The National Stormwater Best Management Practices Database Project

Progress Towards Improving the State of the Practice

Principal Investigators

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URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

WWE

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ASCE
American Society of Civil Engineers

Urban Water Resources Research Council

EPA
United States Environmental Protection Agency

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The Problem

- Widespread use of BMPs without sufficient understanding of performance and factors leading to performance
- Inconsistent data reporting methods limit scientific comparison/evaluation of studies

- Differences in monitoring strategies and data evaluation methods result in wide range of reported “effectiveness”

Examples of Inconsistencies In BMP Monitoring Studies

- Constituents
- Sample collection techniques
- Sampling approaches
- Data reporting
- Effectiveness estimation
- Statistical validation of results

Several Studies Have Attempted to Summarize BMP Performance

National Pollutant Removal Performance Database, CWP, 2000

Guidance Specifying Management Measures for Sources of Nonpoint Pollution In Coastal Waters –EPA 1993

The Use of Wetlands for SW Pollution Control – Strecker, 1992

Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs - Schueler 1987

Numerous local and state efforts

State of the Practice: Estimated BMP Pollutant Removal Performances in BMP Manuals

BMP List	Design Rate	Range of Average TSS Removal Rates	Brief Design Requirements
Extended Detention Pond	70%	60-80%	Sediment forebay
Wet Pond (a)	70%	60-80%	Sediment forebay.
Constructed Wetland (b)	80%	65-80%	Designed to infiltrate or retain.
Water Quality Swale	70%	60-80%	Designed to infiltrate or retain.
Infiltration Trench	80%	75-80%	Pretreatment critical.
Infiltration Basin	80%	75-80% (predicted)	Pretreatment critical.
Dry Well	80%	80% (predicted)	Rooftop runoff (uncontaminated only)
Sand Filter (c)	80%	80%	Pretreatment.
Organic Filter (d)	80%	80%+	Pretreatment.
Water Quality Inlet	25%	15-35% w/ cleanout	Off-line only; 0.1" minimum Water Quality Volume (WQV) storage
Sediment Trap (Forebay)	25%	25% w/ cleanout	Storm flows for 2 year event must not cause erosion; 0.1" minimum WQV storage
Drainage Channel	25%	25%	Check dams; non-erosive for 2 yr.
Deep Sump and Hooded Catch Basin	25%	25% w/ cleanout	Deep sump general rule = 4 x pipe diameter or 4.0' for pipes 18" or less.
Street Sweeping	10%	10%	Discretionary non-structural credit, must be part of approved plan.

Source: Stormwater Management Volume One Stormwater Policy Handbook March 1997, MDEP and MCZM, Based on Scheuler, 1996 and EPA, 1993

Estimated BMP Pollutant Removal Performances in BMP Manuals (Cont.)

	TSS	TP	COD	PB	CU	ZN
Stormwater Ponds						
Wet Pond	80	45	40	75	NA	60
Dry Extended Detention	45	25	20	50	NA	20
Wet Extended Detention						
Stormwater Marsh	-20 to 98	-140 to 98		6 to 94		
Vaults/Tanks	60	30	NA	30	NA	30
Infiltration						
Infiltration Trenches/Dry Well	75	60	65	65	NA	65
Infiltration Basins	75	60	65	65	NA	65
Porous Pavements	90	65	80	100	NA	100
Filtration						
Sand FIlter	85	55	55	82	53	76
Vegetated Swale	83	29	NA	63-72	63-72	63-72

Source: City of Portland, OR, Stormwater Quality Facilities: A Design Guidance Handbook

Project History

- UWRRC of ASCE identified the need to address Urban Stormwater BMP performance in a systematic and scientifically rigorous manner (Crested Butte Engineering Foundation Conference)
- The Council approached with a proposal EPA for grant funding
- ASCE/EPA Cooperative Agreement was Established

Project Approach - A Scientifically Rigorous BMP Data Collection and Analysis Effort

- Development of protocols for collection and reporting of BMP performance information
- Establish tool to store BMP monitoring and design data in standard format
- Tool has been a driver for formal discussion and specification of protocols

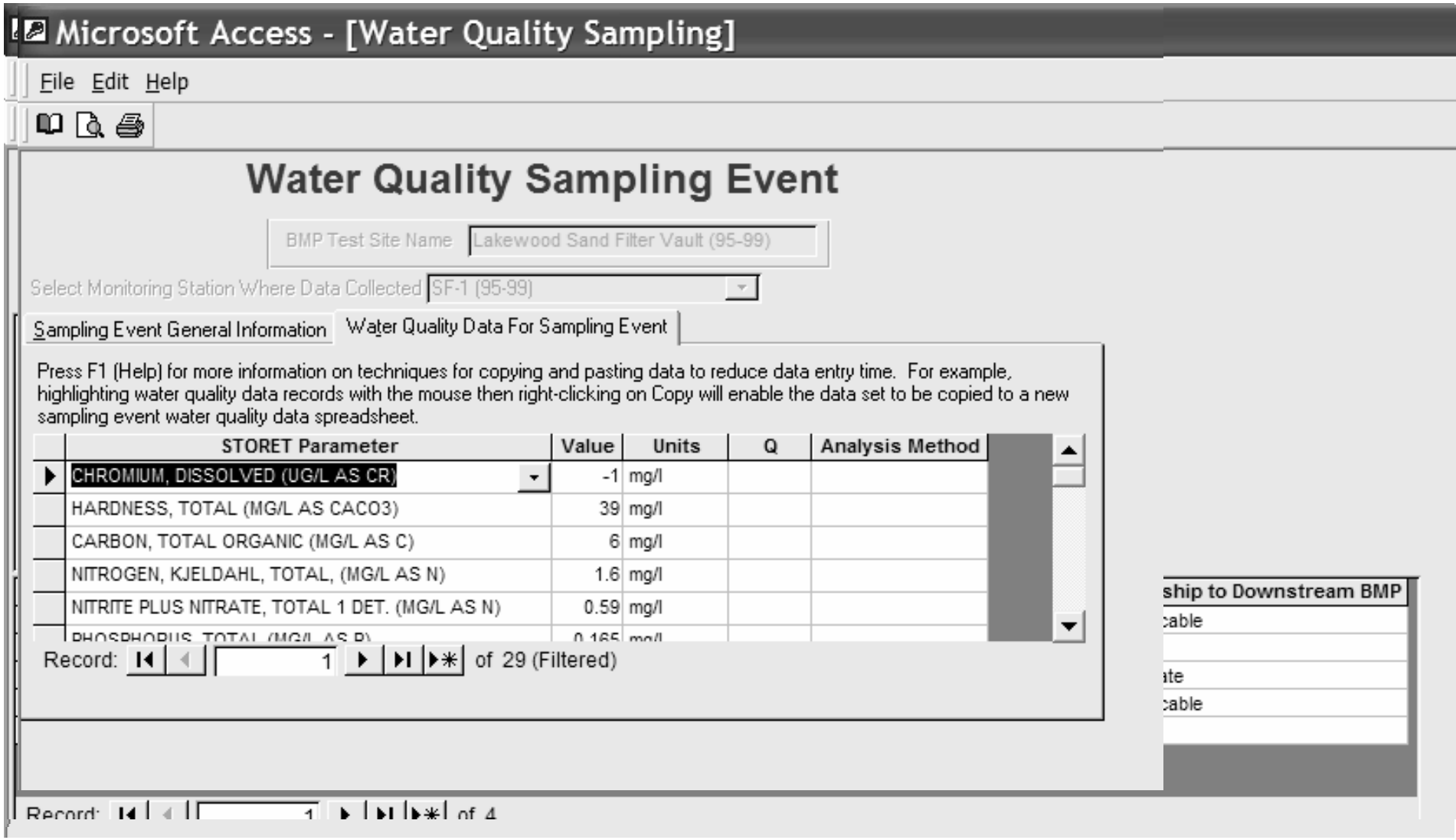
- Establish standard techniques for data collection, storage, reporting, and analysis (guidance document)
- Conduct data analysis and exploration
- Disseminate findings
- Promote technical design improvements

Products Produced to Date

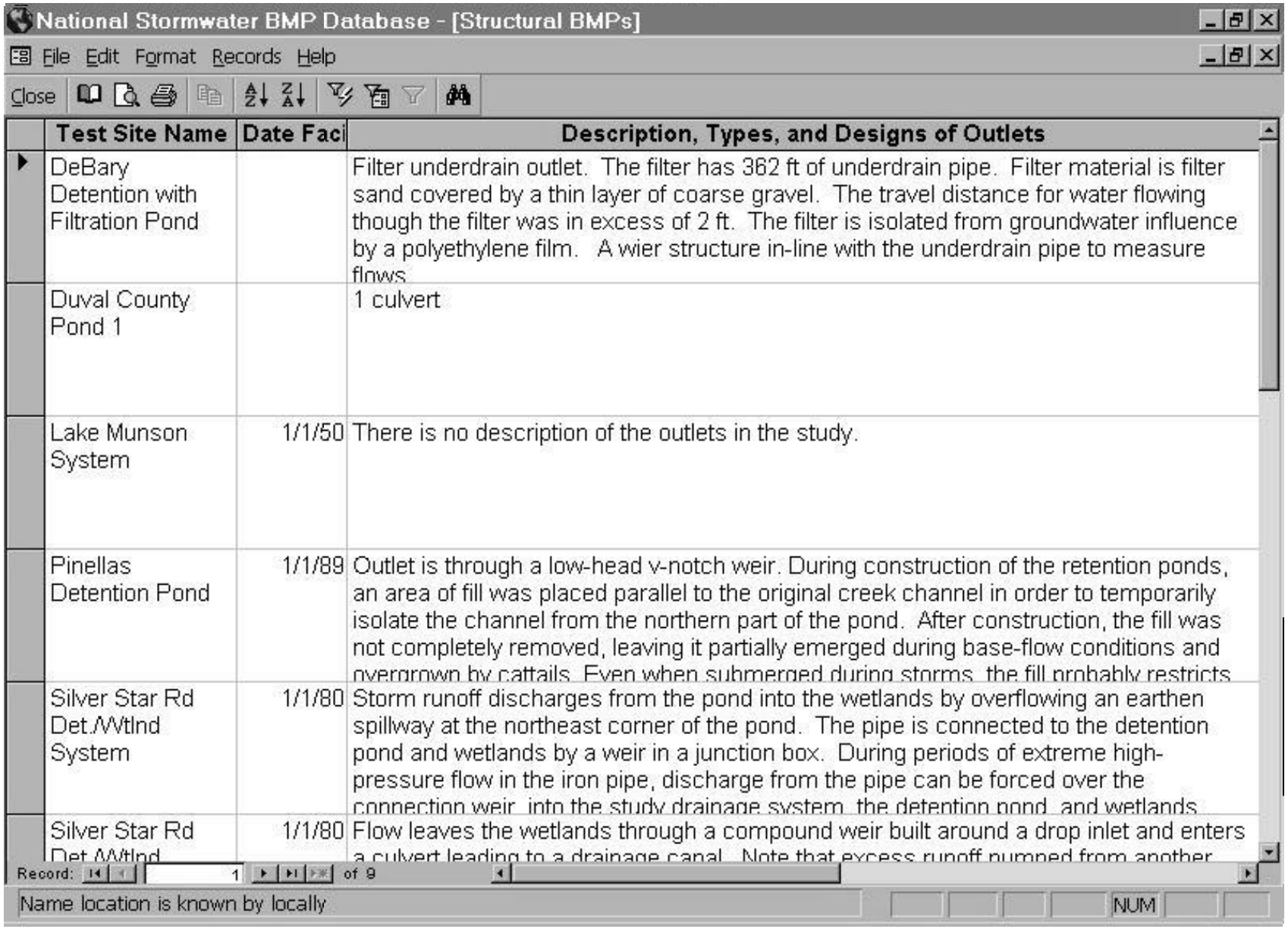
- Protocol Documents

- Database Tool
  - Data Input and Search
  - Available in CD (1700 distributed to-date) and Downloadable Formats
- Web Site (www.bmpdatabase.org)
  - Searchable Database
  - Project Deliverables Available
  - Downloads
  - Project Information
- Guidance Manual

BMP Software: BMP Database Data Entry Module



BMP Database Data Search Engine


National Stormwater BMP Database - [Structural BMPs]

File Edit Format Records Help

Close

	Test Site Name	Date Faci	Description, Types, and Designs of Outlets
▶	DeBary Detention with Filtration Pond		Filter underdrain outlet. The filter has 362 ft of underdrain pipe. Filter material is filter sand covered by a thin layer of coarse gravel. The travel distance for water flowing though the filter was in excess of 2 ft. The filter is isolated from groundwater influence by a polyethylene film. A wier structure in-line with the underdrain pipe to measure flows
	Duval County Pond 1		1 culvert
	Lake Munson System	1/1/50	There is no description of the outlets in the study.
	Pinellas Detention Pond	1/1/89	Outlet is through a low-head v-notch weir. During construction of the retention ponds, an area of fill was placed parallel to the original creek channel in order to temporarily isolate the channel from the northern part of the pond. After construction, the fill was not completely removed, leaving it partially emerged during base-flow conditions and overgrown by cattails. Even when submerged during storms, the fill probably restricts
	Silver Star Rd Det./Wtlnd System	1/1/80	Storm runoff discharges from the pond into the wetlands by overflowing an earthen spillway at the northeast corner of the pond. The pipe is connected to the detention pond and wetlands by a weir in a junction box. During periods of extreme high-pressure flow in the iron pipe, discharge from the pipe can be forced over the connection weir, into the study drainage system, the detention pond, and wetlands
	Silver Star Rd Det./Wtlnd	1/1/80	Flow leaves the wetlands through a compound weir built around a drop inlet and enters a culvert leading to a drainage canal. Note that excess runoff pumped from another

Record: 1 of 9

Name location is known by locally

NUM

BMP Database Website

National Stormwater BMP Database - Microsoft Internet Explorer

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Back Search Favorites Media

Address http://www.bmpdatabase.org/docs.html Go Links

NATIONAL STORMWATER BEST MANAGEMENT PRACTICES (BMP) DATABASE

HOME

DATA SEARCH ENGINE

DOWNLOADS

DOCUMENTS

BACKGROUND ON DATABASE

WHAT'S NEW

FREQUENTLY ASKED QUESTIONS (FAQS)

CONTACT INFORMATION

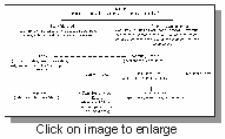
On-line Documents

This section provides downloadable documents produced by the National Stormwater BMP Database Project Team.

Database Documents

- 2001 BMP Database User's Guide (376kb PDF)
  - Provides more complete information on both the data entry and retrieval modules of the database.
- Description of data elements document (139kb PDF)
  - A complete list and description of each field in the database.
- **Database Structure Diagram**

Database Structure Diagram



Click on image to enlarge

Database Background Documents

- **Master Bibliography for Database Development**
  The initial bibliography consisted of 779 entries, which were organized into 6 text files. These files are organized into BMP categories and can be downloaded in .PDF format below.

Select BMP Type

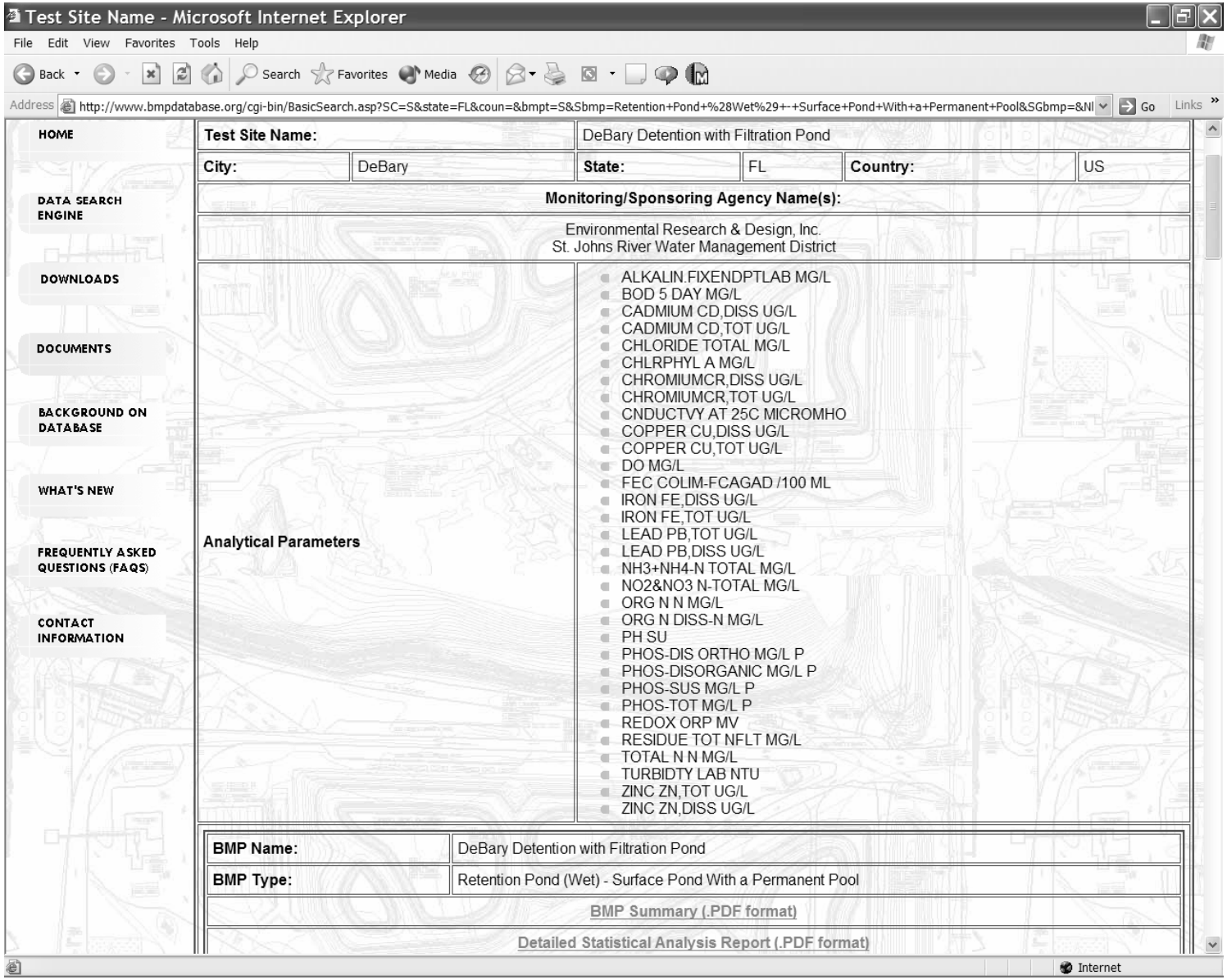
Select One GO!

