Drainage and flooding issues
- Future conditions

Moving Beyond Site-Level Planning

- **Successful local post-construction stormwater programs will need to actively engage at multiple scales to protect and restore watersheds**
  - **Regional/Watershed**
  - **Neighborhood**
  - **Site**

Land Use Planning is the First BMP!



Lincoln, Nebraska

Wide buffers along major drainageways, master planning entire city, comprehensive drainage criteria manual

Post-Construction Manual Coming Soon!

- CWP (with help from EPA and Tetra Tech) is finalizing a comprehensive manual for local governments on managing post-construction runoff – Release in early Spring 2008
  - Will discuss managing stormwater at multiple scales

Comparison of (a few) BMP Types

Pollutant Removal, Volume Reduction, Costs, Maintenance, etc.

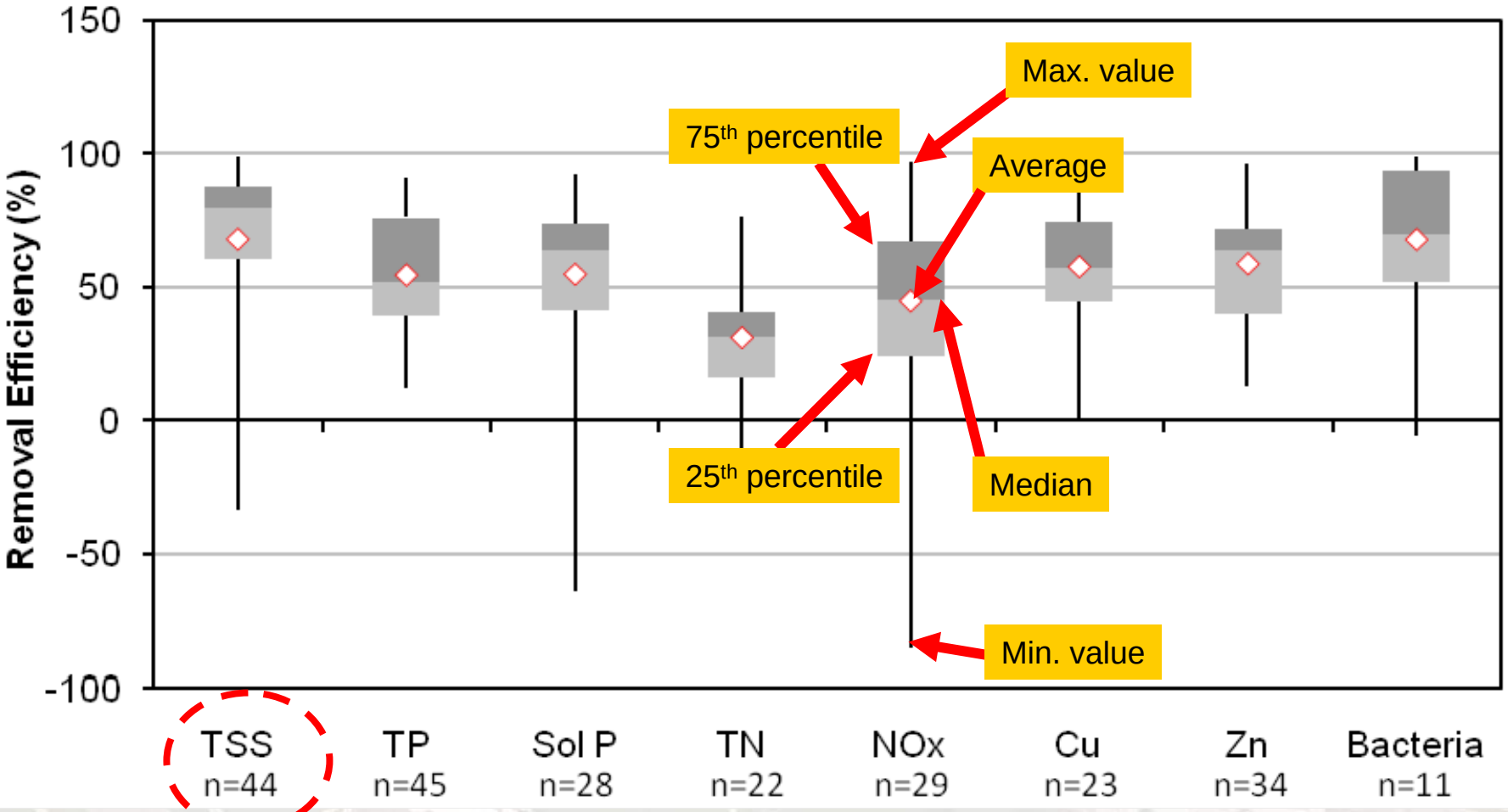
The "Small Print"

