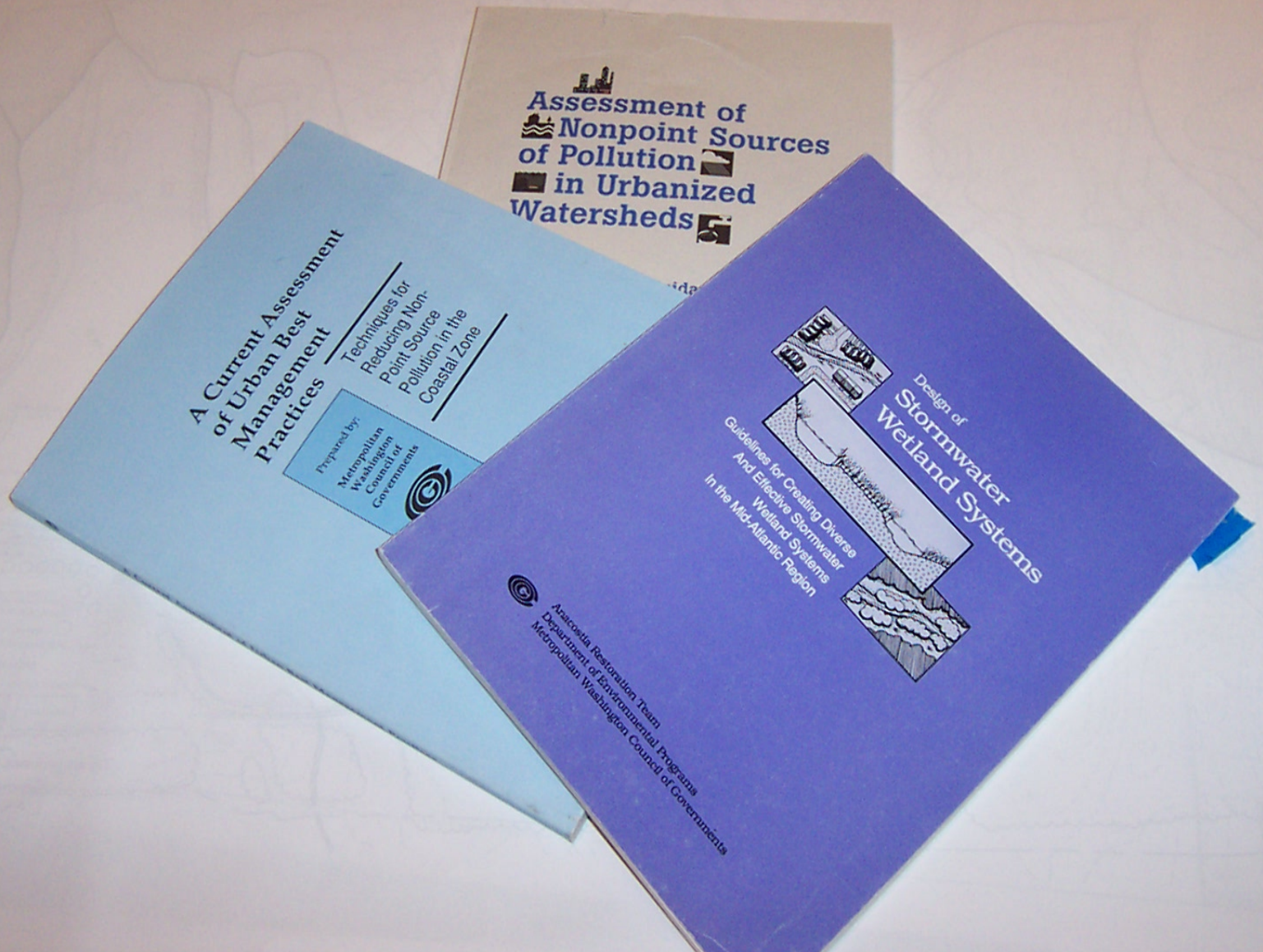
A String of Pearls

Designing Stormwater Basins In Series for Nutrient Removal

By:
Terri-Ann P. Hahn
ASLA, CPESC

THE HIGHLANDS SHOPPING CENTER – Brewster, NY

includes multiple stormwater facilities designed in series to remove phosphorus from stormwater runoff.