- Initial Recommendations on Database Structure (September 1996)*
  Data elements and tables (31 pages, 120kb file)

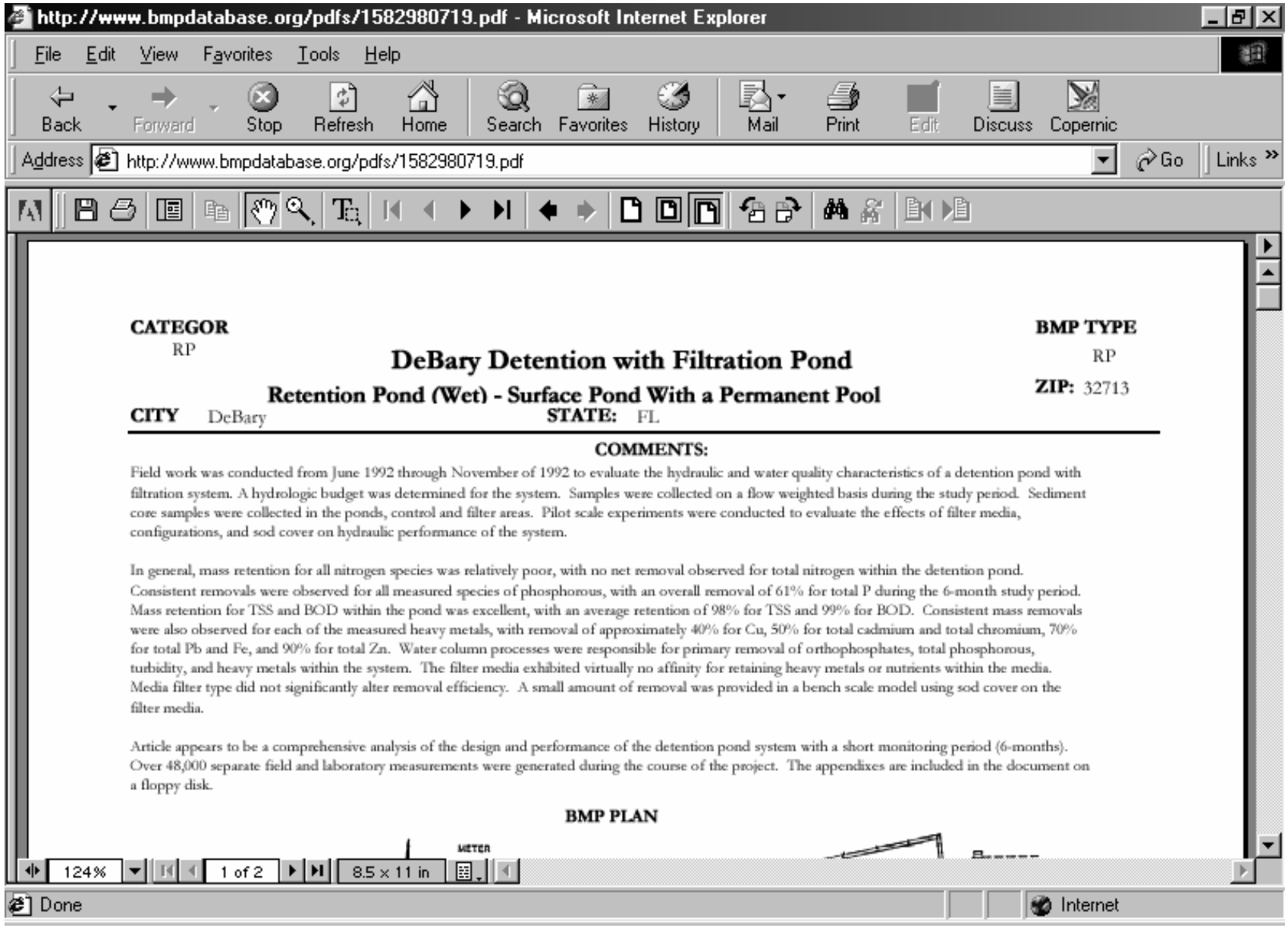
BMP Performance Measures Documents

Done Internet

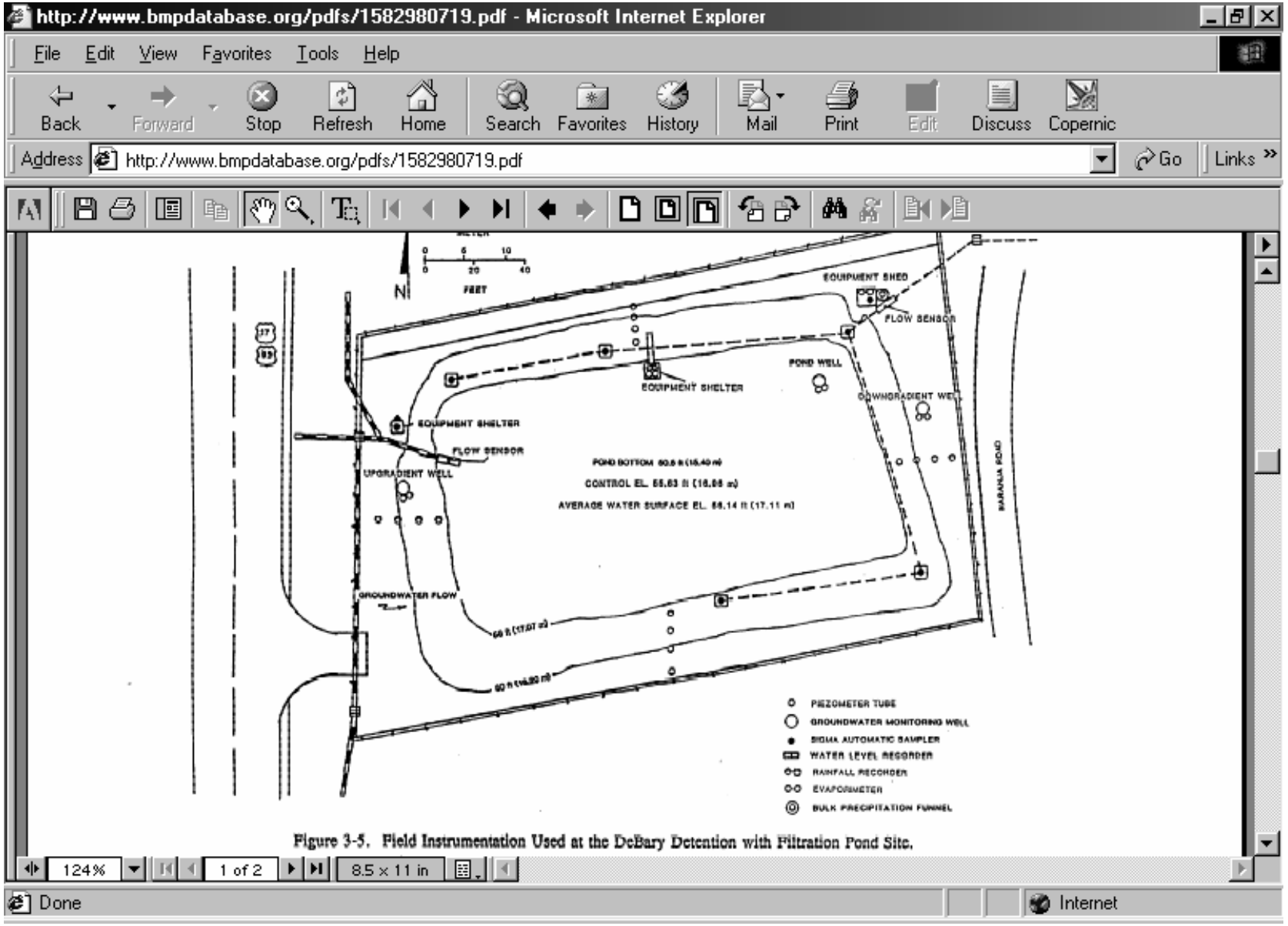
Online Data Search Engine



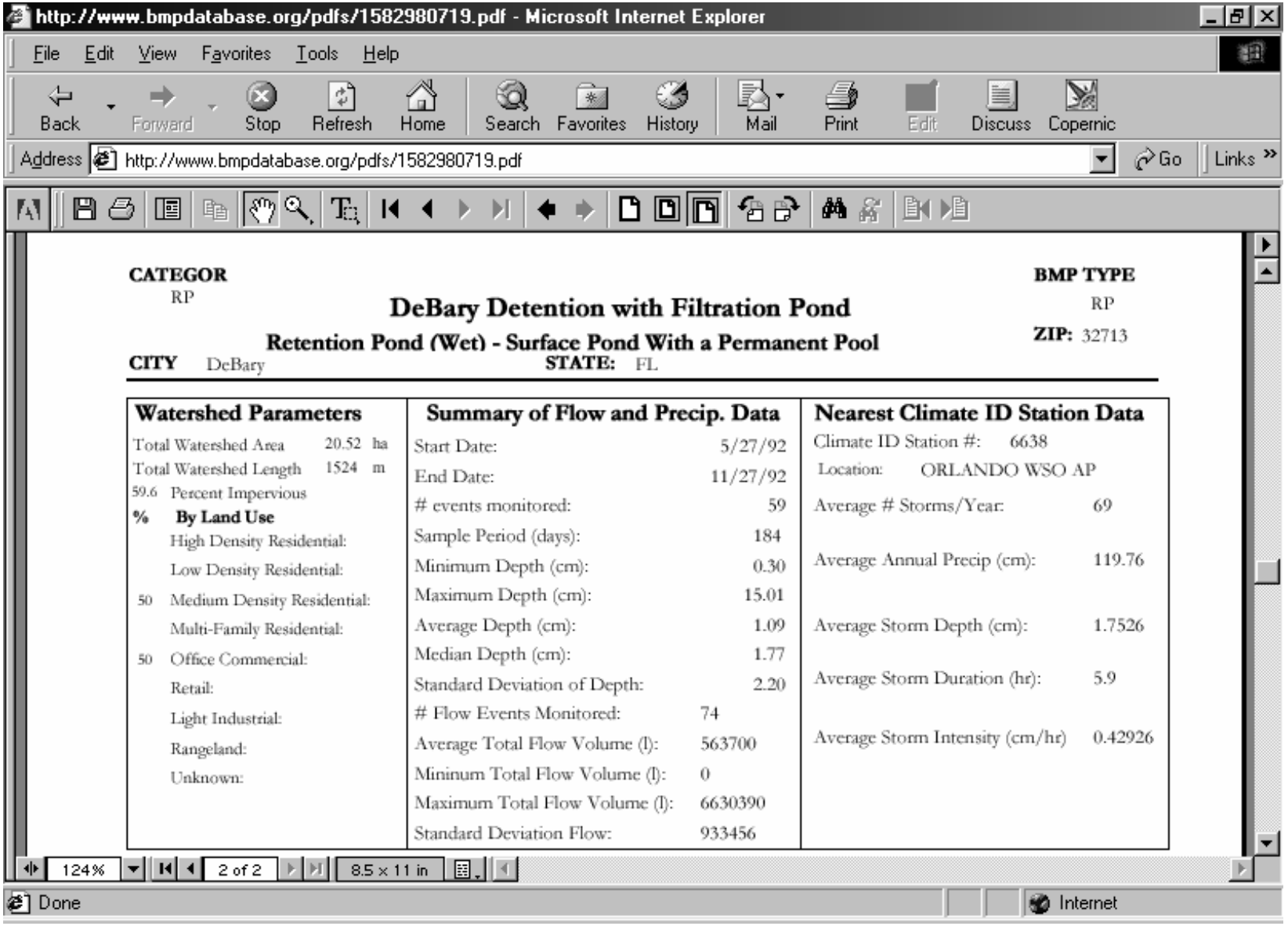
Online Results of Analysis - Summary



Online Results of Analysis
BMP Plans and Images



Online Results of Analysis
Quantitative Summary of Study



Online Results of Analysis
Statistical Water Quality Summary By BMP and Parameter

CATEGOR RP

Lake McCarrons Sedimentation Basin

Retention Pond (Wet) - Surface Pond With a Permanent Pool

BMP TYPE RP

CITY Roseville **STATE:** MN **ZIP:** 55126

Solids, Total Suspended (mg/l)

530

	Count	Log Data Mean	STDEV	Upper CL	Lower CL
Inlet	23	5.72	1.1	6.19	5.25
Outlet	28	3.02	1.17	74.42	26.82

	Arithmetic Data Mean	Median	COV	Upper CL	Lower CL
Inlet	554.69	304.51	1.52	1045.79	366.72
Outlet	40.64	20.42	1.72	74.42	26.82

Pollutant Removals	
Mean Inflow - Mean Outflow	Percent Difference
514.05	93%

Analysis of Variance (Mann Whitney Test)		
U-Statistic	Probability	CHI Square
616	0	30.98

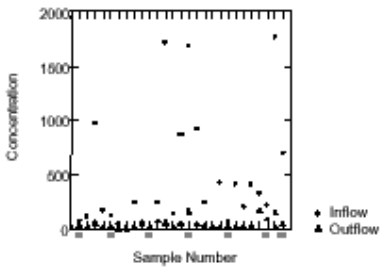
Analysis of Variance (ANOVA)		
Sum of Squares	F-ratio	P-Value
92.19	71.09	0

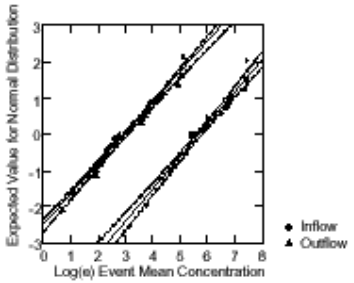
Kolmogorov-Smirnoff Test	
Maxiumum Difference for Pai	Probability
0.77	0

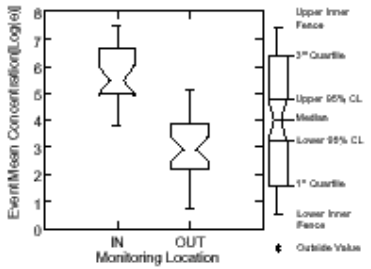
	Inlet	Outlet
10th Percentile	20.55	4.54
25th Percentile	58.23	9.26
75th Percentile	589.22	45.06
90th Percentile	1669.6	91.85

	Difference	% Difference
Inflow 10th Percentile - Outflow 10th Percentile	16.01	78.0%
Inflow 90th Percentile - Outflow 90th Percentile	1577.75	94.0%

Maximum Percent Removal (upper unflow CI to lower outflow CL)	97.4%
Minimum Percent Removal (lower inflow CI to upper outflow CL)	79.7%



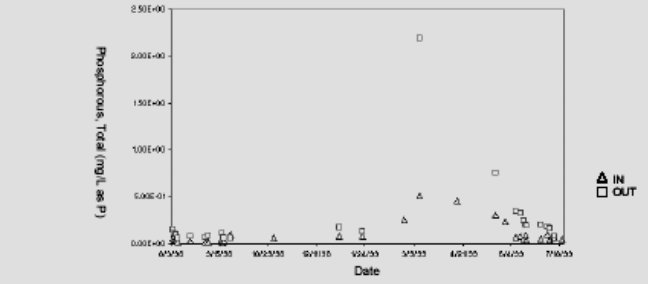


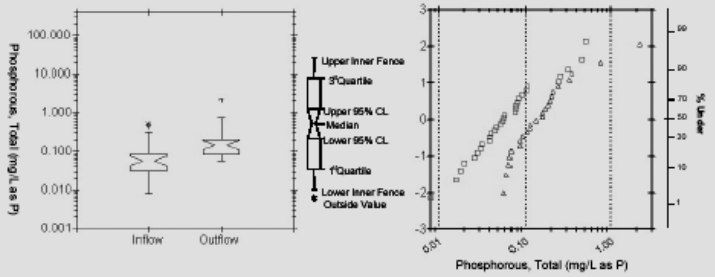


Updated Statistical Analysis – PDF Documents
Water Quality Analysis

Swale - F4
Biofilter - Grass Swale
Phosphorous, Total (mg/L as P)