aka Caveats

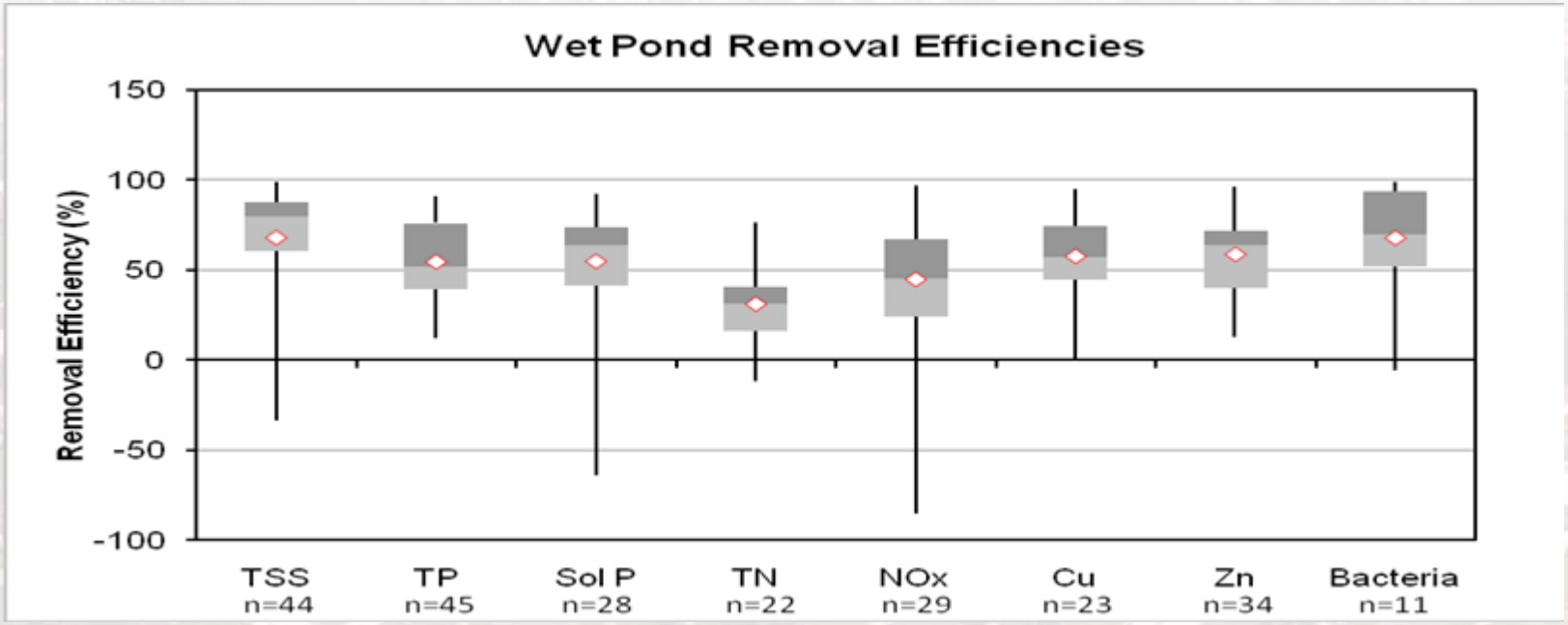
- NPRD/CWP data mixes load reduction and percent removal
- International BMP data is concentration-based
- Data sets are sometimes limited
- Variability in data is often high
- Includes WAG (e.g. Wild A_____ Guesses…)

Wet Ponds and Created Wetlands

Example “Box and Whiskers” plot



Wet Pond Performance



Median concentrations, International BMP Database (n=25)

	TSS	TP	DP	TN	NO_3	Cu	Zn	Bacteria
	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	
Median Influent	37.73	0.21	0.09	1.64	0.38	9.84	60.75	na
Median Effluent	9.74	0.1	0.05	1.31	0.20	5.82	21.58	na