Assessment of Nonpoint Sources of Pollution in Urbanized Watersheds
A Current Assessment of Urban Best Management Practices
Techniques for Reducing Non-Point Source Pollution in the Coastal Zone
Prepared by:
Metropolitan Washington Council of Governments
Design of Stormwater Wetland Systems
Guidelines for Creating Diverse And Effective Stormwater Wetland Systems In the Mid-Atlantic Region
Anacostia Restoration Team
Department of Environmental Programs
Metropolitan Washington Council of Governments

Typical Nutrient levels in stormwater runoff which can be calculated using the Simple Method

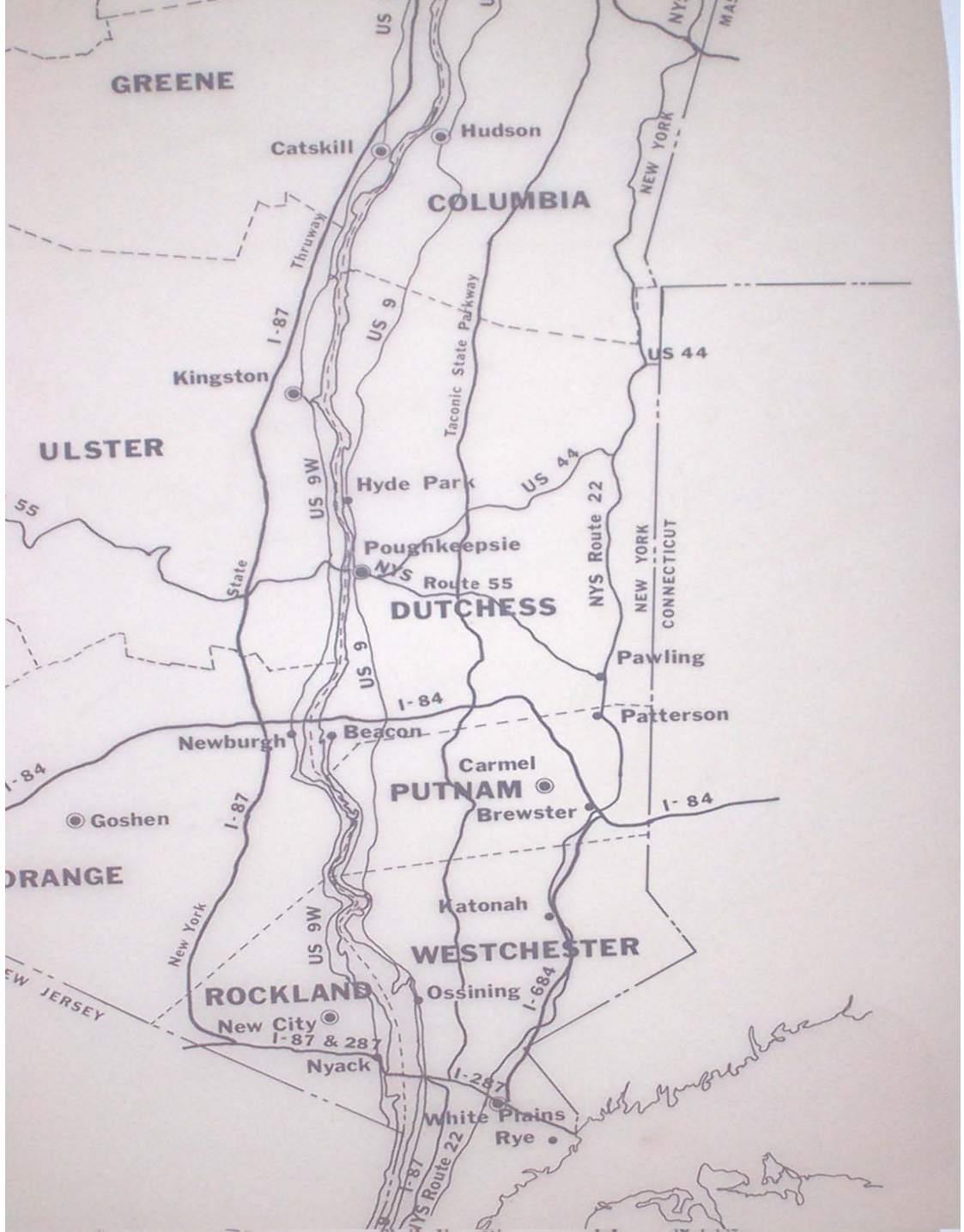
- Phosphorus
- Nitrogen
- Biological Oxygen Demand (BOD)
- Total Suspended Solids (TSS)

Our Theory:

Basins in series increase
holding time
and
stormwater treatment

And,
therefore,
creates a “String of Pearls”
which will improve water quality.