Inflow		Outflow	
Number of Inflow EMCs	**30**	**Number of Outflow EMCs**	**24**
Upper 95% Confidence Limit	0.1554	Upper 95% Confidence Limit	0.3356
Arithmetic Estimate of the Mean Inflow EMC	**0.1002**	Arithmetic Estimate of the Mean Outflow EMC	**0.2228**
Lower 95% Confidence Limit	0.0726	Lower 95% Confidence Limit	0.165
Arithmetic Estimate of Standard Deviation of the Inflow EMC	0.127	Arithmetic Estimate of Standard Deviation of the Outflow EMC	0.2275
Mean Inflow EMCs	0.103	Mean Outflow EMCs	0.2586
Standard Deviation of Inflow EMCs	0.1266	Standard Deviation of Outflow EMCs	0.4371
Log Mean of Inflow EMCs	-2.779	Log Mean of Outflow EMCs	-1.858
Log Standard Deviation of Inflow EMCs	0.9788	Log Standard Deviation of Outflow EMCs	0.845





Summary Statistics - Event Mean Concentrations
Swale - F4
Biofilter - Grass Swale
Phosphorous, Total (mg/L as P)

Summary of Distributional Charateristics

Shapiro-Wilks W-test (n<50) $\alpha = 0.05$

Inflow		Outflow	
Inflow EMCs Normally Distributed?	No	Outflow EMCs Normally Distributed?	No
Inflow EMCs Log Normally Distributed?	Yes	Outflow EMCs Log Normally Distributed?	No

Lilliefors Test (used when n>50) $\alpha = 0.05$

Inflow		Outflow	
Lillifors Probability for Inflow EMCs	0	Lillifors Probability for Outflow EMCs	0
Lillifors Probability for Log Transformed Inflow EMCs	0.193	Lillifors Probability for Log Transformed Outflow EMCs	0.147

Hypothesis Test Results - Raw Data

Nonparametric Analysis - Mann-Whitney Test $\alpha = 0.05$

Reject the Null Hypothesis that the two means are the same?	Yes	Mann-Whitney Probability	0

Parametric Analysis - t-Test $\alpha = 0.05$

Reject the Null Hypothesis that the two means are the same? Assuming Equal Varience.	No	Reject the Null Hypothesis that the two means are the same? Assuming Unequal Varience.	No
Separate Proabability	0.103	Pooled Probability	0.069

Hypothesis Test Results - Log Transformed Data

Nonparametric Analysis - Mann-Whitney Test $\alpha = 0.05$

Reject the Null Hypothesis that the two means are the same?	Yes	Mann-Whitney Probability	0

Parametric Analysis - t-Test $\alpha = 0.05$

Separate Proabability	0.001	Pooled Probability	0.001
Reject the Null Hypothesis that the two means are the same? Assuming Equal Varience.	Yes	Reject the Null Hypothesis that the two means are the same? Assuming Unequal Varience.	Yes

Test of Equal Variance - Levene Test - Log Transformed Data

Equal Varience?	No	Probability	0.444

Updated Statistical Analysis – PDF Documents
Flow and Precipitation

BMP TYPE Detention Basin — **15/78** — **BMP TYPE** DB

Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm

CITY: Escondido **STATE:** CA **ZIP:** 92025

Characterization of Nearby Climate Station Indicative of Precipitation at Site [1]

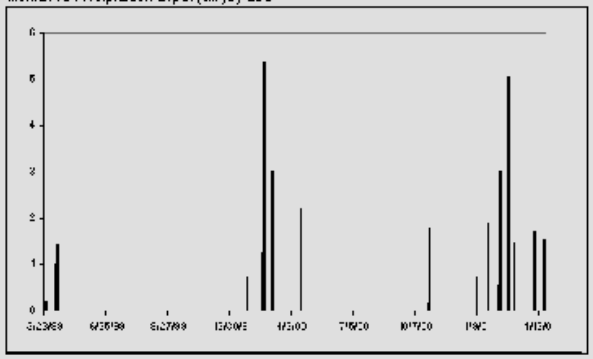
Station Name	SAN DIEGO WSO AP
Station ID or Gage Number	7740
Period of record augmented # of storms 0.10" or > in depth	18
Coefficient of variation for # of storms	0.41
Period of record augmented precipitation total - inches	8.97
Coefficient of variation for precip total	0.44
Period of record duration of storms 0.10" or > in depth	11.8
Coefficient of variation for storm duration	0.75
Period of record intensity of storms 0.10" or > in depth	0.052
Coefficient of variation for storm intensity	0.82
Period of record period between storms 0.10" or > in depth	503
Coefficient of variation of period between storms	2

[1] Data are limited to those identified in "Analysis of Storm Event Characteristics for Selected Rainfall Gages Throughout the United States", (Driscoll, 1990).

Summary of Monitored Precipitation Events Associated with Water Quality Events

Number of Precipitation Events Monitored	19
Average Depth of Precipitation Event	2.01
Minimum Depth of Precipitation	0.51
Maximum Depth of Precipitation	5.05
Standard Deviation of Depth of Precipitation	1.255
Variance of Depth of Precipitation	1.574

Monitored Precipitation Depth (cm) by Date



BMP TYPE Detention Basin — **15/78** — **BMP TYPE** DB

Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm

CITY: Escondido **STATE:** CA **ZIP:** 92025

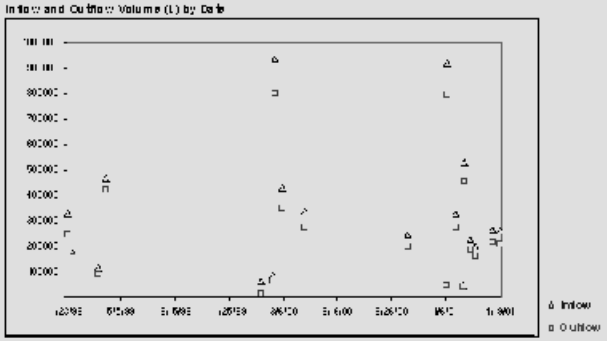
Summary of Monitored Inflows Associated with Water Quality Events

Number of Inflow Measurements Collected	19
Number of Water Quality Events Where Inflows Were Measured	19
Average of Total Event Inflow Volume	317207
Minimum Total Event Inflow Volume	45156
Maximum Total Event Inflow Volume	938732
Standard Deviation of Total Event Inflow Volume	250200

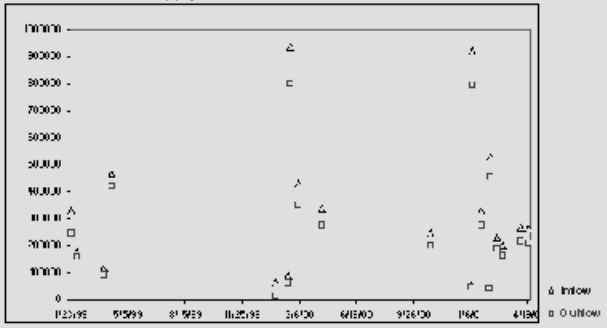
Summary of Monitored Outflows Associated with Water Quality Events

Number of Outflow Measurements Collected	19
Number of Water Quality Events Where Outflows Were Measured	19
Average of Total Event Outflow Volume	263704
Minimum Total Event Outflow Volume	10506
Maximum Total Event Outflow Volume	801678
Standard Deviation of Total Event Outflow Volume	218972

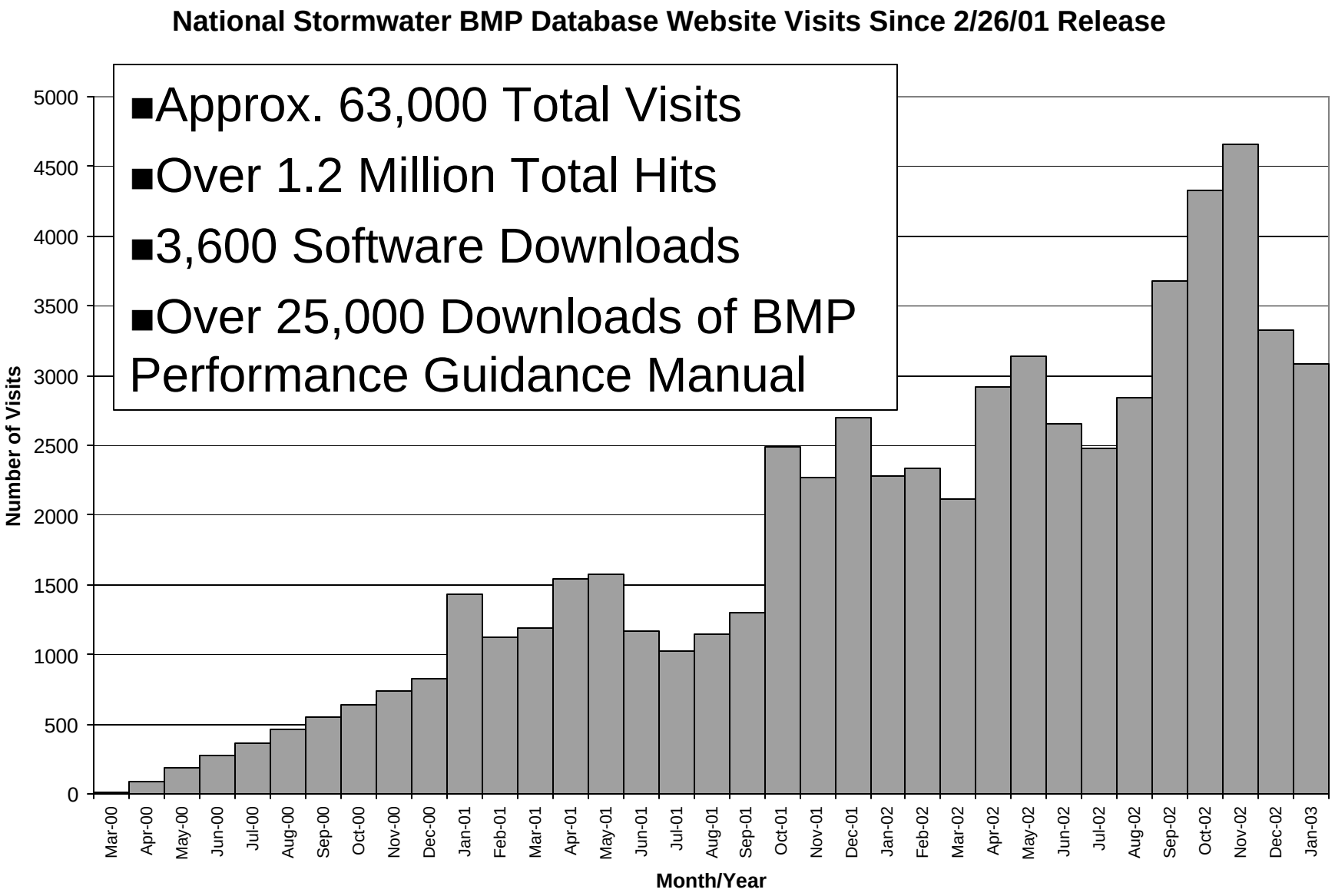
Inflow and Outflow Volume (L) by Date



Inflow and Outflow Volume (L) by Rank



Growth of Database Use - Website



Distribution of Current Studies (2/5/03)

BMP TOTALS BY CATEGORY

BMP CATEGORY	NUMBER OF BMPS
Structural	
Biofilter (Grass Swales)	32
Detention Basin	24
Hydrodynamic Device	16
Media Filter	30
Percolation Trench/Well	1
Porous Pavement	5
Retention Pond	33
Wetland Basin	15
Wetland Channel	14
Total	**170**
Non-Structural	
Maintenance Practice	28
Total	**28**
Grand Total	**198**

BMP TOTALS BY STATE/COUNTRY

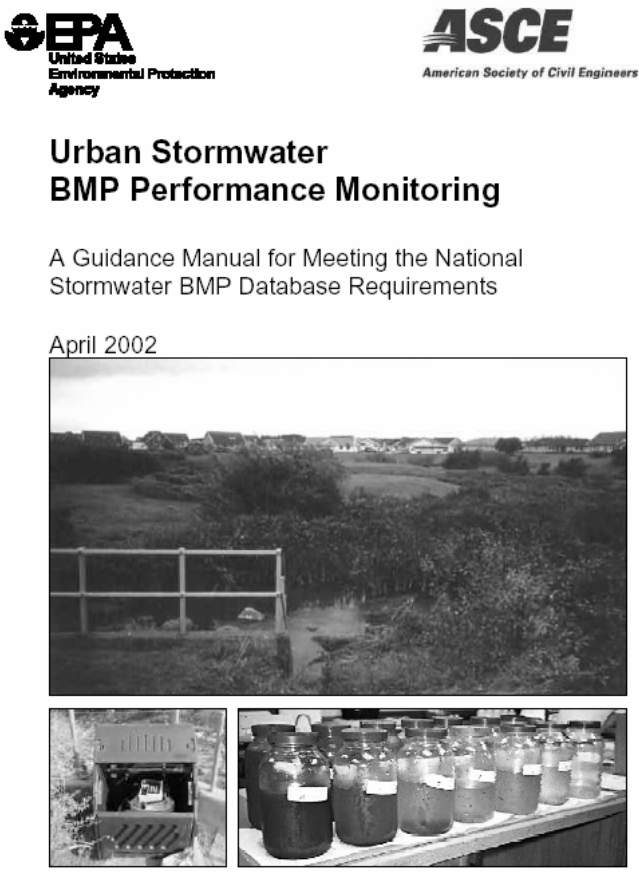
STATE	NUMBER OF BMPS
Domestic	
AL	13
CA	**41**
CO	4
FL	24
GA	2
IL	5
MD	4
MI	5
MN	7
NC	6
NJ	3
OH	1
OR	3
TX	19
VA	29
WA	20
WI	10
International	
Sweden	1
Canada	1

Potential Future Studies

- 112 Potential Data Providers Identified (9 International)
  - Integrated into Contacts Database
- 9ICUD Identified Additional Sources (At Least 3)
- New Studies for 2003

Data Provider	Number of Studies	BMP Types
Domestic		
City of Greenboro, North Carolina	2	Bioretention
Washington State Department of Transportation	2	Infiltration Trench and Hydrodynamic Device
Denver Urban Drainage and Flood Control District	4	3 Media Filters and 1 Porous Pavement
BaySaver, Inc.	1	Hydrodynamic Device
Penn State University	1	Porous Pavement
Vortechnics, Inc.	1	Hydrodynamic Device
International		
University of Canberra, Australia	Numerous BMPs	Unknown
University of Abertay Dundee, United Kingdom	3	2 Swales and 1 Porous Pavement
Total	**14**	

Protocols in Practice - The Manual



- The manual is available in three formats:
  - EPA will be publishing the Manual in Paper Form- first ½ of 2003
  - Available on CD – Limited Production
  - Available for download on WWW.BMPDATABASE.ORG
- Approximately 25,000 downloads to date from web site
- Guidance is highly relevant for various levels of BMP monitoring

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

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 <u>Average</u>!

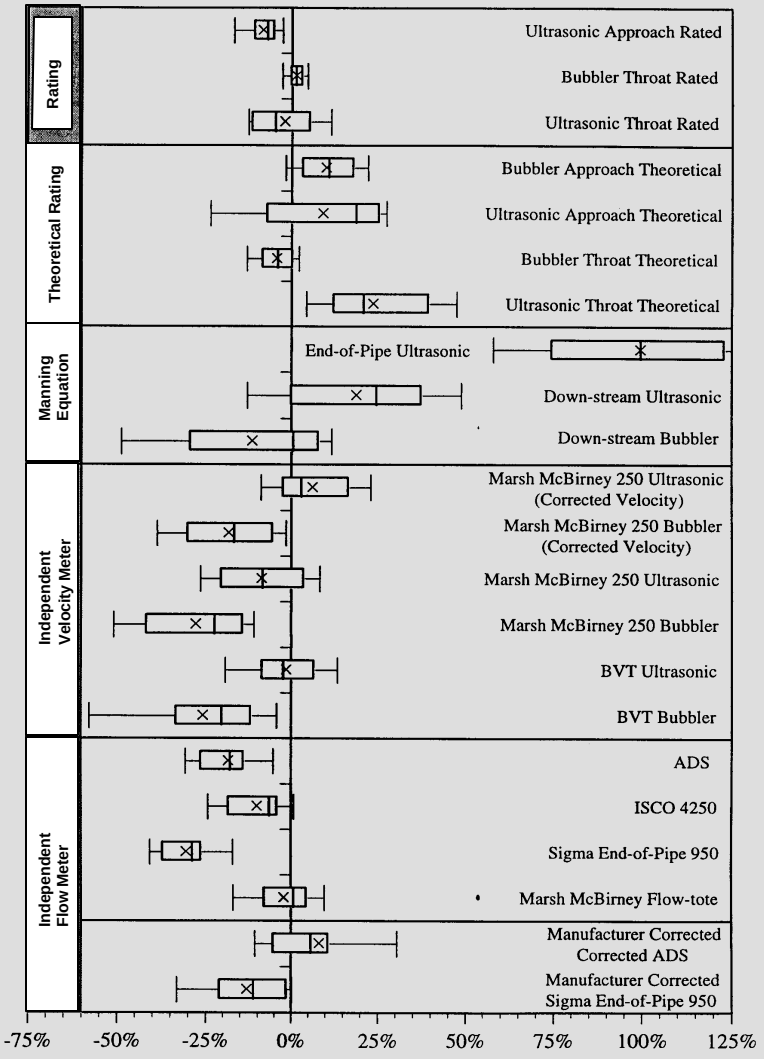


Figure 7. Boxplot of the percent differences between total storm volumes computed using various flow estimation methods and the total storm volume of the bubbler approach rated discharge (bold line at 0%).