WAG Assessment ★ ★ ★ ~ ~/★ ★ ★

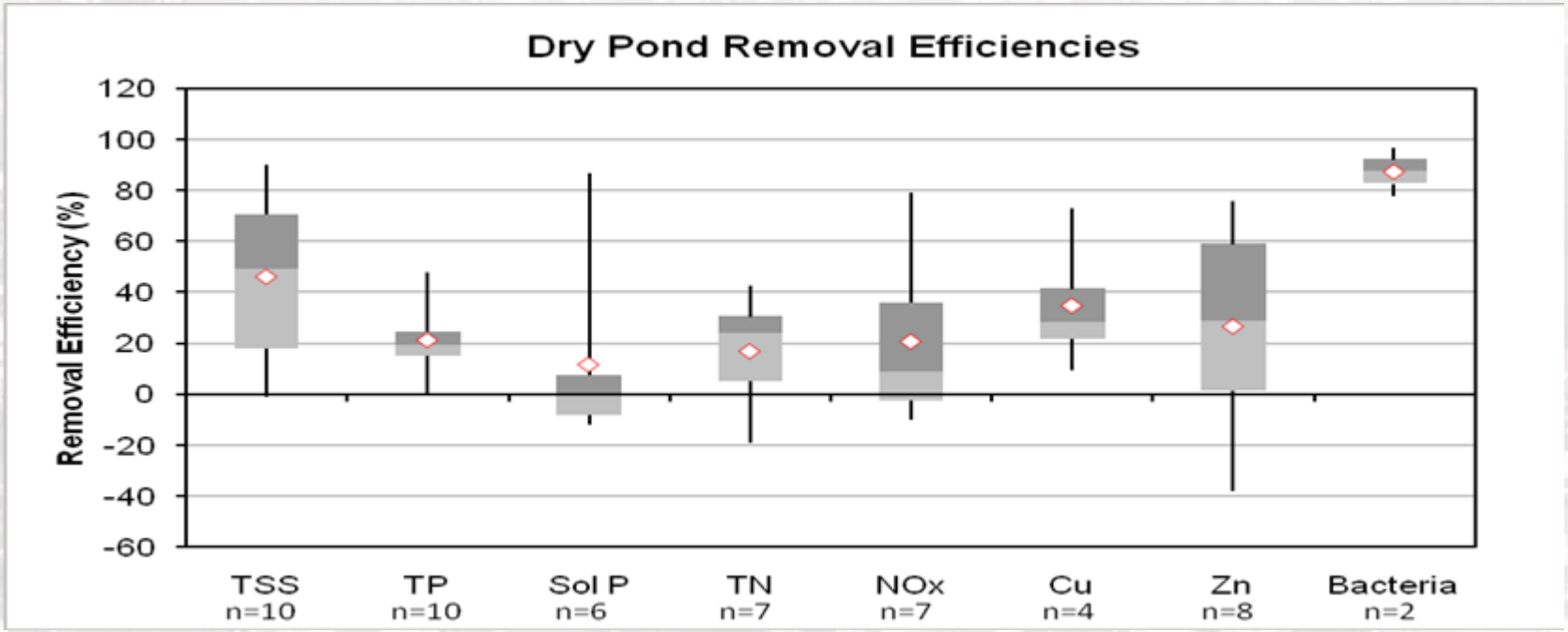
Wet Ponds

Construction cost per impervious acre = $8,350 (CWP)
Infiltration Capacity +/- 10%

- **Pros**
  - Pollutant removal generally good
  - Peak flow control
  - Can be community assets
  - Can be (re)designed to include trees, wetland plants, etc. Could also lower some maintenance costs
- **Cons**
  - Little volume reduction (+/- 10%)
  - Potential outflow impacts on stream channel
  - Increases water temp
  - Traditional designs offer little habitat value
  - Design may lead to high maintenance costs

Dry Ponds

Dry Pond Performance



Median concentrations, International BMP Database (n =25)

	TSS	TP	DP	TN	NO_3	Cu	Zn	Bacteria
	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	
Median Influent	72.64	0.19	0.09	1.25	0.7	20.13	111.56	na
Median Effluent	26.74	0.19	0.09	2.22	0.48	15.91	58.66	na