Case Study: The Highlands


GREENE
Catskill
Hudson
COLUMBIA
NEW YORK
Thruway
I-87
US 9
Taconic State Parkway
US 44
Kingston
ULSTER
US 9W
Hyde Park
US 44
Poughkeepsie
NYS Route 55
DUTCHESS
NYS Route 22
NEW YORK
CONNECTICUT
State
US 9
Pawling
I-84
Patterson
Newburgh
Beacon
Carmel
PUTNAM
Brewster
I-84
Goshen
I-87
ORANGE
New York
US 9W
Katonah
WESTCHESTER
ROCKLAND
Ossining
I-684
New City
I-87 & 287
Nyack
I-287
White Plains
Rye
NYS Route 22
I-87

THE HIGHLANDS

- 61 acres
- 377,000+/- s.f. of big box retail
- 21 acres impervious surface (34%of site)

REGULATORY REQUIREMENTS Part 1

- NPDES requirements
  - Capture and Treat first ½” of runoff
  - 100 year detention

REGULATORY REQUIREMENTS Part 2

- NYCDEP Requirements
  - Capture and Treat the 2- year storm – 3.5”

REGULATORY REQUIREMENTS Part 3

- Phosphorus Offset Program
  - Reduce post-development phosphorus levels to pre-development level or below
  - Reduce (from some source) the equivalent of 3 times the phosphorus load from the wastewater treatment plant (WWTP)

The Highlands – Phosphorus Offset Program Calculation

Project Predevelopment Phosphorus Discharge

46 lbs per year

WWTP Discharge

4 lbs per year

POP Required Removal

4 x 3 = 12 lbs per year

Project Post-development Phosphorus Limit

34 lbs per year

Problem Statement

- How do we design a system that addresses:
  - Lots and Lots of water to be stored
  - Required reductions in pollutant loads
  - Must be quantifiable and consistently attainable
  - Multiple detention requirements
    - 2 year storm
    - 10 year storm
    - 25 year storm
    - 100 year storm

THE DESIGN


WATER QUALITY BASIN #1
WATER QUALITY BASIN #2
DETENTION BASIN #1
DETENTION BASIN #2
WATER QUALITY BASIN #5
WATER QUALITY BASIN #4
WATER QUALITY BASIN #3
WATER QUALITY BASIN #C
INFILTRATOR ISLAND
STORMWATER MANAGEMENT AND QUALITY IMPROVEMENT PLAN
THE HIGHLANDS
A Retail Shopping Center


% PHOSPHORUS REMOVAL RATE
TENDED DETENTION
TTLING
TAKE BY ALGAE AND PLANTS
BITAT ENHANCEMENT
Eastbound
Interstate 84
N
EAR STORM
RAGE)
. POND VOLUME)
DESIGN 6)
EMOVAL RATE
N
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WATER QUALITY BASIN #1

Stormwater Management:	EXTENDED DETENTION COLLECT 2-YEAR STORM
Stormwater Quality:	334,634+/- C.F. CAPTURE AND TREAT 2-YEAR STORM 40% PHOSPHORUS REMOVAL RATE
Quality Improvement Aspects:	EXTENDED DETENTION SOLIDS/SEDIMENT SETTLING

ALITY BASIN #2

WCB #2 - 32,500+/- C.F.
WCB #2A - 5,540+/- C.F.
TREAT 2-YEAR STORM
60% PHOSPHORUS REMOVAL

Aspects:	
ow Marsh:	SETTLING ABSORPTION INFILTRATION BIOLOGICAL UPTAKE FILTRATION BY PLANTS MICROBIAL ACTIVITY


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WQB #2 - Shallow Marsh:
SETTLING
ABSORPTION
INFILTRATION
BIOLOGICAL UPTAKE
FILTRATION BY PLANTS
MICROBIAL ACTIVITY
HABITAT ENHANCEMENT
Typical Depth: 6"
Maximum Depth: 36"

WQB #2A - Wooded Wetland:
SAME AS WQB #2
Typical Depth: 6 -24"
Maximum Depth at outlet structure: 48"

DETENTION BASIN #1

Stormwater Management:
EXTENDED DETENTION
2, 10, 25, and 100 YEAR STORM

Stormwater Quality:
213,597+/- C.F. (STORAGE)
182,648+/- C.F. (PERM. POND VOLUME)
WET POND (NYSDEC DESIGN 6)
60% PHOSPHORUS REMOVAL RATE