Measures of Performance

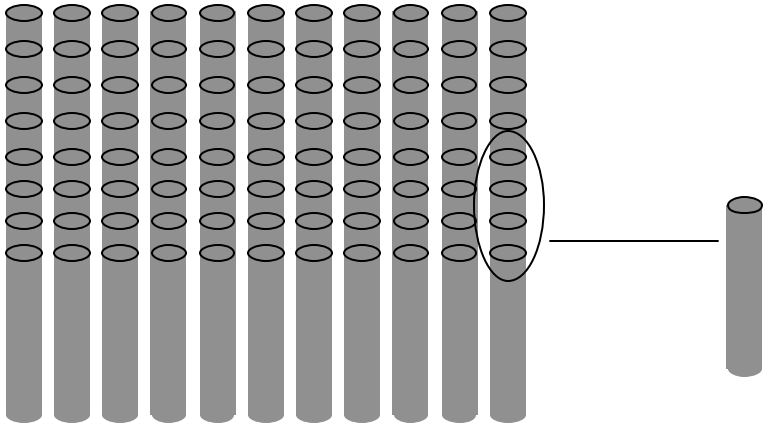
- How much stormwater runoff is prevented? (“hydrological source control”)
- How much of the runoff that occurs is treated by the BMP or not (“hydraulic performance”)?
- Of the runoff treated, what is the effluent quality? (“concentration characteristics achieved”)

Measures of Performance Cont.

- Guidance manual review of historical approaches
- Recommended approach for water quality
  - Effluent Probability Method
  - Statistically determine that the BMP removes pollutants
  - Focus on EFFLUENT QUALITY
- Percent Removal is Very Problematic

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

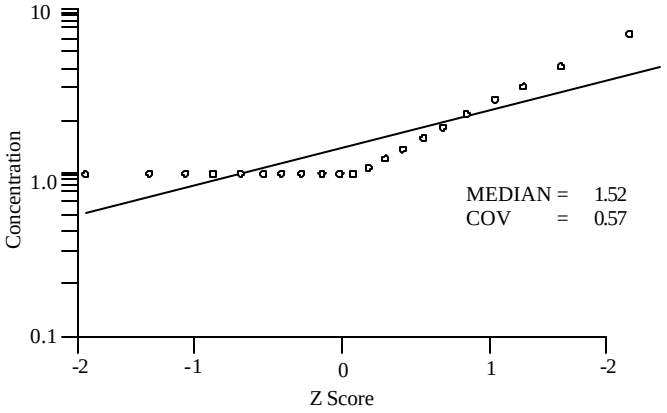
- Grab Versus Composite Samples
- Manual Versus Automated Sampling Methods
  - Cost
  - Study Objectives
  - Sampling issues with regards to larger particles/debris
- Composite Sampling Approaches
  - Constant volume - time proportional to flow volume increment
  - Constant time - constant volume
  -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

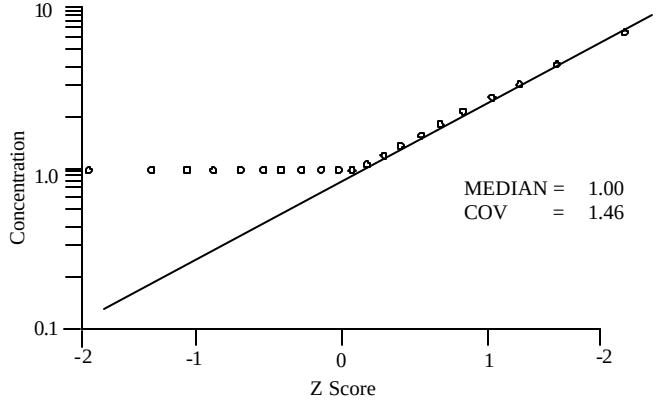
Appendices

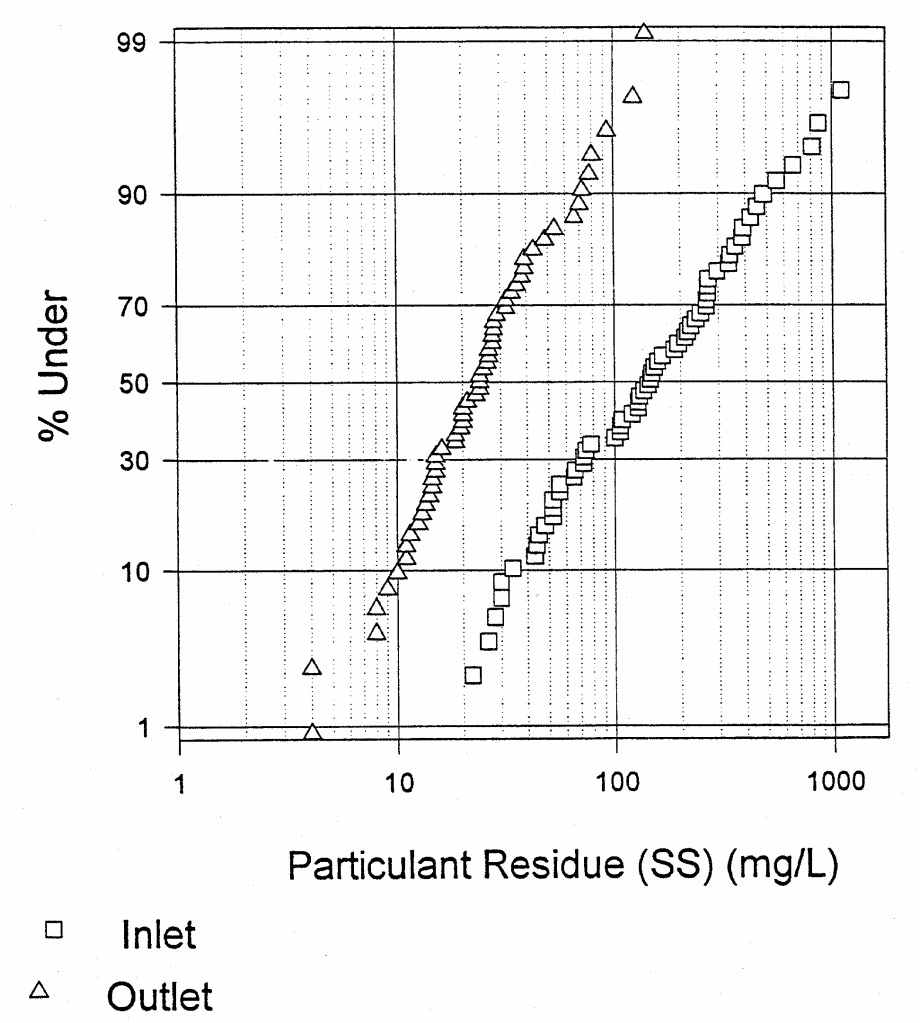
- Data Evaluation and Statistical Hypothesis Testing
- Generic Health and Safety Plan for Monitoring
  - Specific to the Near-highway Environment
- Example Standard Operating Procedures for Field Sampling
  - Plan Used for Monitoring Work for Field Studies

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



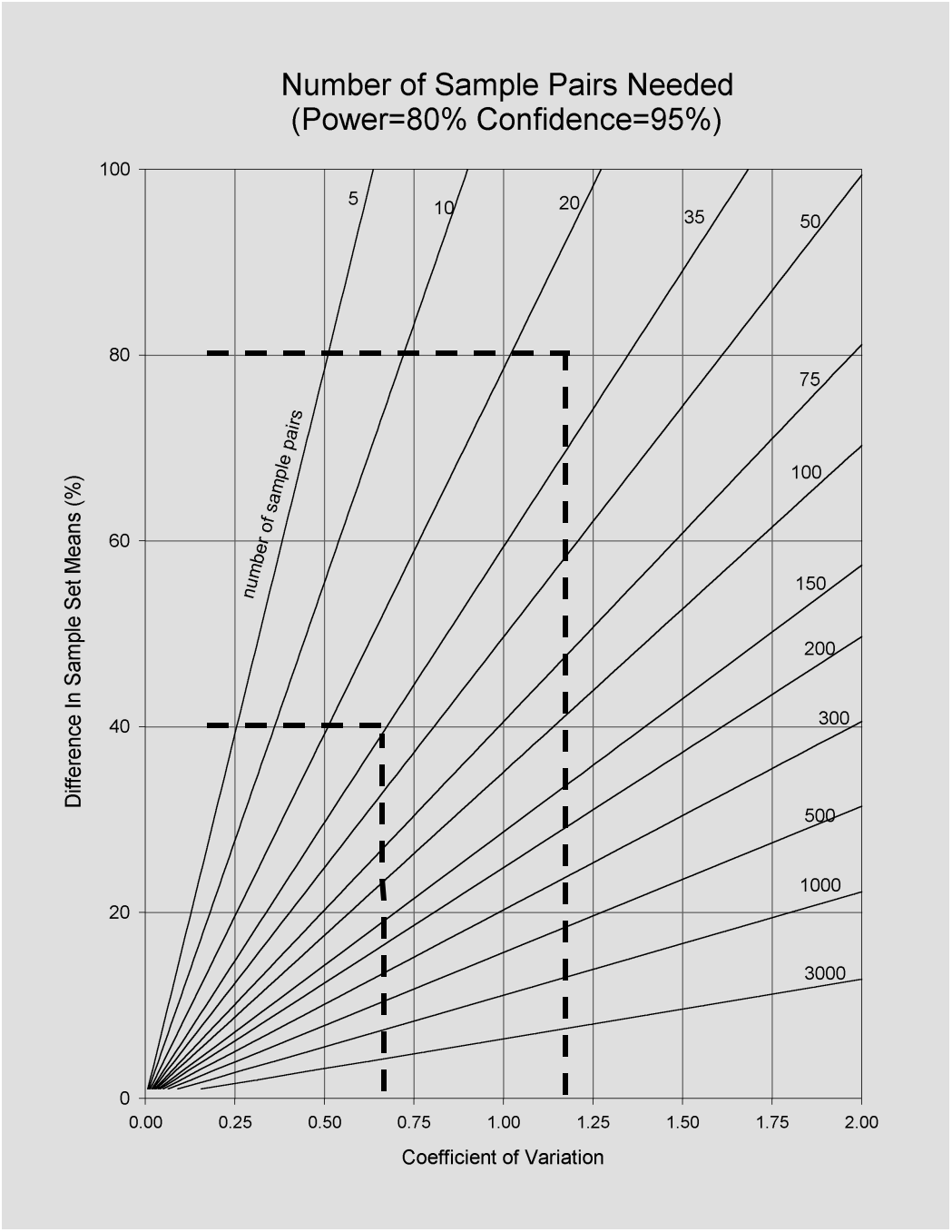




Effluent Probability Method
Normal Probability Plots

Understanding Water Quality Variability

- Many sampling programs do not yield useful results – they are reported as valid assessments of performance
- Number of samples to obtain a statistically valid result from monitoring program
- Feedback to monitoring program design
- More events vs. fewer parameters –cost trade offs?



Adapted from Pitt and Parmer

Recent Results From the NSW BMP Database

- 198 BMPs (~215 by Spring 2003)
- >122,000 water quality records
- ~45,000 EMCs
- Statistical Analysis of Each BMP for Each Pollutant (~2000 separate statistical analyses)
  - Descriptive Statistics (Arithmetic and Log Trans.)
  - Tests of normality (W-test and Lilliefors)
  - Tests of equal variance (F-test and Levene test)
  - Parametric and Non-Parametric Hypothesis Testing
  - Normal prob. plots, Scatter plots, Box and Whisker plots

Distribution of Current Studies (2/5/03)

BMP TOTALS BY CATEGORY

BMP CATEGORY	NUMBER OF BMPS
Structural	
Biofilter (Grass Swales)	32
Detention Basin	24
Hydrodynamic Device	16
Media Filter	30
Percolation Trench/Well	1
Porous Pavement	5
Retention Pond	33
Wetland Basin	15
Wetland Channel	14
Total	**170**
Non-Structural	
Maintenance Practice	28
Total	**28**
Grand Total	**198**

BMP TOTALS BY STATE/COUNTRY

STATE	NUMBER OF BMPS
Domestic	
AL	13
CA	**41**
CO	4
FL	24
GA	2
IL	5
MD	4
MI	5
MN	7
NC	6
NJ	3
OH	1
OR	3
TX	19
VA	29
WA	20
WI	10
International	
Sweden	1
Canada	1

Table 1: Number of Statistical Summaries that are Available from the ASCE/EPA Database Analysis by BMP Type and Parameter

Parameter	Biofilter Grass Strip	Biofilter Grass Swale	Detention Underground Vault, Tank or Pipe(s)	Detention Basin (Dry) Concrete or Lined Tank/Basin With Open Surface	Detention Basin (Dry) Surface Grass-Lined Basin That Empties Out After A Storm	Filter Geotextile Fabric Membrane (Vertical)	Filter Other Media	Filter Peat Mixed With Sand	Filter Sand
Cadmium, Dissolved	1	6	1		3		1	3	4
Cadmium, Total	1	7	1	1	5		2	3	4
Copper, Dissolved	3	8	1	1	4	6	1	3	6
Copper, Total	3	11	1	2	9	6	3	3	6
Lead, Dissolved	3	8	1	1	4	6	1	3	6
Lead, Total	5	12	1	2	9	6	3	3	6
Nitrate + Nitrite, Dissolved					1				
Nitrate + Nitrite, Total		2	1		1			1	
Nitrate Nitrogen, Dissolved			1		1			1	
Nitrate Nitrogen, Total	5	10		2	5	6	2	2	6
Nitrogen, Kjeldahl, Total	5	7		1	6	6	1	2	6
Nitrogen, Total		4			4				
Nitrogen, Total Organic					1				
Oil and Grease		2			4		2		1
Phosphate, Ortho	2	8	1		9	1	1	3	5
Phosphorous, Dissolved					1				
Phosphorous, Suspended					1				
Phosphorous, Total	5	13		2	8	6	3	2	6
Phosphorous, Total					3				
Residue, Total			1					1	
Solids, Total		2							

Table 1 cont: Number of Statistical Summaries that are Available from the ASCE/EPA Database Analysis by BMP Type and Parameter

Parameter	Hydrodynamic Devices	Infiltration (Percolation) Trench	Oil & Water Separator	Porous Pavement Asphalt	Porous Pavement Poured Concrete	Retention Pond (Wet) Surface Pond With a Permanent Pool	Wetland Basin With Open Water Surfaces	Wetland Basin Without Open Water (Wetland Meadow Type)	Wetland Channel With Wetland Bottom
Cadmium, Dissolved	4					1	1		
Cadmium, Total	5			1	1	10	2		
Copper, Dissolved	7					4	1		
Copper, Total	9			1	1	13	2		
Lead, Dissolved	7					5	1		2
Lead, Total	8	1		1	1	16	3		3
Nitrate + Nitrite, Dissolved									
Nitrate + Nitrite, Total	4					10	3		
Nitrate Nitrogen, Dissolved	1								
Nitrate Nitrogen, Total	2	1		1		4	3		3
Nitrogen, Kjeldahl, Total	4	1		1	1	13	4		2
Nitrogen, Organic Dissolved						2			
Nitrogen, Organic Kjeldahl, Total									
Nitrogen, Total	1	1		1		6	6		4
Nitrogen, Total Organic						6	3		1
Oil and Grease	3			1	1	2	2		1
Phosphate, Ortho	3					4	2	2	

CATEGOR
RP

Lake McCarrons Sedimentation Basin

Retention Pond (Wet) - Surface Pond With a Permanent Pool

BMP TYPE
RP

CITY Roseville **STATE:** MN **ZIP:** 55126

Solids, Total Suspended (mg/l)

530

	Count	Log Data Mean	STDEV	Upper CL	Lower CL
Inlet	23	5.72	1.1	6.19	5.25
Outlet	28	3.02	1.17	74.42	26.82

	Arithmetic Data Mean	Median	COV	Upper CL	Lower CL
Inlet	554.69	304.51	1.52	1045.79	366.72
Outlet	40.64	20.42	1.72	74.42	26.82

Pollutant Removals	
Mean Inflow - Mean Outflow	Percent Difference
514.05	93%

Analysis of Variance (Mann Whitney Test)		
U-Statistic	Probability	CHI Square
616	0	30.98

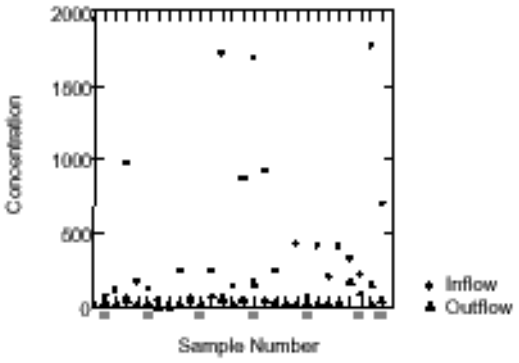
Analysis of Variance (ANOVA)		
Sum of Squares	F-ratio	P-Value
92.19	71.09	0

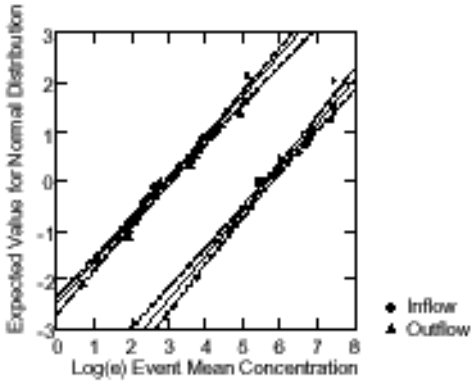
Kolmogorov-Smirnoff Test	
Maxiumum Difference for Pai	Probability
0.77	0