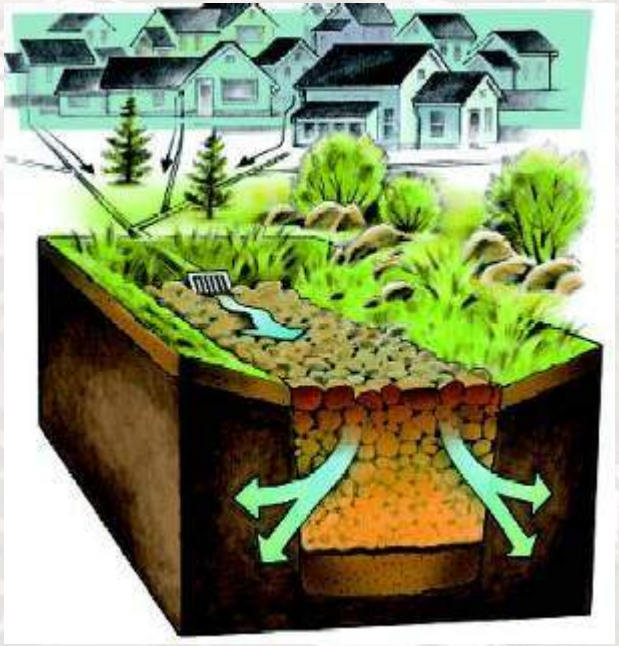
WAG Assessment ★ ✗ ✗ ✗ ~ ~ ~

Dry Pond

Construction cost per impervious acre = $3,800 (CWP)
Infiltration Capacity +/- 20%-30%

- **Pros**
  - Can be multiple use areas, such as ball fields
  - Reduce “peak” flow impacts
  - Often unrecognized, moderate infiltration capacity
- **Cons**
  - Generally not very effective at pollutant removal
  - Infiltration capacity moderate to low
  - Maintenance cost can be high due to frequent mowing and trash removal