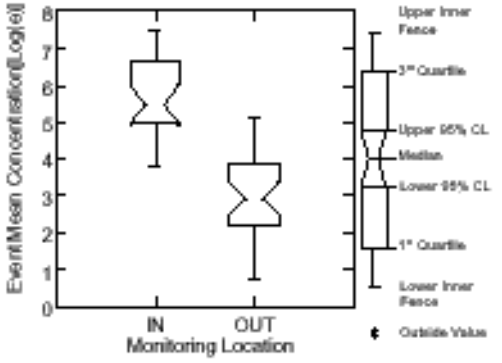
	Inlet	Outlet
10th Percentile	20.55	4.54
25th Percentile	58.23	9.26
75th Percentile	589.22	45.06
90th Percentile	1669.6	91.85

	Difference	% Difference
Inflow 10th Percentile - Outflow 10th Percentile	16.01	78.0%
Inflow 90th Percentile - Outflow 90th Percentile	1577.75	94.0%

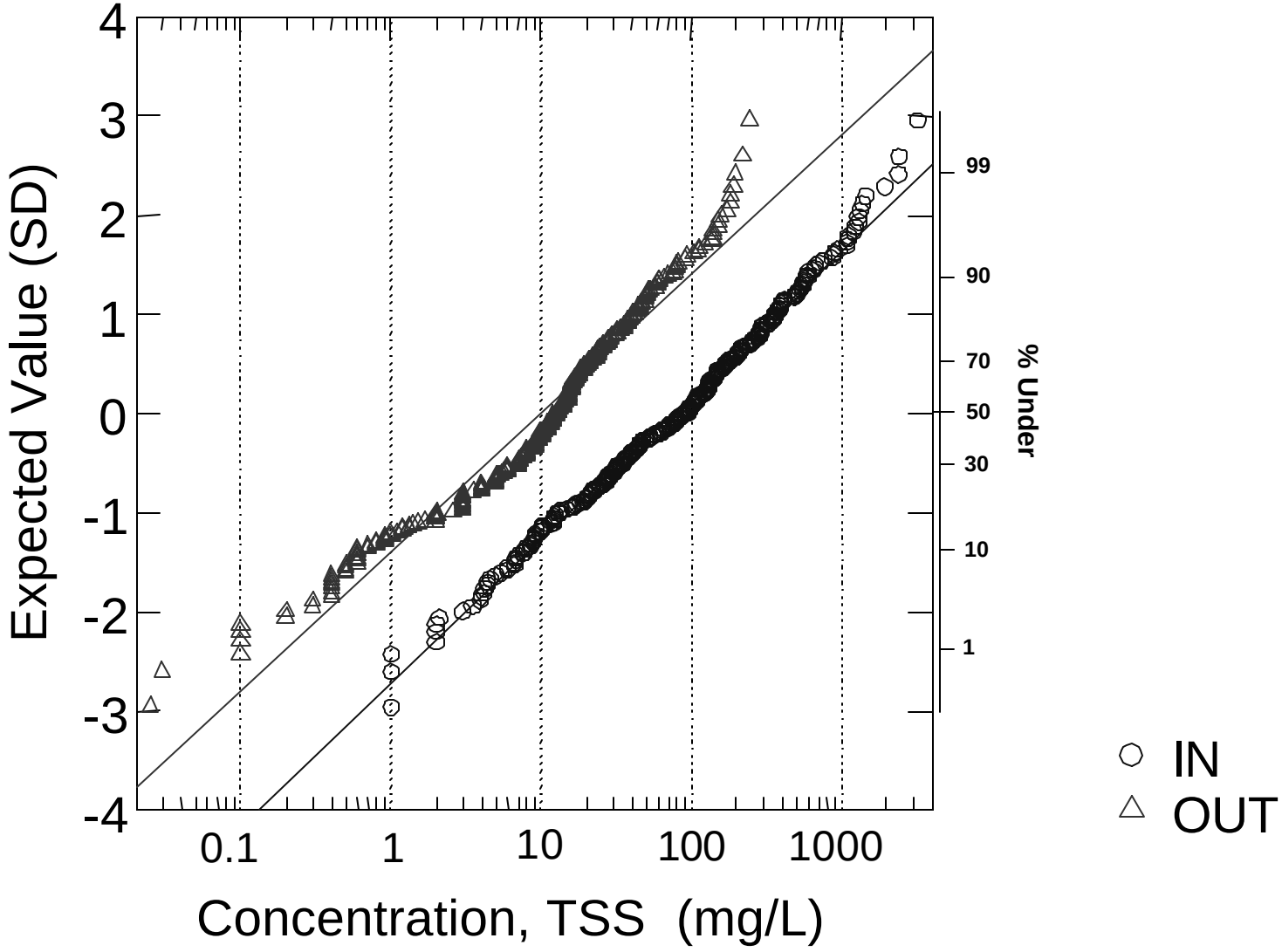
Maximum Percent Removal (upper unflow CI to lower outflow CL)	97.4%
Minimum Percent Removal (lower inflow CI to upper outflow CL)	79.7%



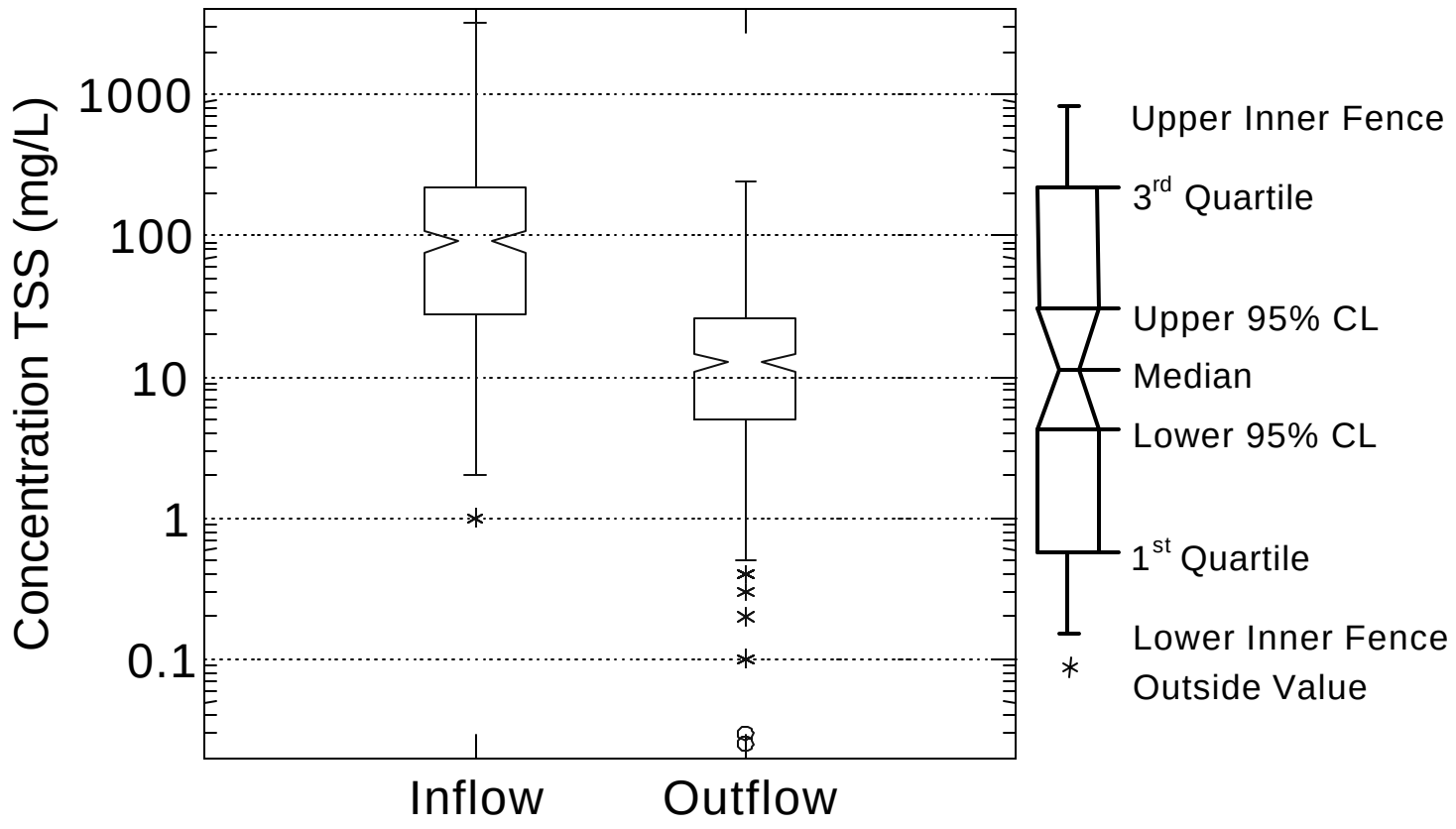




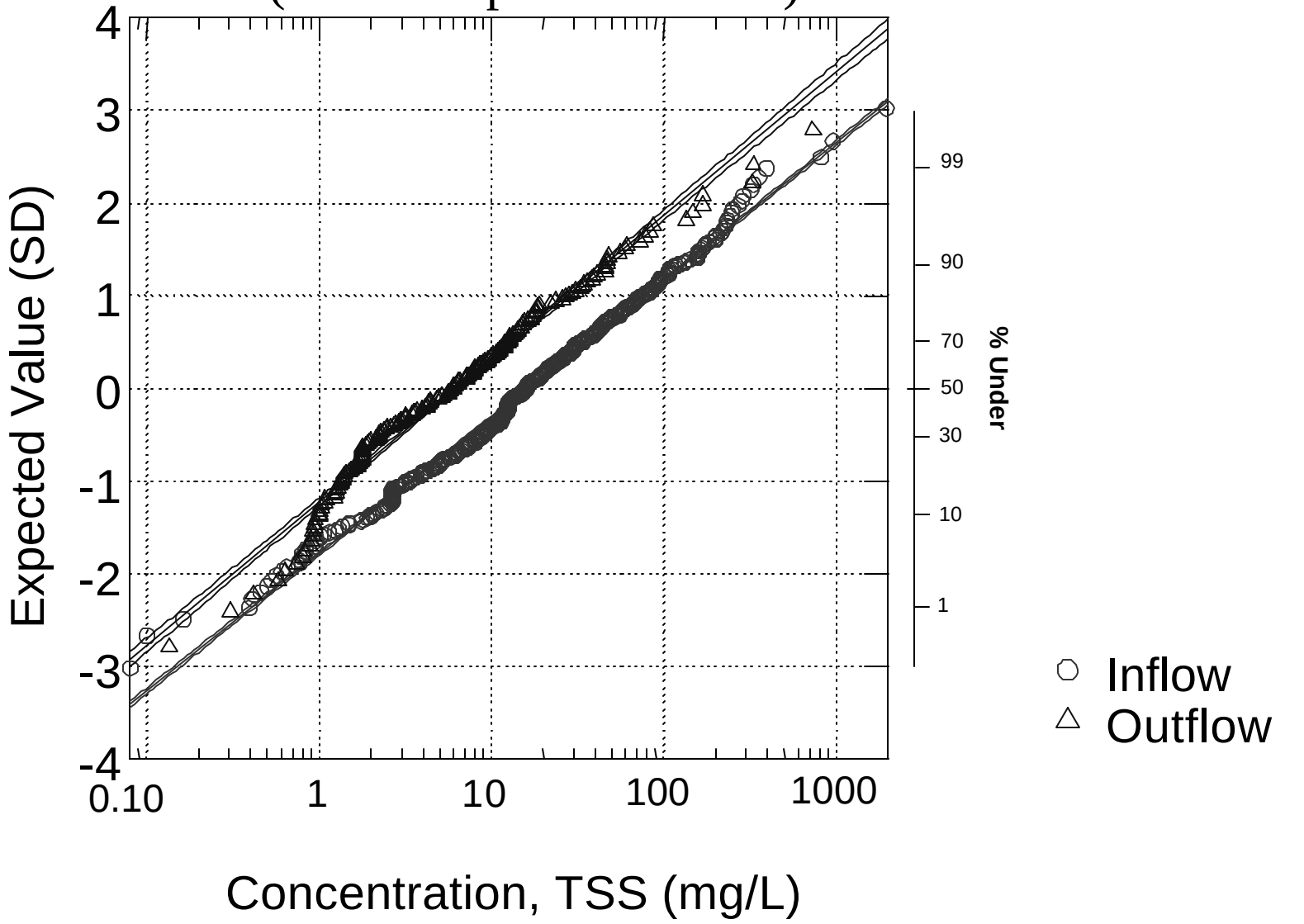
Normal Probability Plot of Influent and Effluent Event Mean Concentration (Total Suspended Solids) for All Retention Ponds



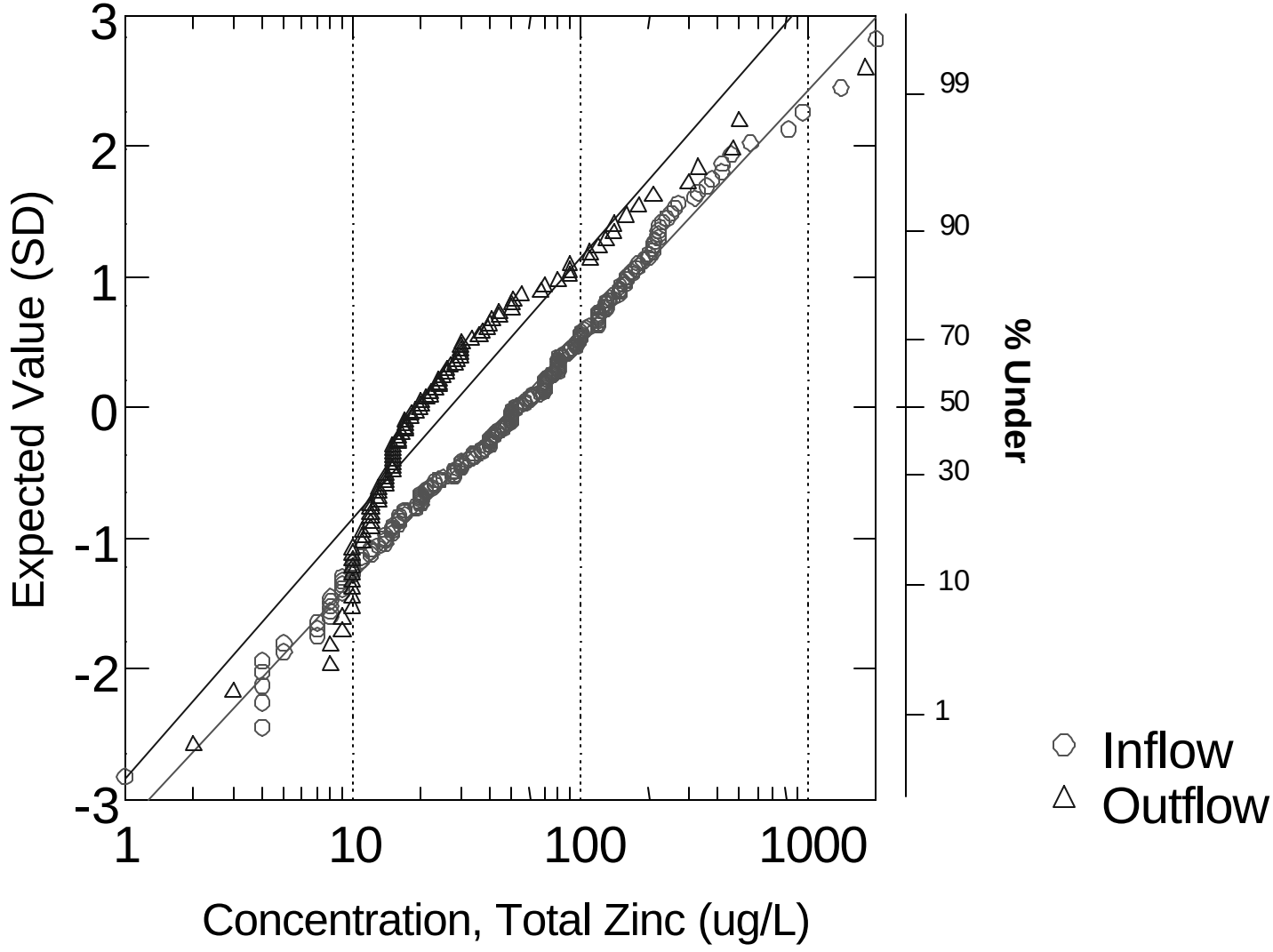
Box and Whisker Plot of Influent and Effluent Event Mean Concentration (Total Suspended Solids) for All Retention Ponds



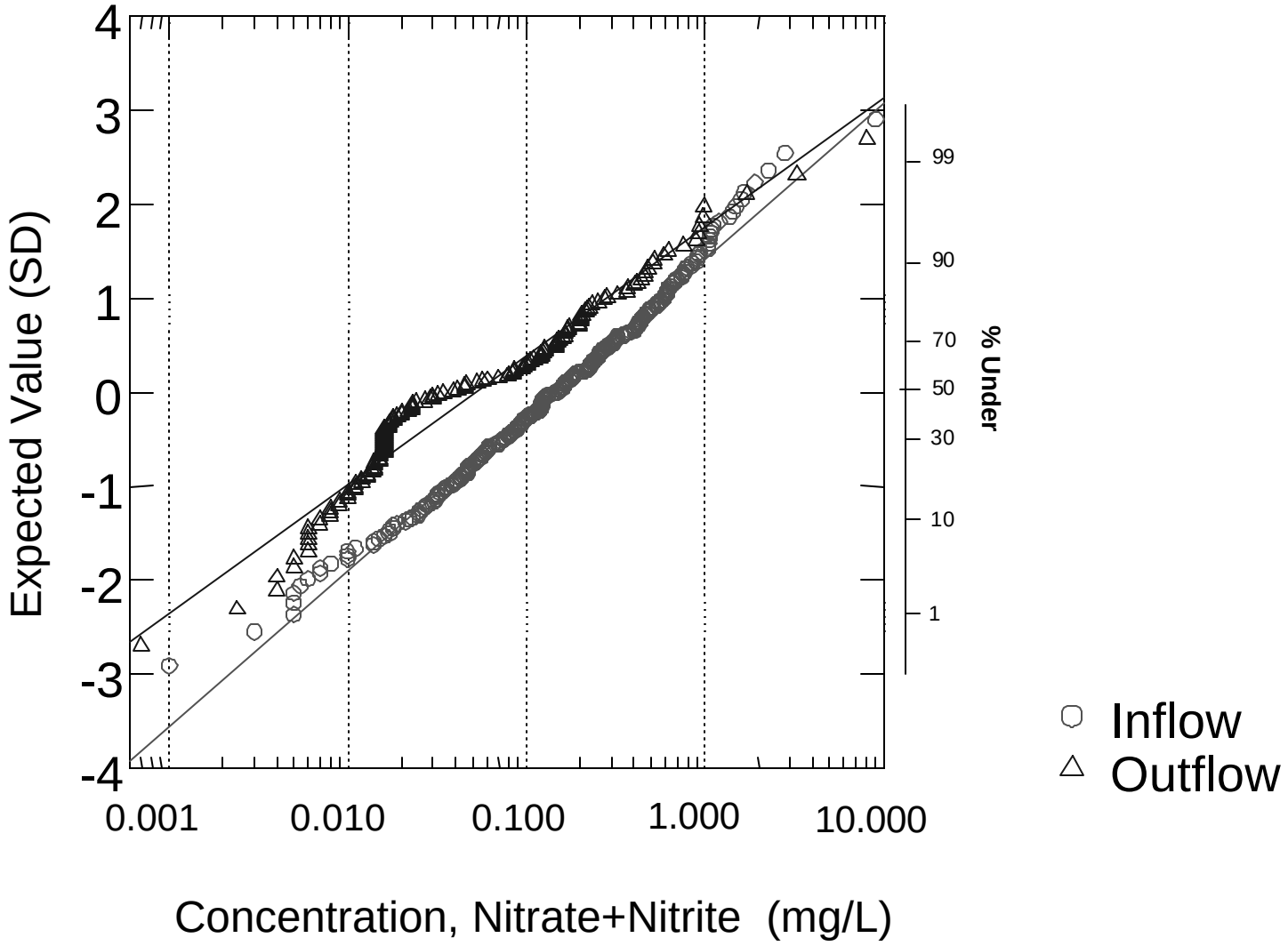
Normal Probability Plot of Influent and Effluent Event Mean Concentration (Total Suspended Solids) for All Wetland Basins



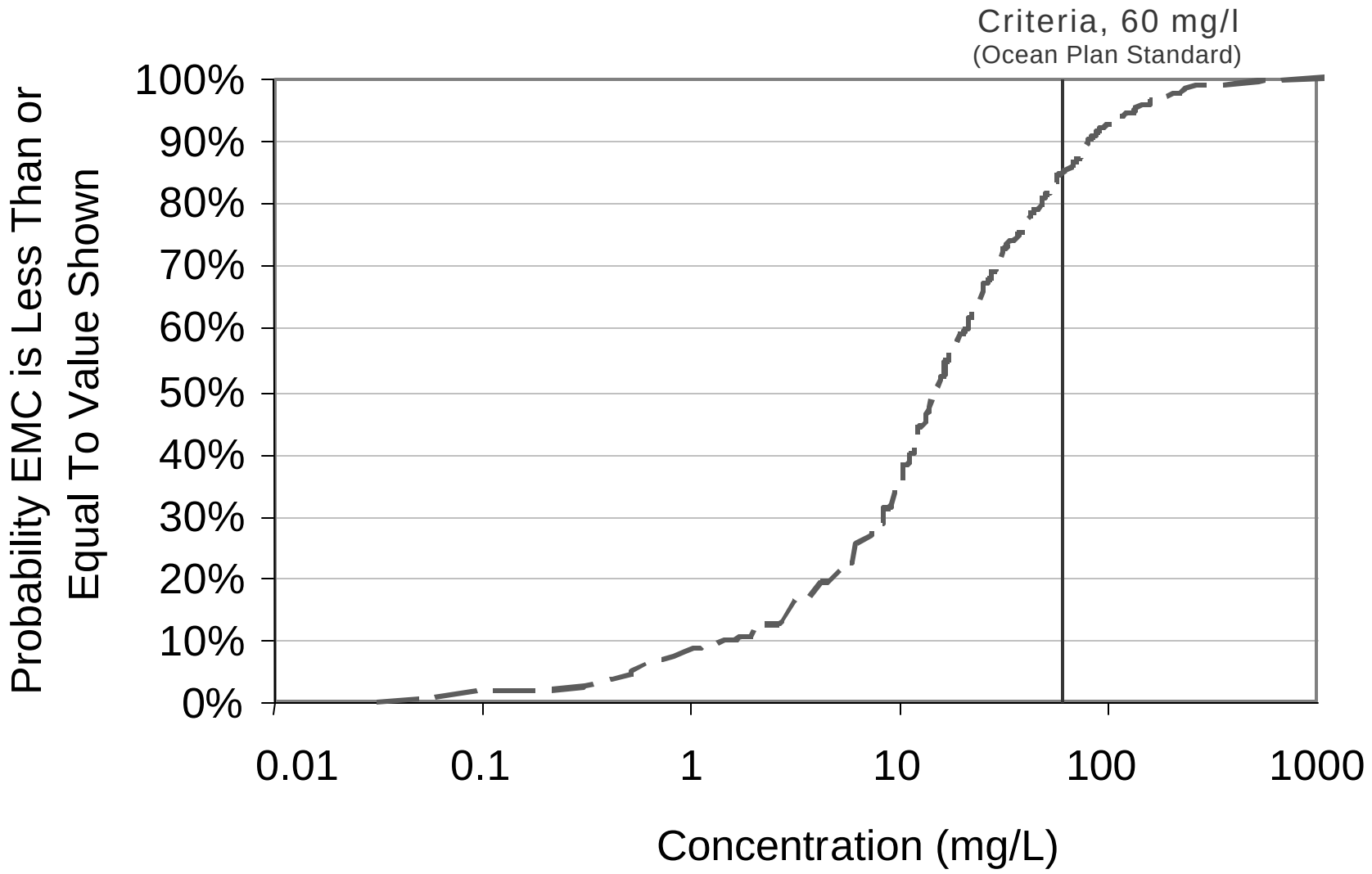
Normal Probability Plot of Influent and Effluent Event Mean Concentration (Total Zinc) for All Wetland Basins



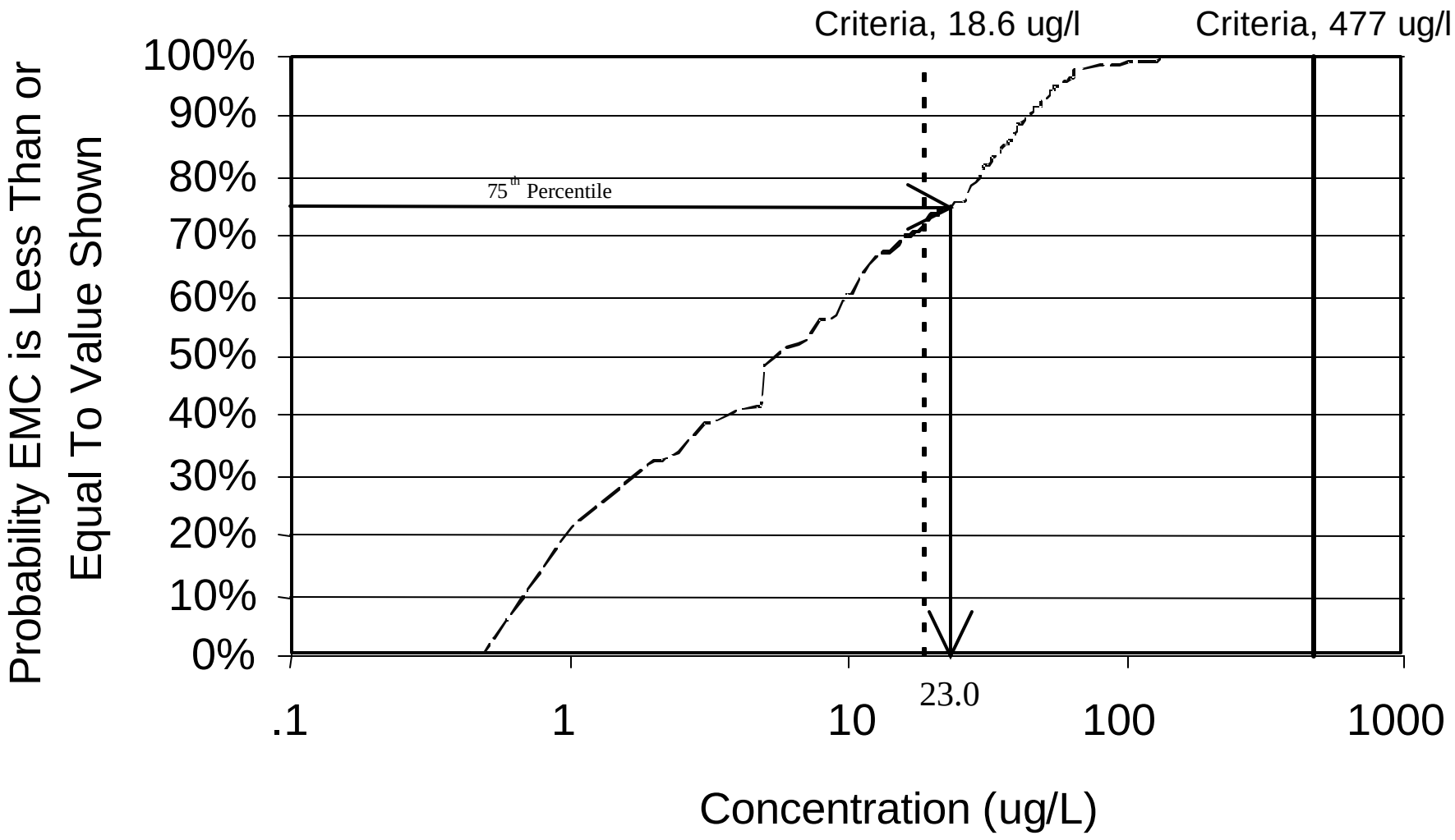
Normal Probability Plot of Influent and Effluent Event Mean Concentrations (Nitrate + Nitrite) for All Retention Ponds



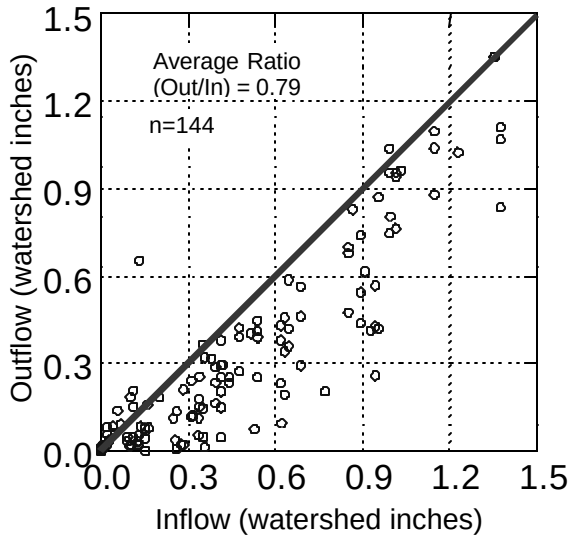
Cumulative Distribution Function for Total Suspended Solids (Retention Ponds with Permanent Pools)

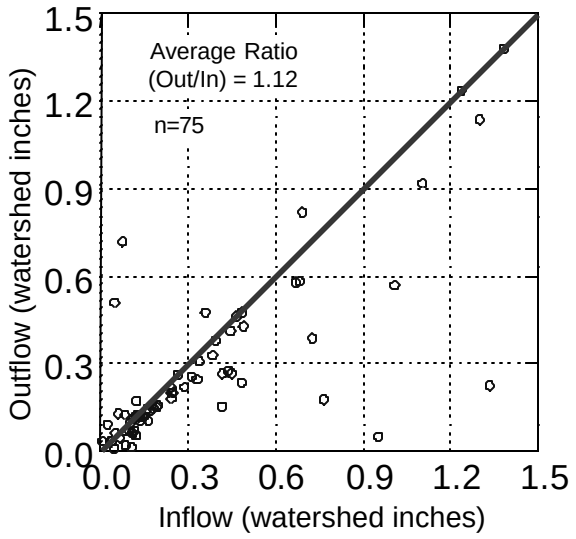


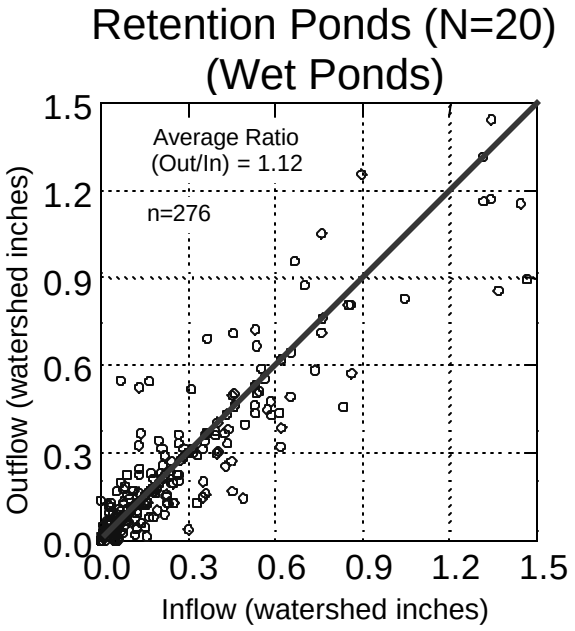
Cumulative Distribution Function for Total Lead (Retention Ponds with Permanent Pools)