Green Infrastructure
Low Impact Development



Rain Gardens

Wetland Swales

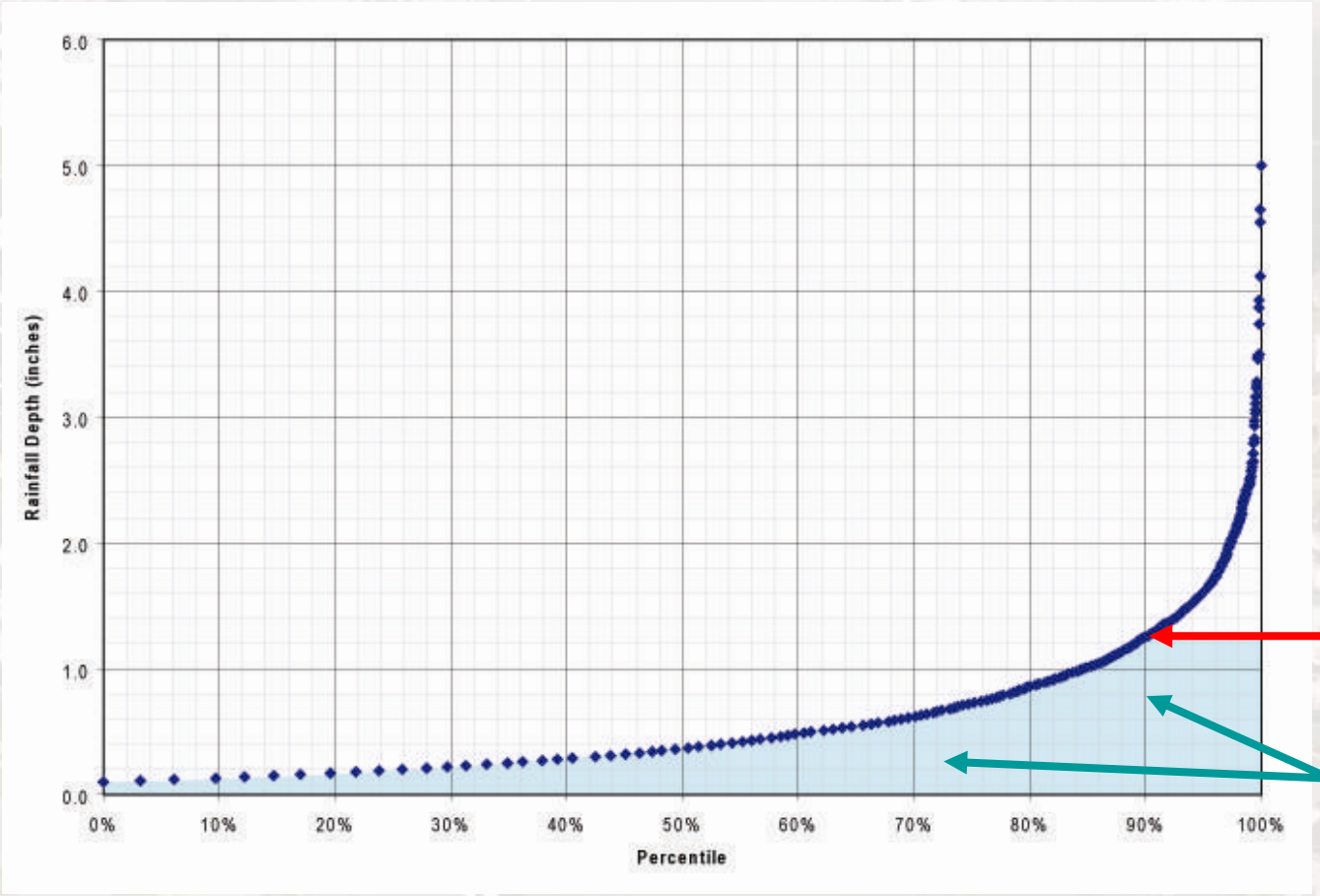
Porous Landscape Detention

Portland, OR

Curbless Streets

Infiltrating Rainfall Can Result in Dramatic Pollutant Reductions

Worchester, MA – Rainfall events 1948-2004



90% Storm event = 1.25 inches

In Worchester, infiltrating the first 1.25” = 90% of the total stormwater volume

Bioretention

Construction cost/ impervious acre = $25,000 (CWP)
Infiltration potential - +/- 90%

- **Pros**
  - **Generally high volume reduction (groundwater recharge) (+/- 90%)**
  - **Generally high pollutant removal**
  - **Performance improved without underdrains or when using BMPs in series**
  - **Routine maintenance may be lower – no mowing**
  - **Possible related savings via reduction in “grey” infrastructure**
- **Cons**
  - **Small size means more BMPs to track and maintain**
  - **Best design specs uncertain at present**
  - **Maintenance issues with private land owners**
  - **Higher construction costs per impervious acre**

Recommendations for BMP Designers

- Use a treatment train approach for BMPs that considers:
  - The pollutants of concern and their form
  - The BMPs that can effectively address these pollutants
  - The volume reduction potential of the BMPs
- Using a treatment train will help to account for the inherent variability and uncertainties that are associated with BMP performance
- Use performance data to help improve designs

Recommendations for Designers (con't)