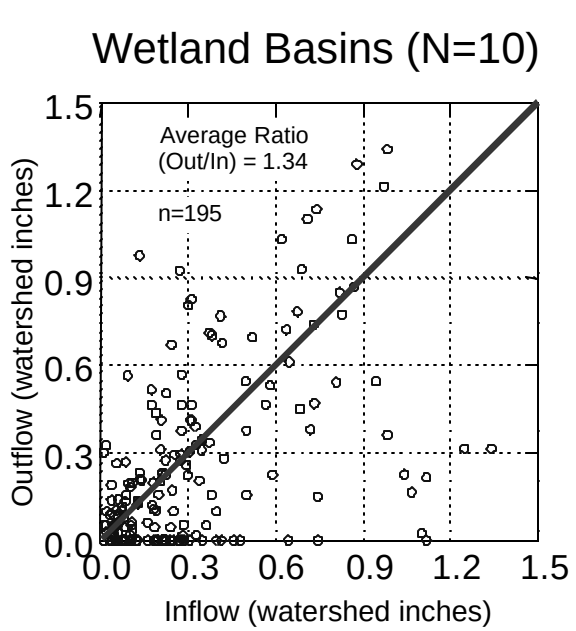


Runoff Volume Control





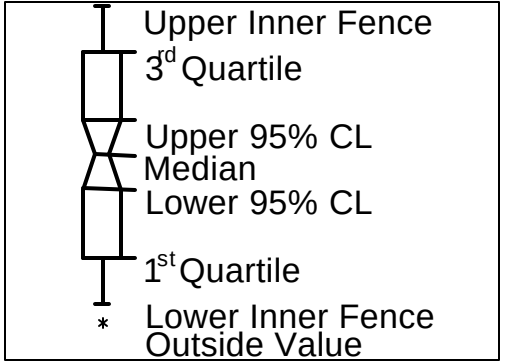


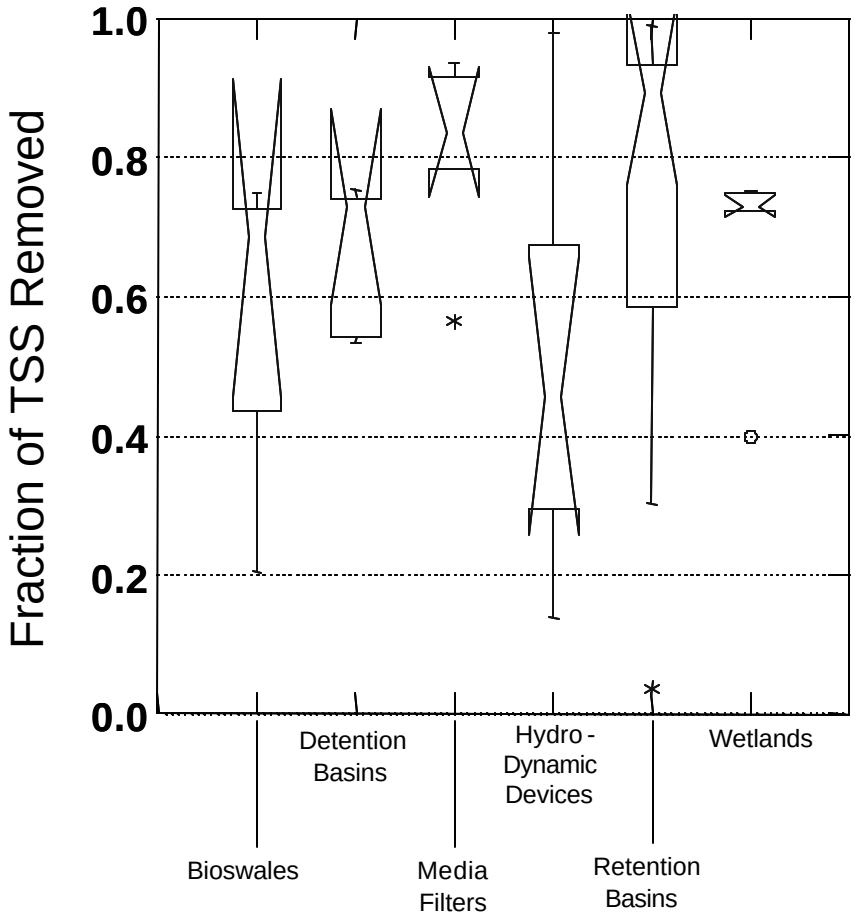


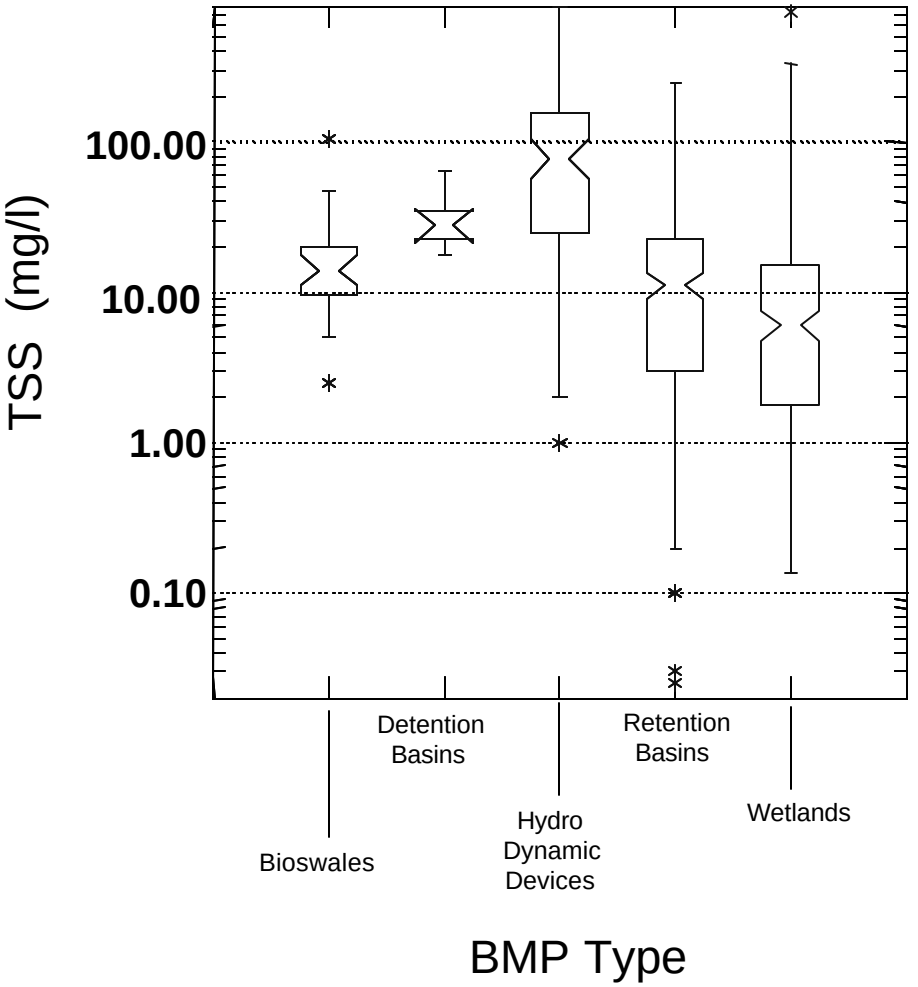
Runoff Volume Control

BMP Type	Mean Monitored Outflow/Mean Monitored Inflow for Events Where Inflow is Greater Than or Equal to 0.2 Watershed Inches
Detention Basins	**0.70**
Biofilters	**0.62**
Media Filters	**1.00**
Hydrodynamic Devices	**1.00**
Wetland Basins	**0.95**
Retention Ponds	**0.93**
Wetland Channels	**1.00**

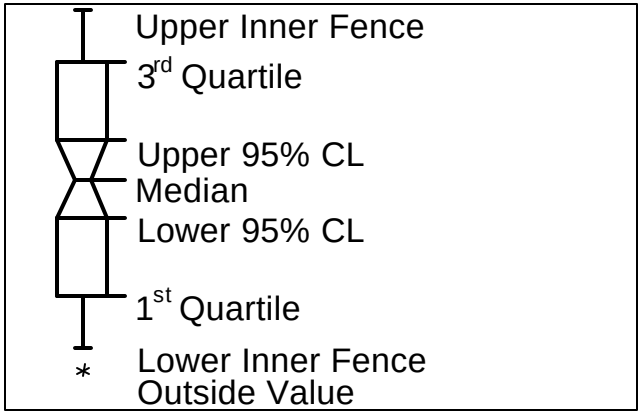
Box plots of the fractions of Total Suspended Solids (TSS) removed and of effluent quality of selected BMP types

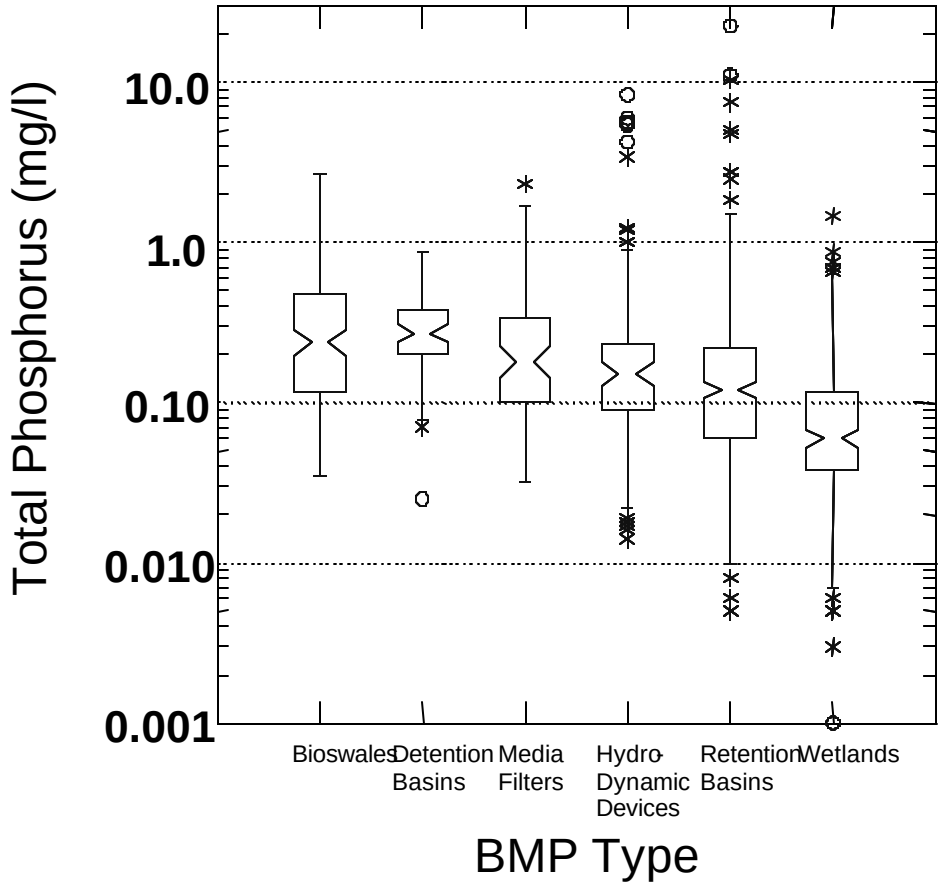


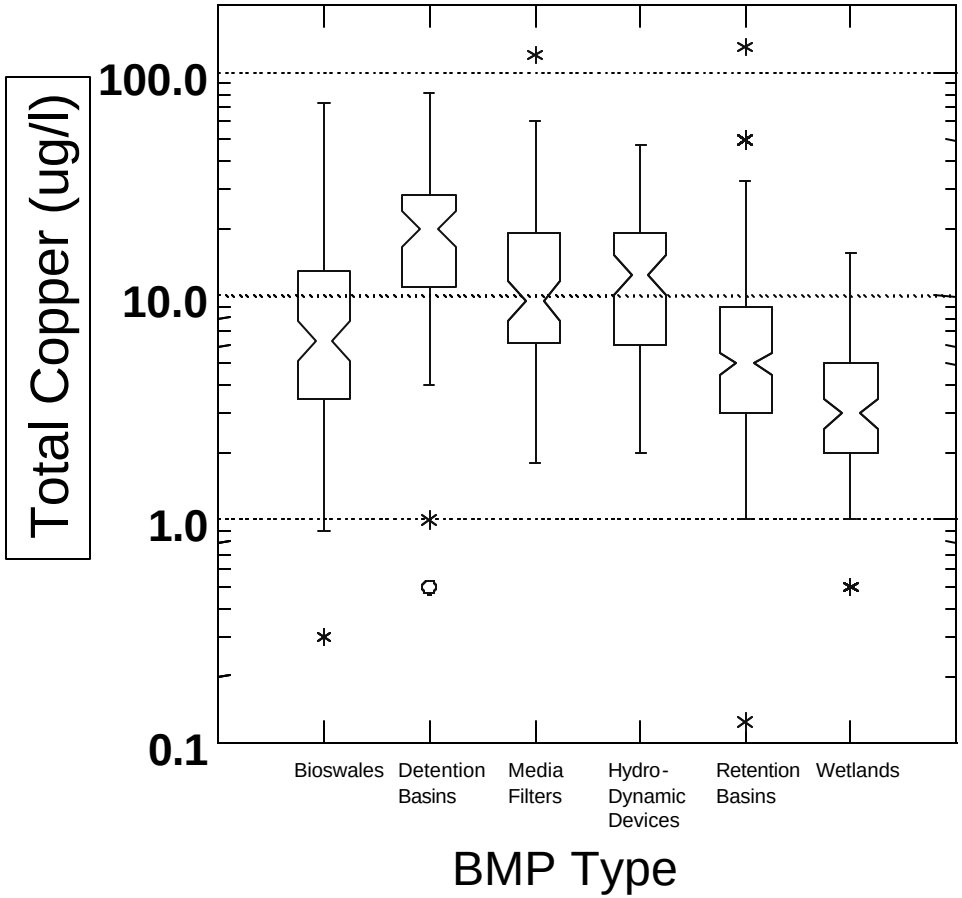




Box plots of effluent quality of selected BMP types for Total Phosphorus and Total Copper

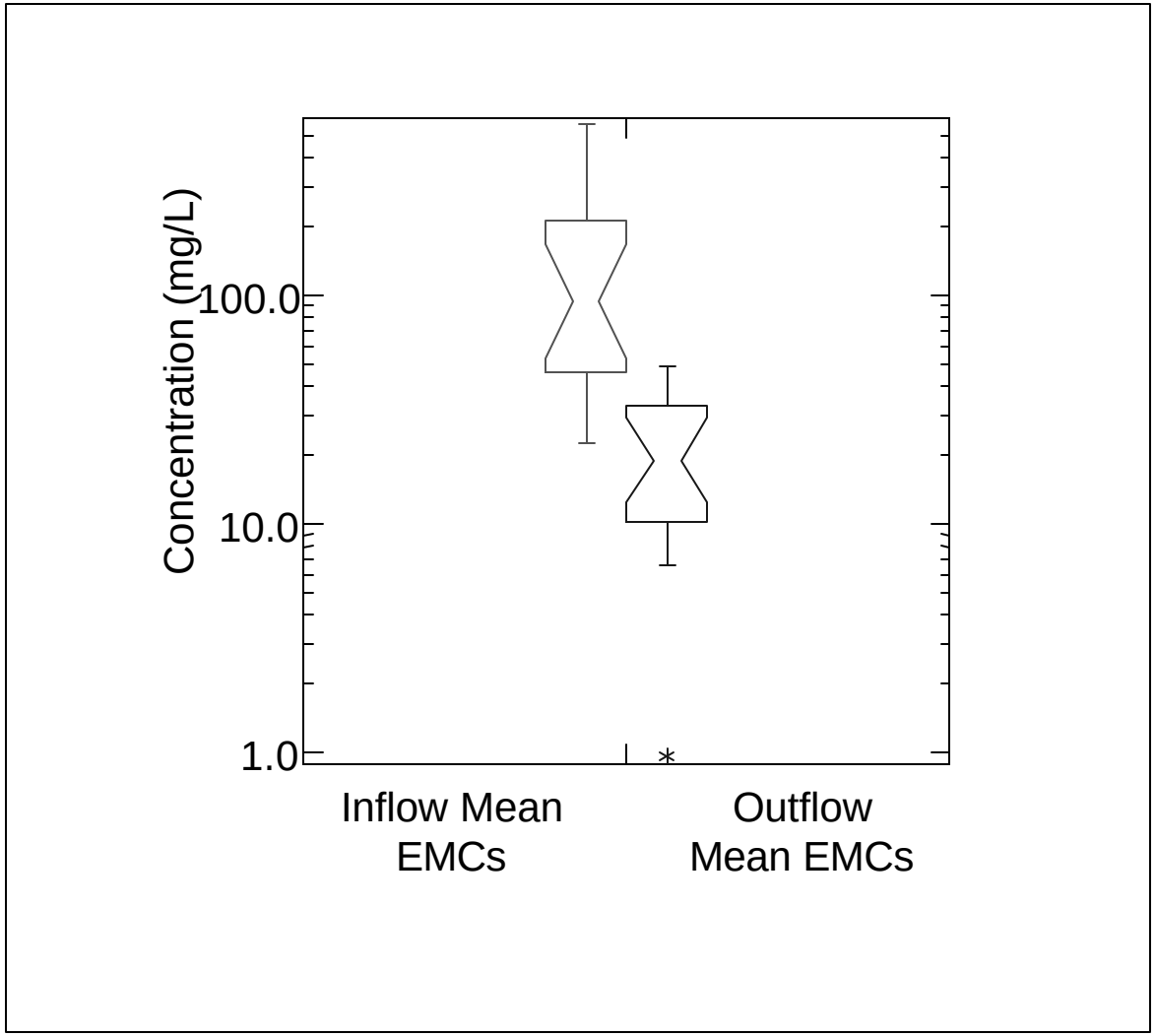






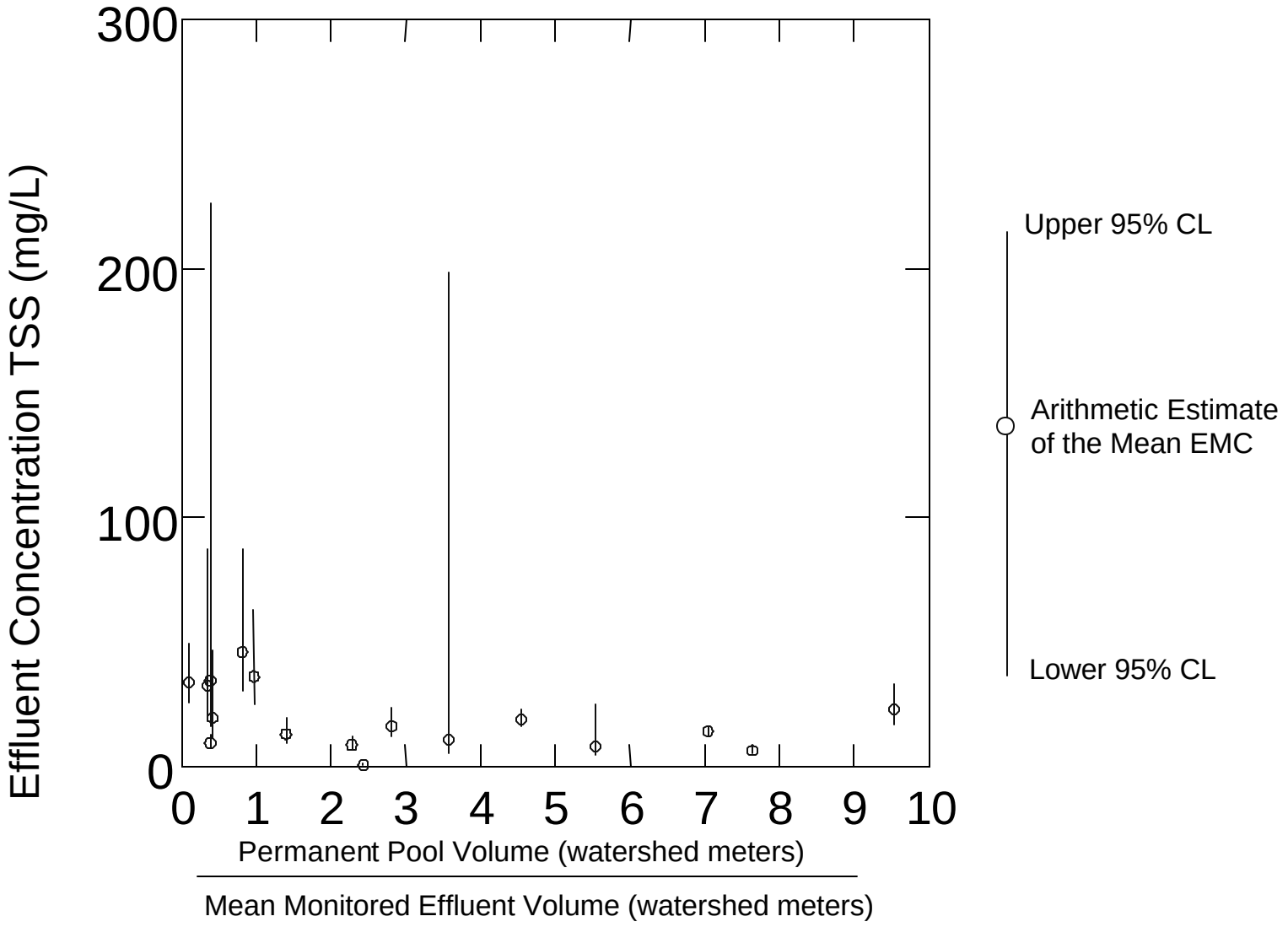
Relating Design to Performance

- One of the primary long-term project objectives
- Multiple regression analysis
- Sub-sample parameter analysis