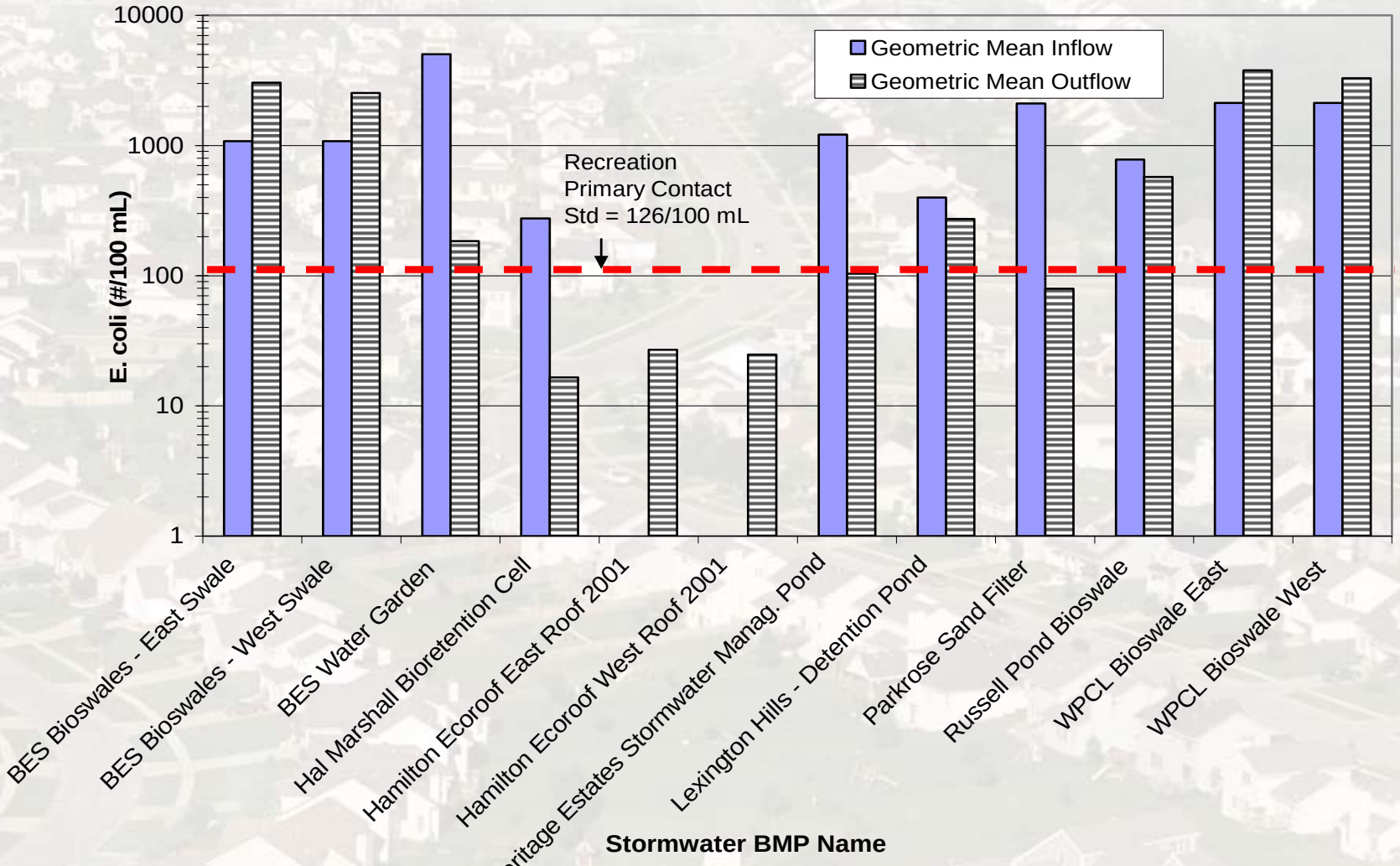
- Design BMPs for better performance than "average" or "median." The upper 75% quartile makes a good target
- Use conservative criteria, including sizing and focusing on longer residence times for volume based BMPs, as well as larger sizing of filters and other flow-through BMPs
- Accomplish multiple benefits in accordance with goals

Future Research Needs

- **Lots of data gaps**
  - **How to best assess infiltrating devices**
  - **Need consistency in study designs and parameters assessed**
  - **Better quality studies, eliminate reliance on “percent removal”**
  - **Start assessing impacts on biology and stream morphology**
  - **Start assessing BMP performance at larger scales (neighborhood, watershed, etc.)**
  - **Bacteria – better measures and more research on BMP performance**

Controlling Bacterial Presents Real Challenges

Figure 2. Comparison of Geometric Mean E. coli Data for Stormwater BMPs in International Stormwater BMP Database



Questions

Using BMP Performance Information in Your Stormwater Program

Using BMP Performance data in your stormwater program

- BMP selection and design
  - Project engineer/consultant
  - Plan review staff
- TMDL implementation
- Watershed modeling

TMDL implementation

Estimating wasteload allocations (WLAs)

Before **WLA is developed:**

- **Better info on BMPs = Better/more complete WLA**

After **WLA is developed:**

- **Use BMP performance data to demonstrate compliance with permits limits that implement WLA**
- **BMP performance data can provide rationale to demonstrate that BMPs achieve goals of WLA**

Example: Portland, OR

- MS4 permit requires the City to develop “pollutant load reduction benchmarks” for areas where TMDLs have been established
- Used to assess overall effectiveness of SWMP in meeting WLA
- Benchmarks developed by modeling pollutant reductions from BMPs

Stormwater and TMDL References

- **Summary of 17 TMDLs with Stormwater Sources**
  www.epa.gov/owow/tmdl/17_TMDLs_Stormwater_Sources.pdf
- **Total Maximum Daily Loads and National Pollutant Discharge Elimination System Storm Water Permits for Impaired Water Bodies: A Summary of State Practices**
  www.epa.gov/region5/water/wshednps/topic_tmdls.htm

- **Forth coming guidance on stormwater/TMDLs for permit writers and TMDL developers**

Watershed modeling

- BMP Performance data can be used in many types of models
  - BMP modeling
  - Water quality/watershed modeling
  - Water quantity/flood modeling
- More accurate data on BMP performance improve the model accuracy

Questions