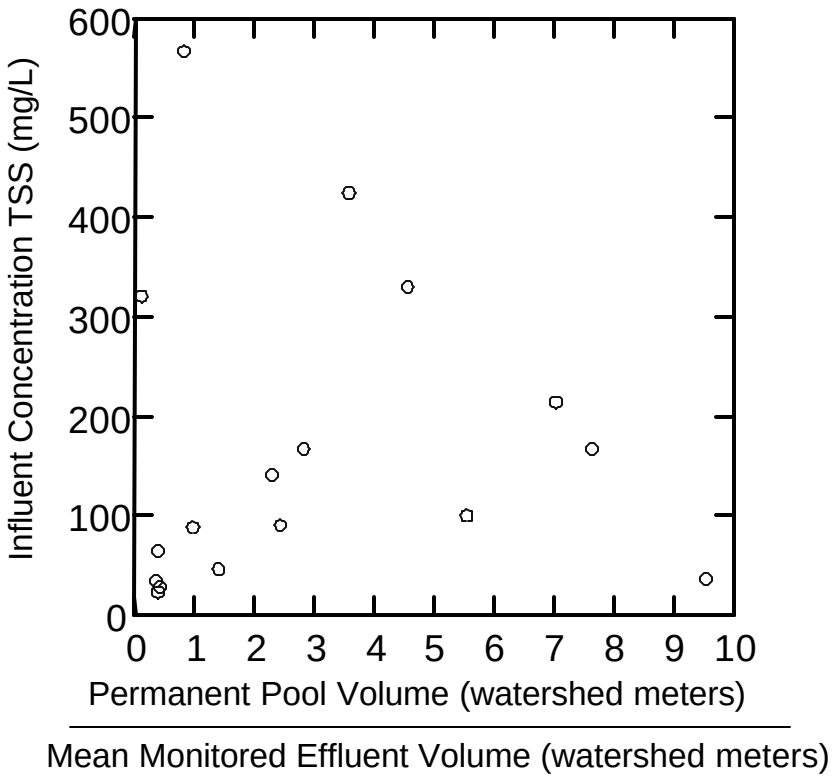


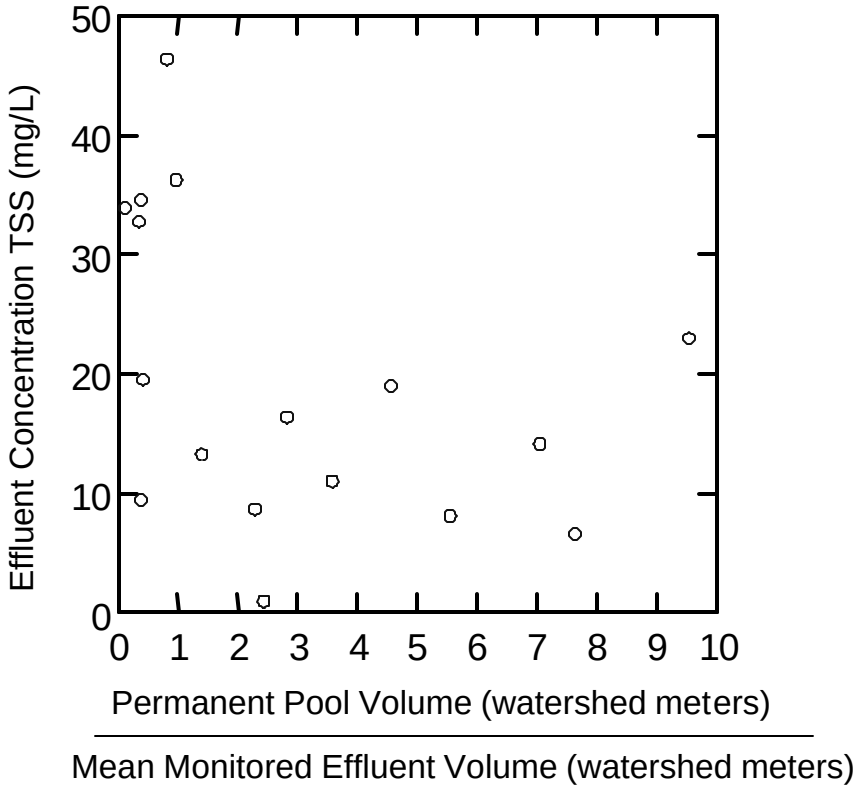
Retention Ponds
Solids, Total Suspended (mg/L)

Effluent Water Quality as a Function of the Permanent Pool Design Volume Ratio

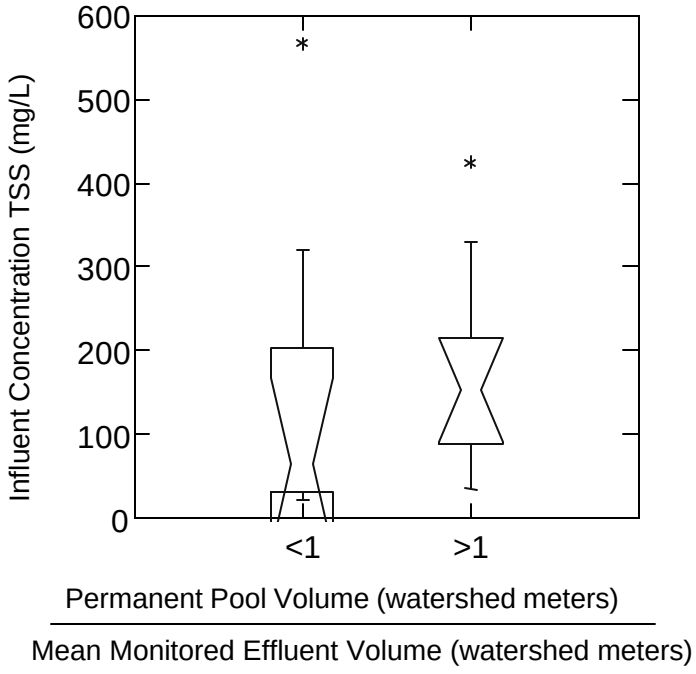


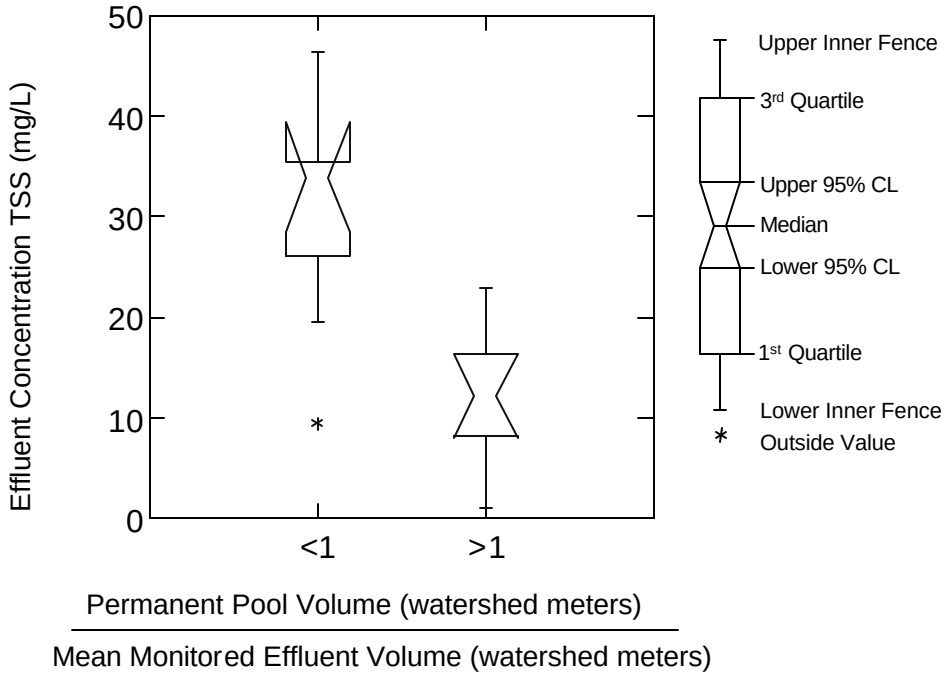
Scatter Plot Showing Effluent Water Quality as a Function of the Permanent Pool Design Volume Ratio





Box Plot Showing Effluent Water Quality as a Function of the Permanent Pool Design Volume Ratio





Analysis Findings

- Results of the analyses of the now expanded database have reinforced the initial finding that BMPs are best described by
  - how much they reduce runoff volumes,
  - how much of the runoff that occurs is treated (and not) by the BMP,
  - and of the runoff treated what effluent quality (concentrations and potential toxicity) is achieved?

Analysis Findings Cont.

- Basic BMP performance descriptions can then be utilized to assess effects on total loadings, frequency of potential exceedances of water quality criteria or other targets, and other desired water quality performance measures.

Analysis Findings Cont.

- The results show that the effluent quality of various BMP types can be statistically characterized as being different from one another.
- Some design parameters (sizing relative to incoming measured storm volumes) may be statistically significant with regards to performance of BMPs

Recent Trends

- Source Controls and LID
  - Careful monitoring more difficult
  - Variability may be higher
  - Highly impervious and “flashy” watersheds (3-4 orders of magnitude in flows that need to be monitored)
  - Very small volumes and flow rates
  - In many cases standard equipment does not exist
    - Roger Bannerman – Modified tipping bucket rain gauges for surface flow measurement on very small plots
  - Accurate assessment of flows is key
  - Low flows are very difficult to measure

Example Use of Database and Product Deliverables by EPA and Others

- Regulatory and Policy
  - Phase II, TMDLs, On-going Phase I, ESA work, and CZARA Manual Update
  - BMP certification programs (ex. City of Reno Nevada)
  - Stormwater Best Management Practice Manual Development
  - BMP monitoring requirements and measurable goals assessment
  - Basis for Tier II Protocol for Interstate Reciprocity
    - Endorsed by California, Massachusetts, New Jersey, Pennsylvania, and Virginia

Example Use of Database and Product Deliverables by EPA and Others

- Research Examples:
  - University of Colorado – BMP Performance Analyses and Database Tools
  - University of Guelph, Canada – Linking database with BMP cost analysis software
  - Tufts University – Graduate Research BMP Performance modeling
  - EPA Edison
- Data Management and BMP Monitoring Programs
  - City of Greensboro (NC)
  - Port of Houston (TX)
  - University of British Columbia (Canada)
- Selection and Design of BMPs Around U.S.

Example Use of Database and Product Deliverables by EPA and Others

- TMDL Implementation Programs
  - Example: San Diego Creek Natural Treatment Systems Master Plan to meet TMDLs
- EIS and/or State EIRs (NEPA and CEQA)
  - Example: Southern California EIR assessments of post-development water quality
- Enforcement Assessments
- Expansion of the database to other BMP types (agriculture?)
- Smart growth - improve evaluations of water quality and quantity performance

Other Efforts

- Chesapeake Bay Program Directive for Reduced Stormwater Contribution
- Lake Tahoe TMDL Development

Database Outreach Efforts

- Conferences and Presentations
  - Extensive national and international publicity with > 20 presentations
  - 2002-2003 9ICUD, AWWA SWAP, EPA Chicago, WEF/TMDL, EWIR Philadelphia
- Paper/Publications
  - > 20 publications
  - 2001 and 1995 Journal of Water Resources Planning and Management
  - New paper to be developed based upon reanalysis of Database

Database Outreach Efforts

- Web Site Usage (shown previously)
- Potential National Training Courses
  - BMP monitoring and design application
  - BMP selection and design

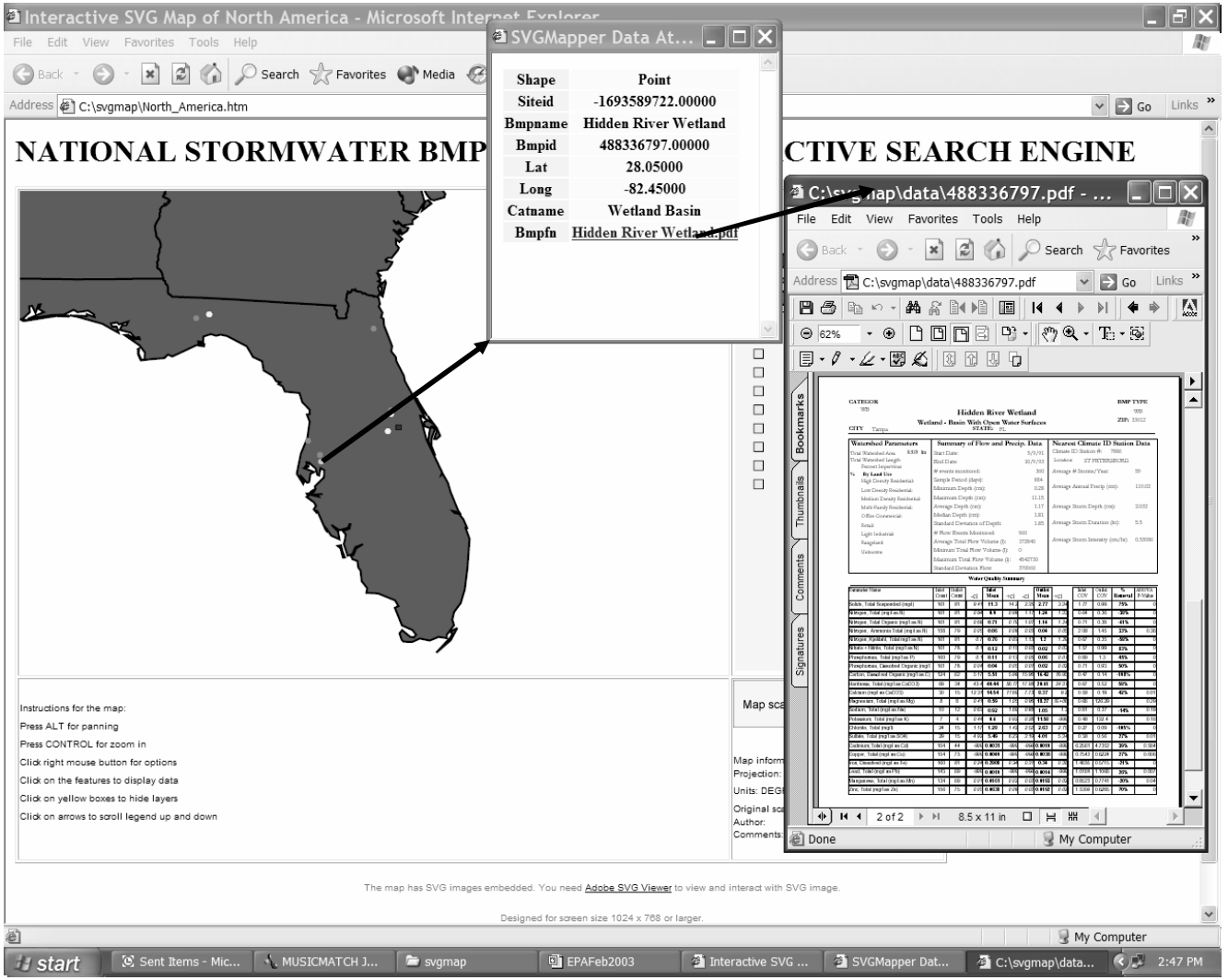
Historical Funding Support

- Primary funding source as been EPA
- Volunteer efforts by Council members and PIs

Future Funding Needs/Challenges

- Website enhancements and development
- Adding and reviewing new studies
- Enhancing database access and analysis tools (ongoing)
- Future assessments and analysis of studies in the database (every 2 to 4 years depending on data input)
- Future review and update of protocols and monitoring methods, if needed

- Potential Website Improvement – GIS Based Search Engine



Current Efforts for Long-Term Funding Support

- EPA
- EWRI,
- WERF,
- NAHB,
- APWA,
- And others.

Question and Discussion