Quality Improvement Aspects:
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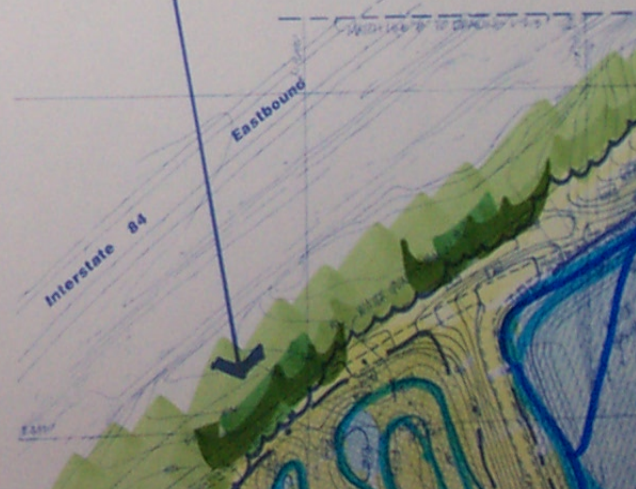
HABITAT ENHANCEMENT



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2, 10, 25, and 100 YEAR STORM


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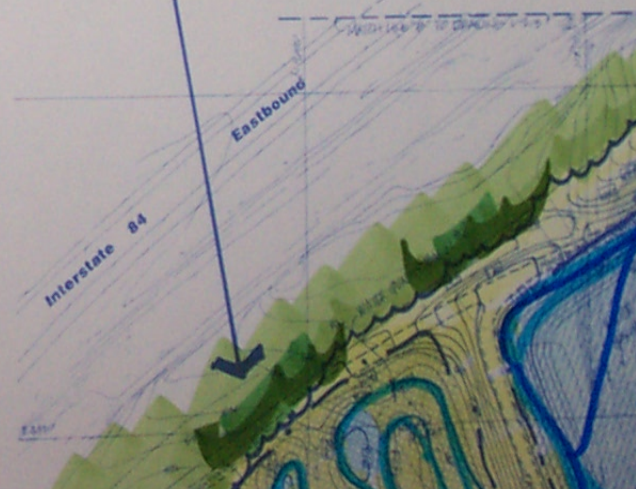

DETENTION BASIN #2

Stormwater Management:
EXTENDED DETENTION
2, 10, 25, and 100 YEAR STORM

EXTENDED DETENTION
SETTLING
UPTAKE BY ALGAE AND PLANTS
HABITAT ENHANCEMENT

DETENTION BASIN #2

Stormwater Management:	EXTENDED DETENTION 2, 10, 25, and 100 YEAR STORM
Stormwater Quality:	101,190+/- C.F. (STORAGE) 86,500+/- C.F. (PERM. POND VOLUME) WET POND (NYSDEC DESIGN 6) 60% PHOSPHORUS REMOVAL RATE
Quality Improvement Aspects:	EXTENDED DETENTION SETTLING UPTAKE BY ALGAE AND PLANTS HABITAT ENHANCEMENT

WATER QUALITY BASIN #5

Stormwater Management:	EXTENDED DETENTION COLLECT 2-YEAR STORM
Stormwater Quality:	11,564+/- C.F. CAPTURE AND TREAT 2-YEAR STORM 60% PHOSPHORUS REMOVAL RATE (NYSDEC Design 3)
Quality Improvement Aspects:	EXTENDED DETENTION SOLIDS/SEDIMENT SETTLING

MONITORING FOR PHOSPHORUS


WATER QUALITY BASIN #1
WATER QUALITY BASIN #2
DETENTION BASIN #1
DETENTION BASIN #2
WATER QUALITY BASIN #5
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SUMMARY OF ACTIVITY

THE HIGHLANDS - STORMWATER MONITORING PROGRAM

MONITORING STATION #4

JANUARY 1 - JANUARY 31, 2003

DATE		RAINFALL		Storm Sampling	Base Flow Sample	COMMENTS
		NOAA Danbury	On-Site	A-Attempted Y-Sample Taken	A-Attempted Y-Sample Taken	
ednesday	January 1, 2003	1.30	0.00			Power Out.
ursday	January 2, 2003	0.24	0.12			Power Out - storm did not sample. Machine manually enabled.
iday	January 3, 2003	0.00	0.00	Y	Y	Samples taken to lab.
turday	January 4, 2003	0.00	0.00			Downloaded December data, level reset.
nday	January 5, 2003	0.19	0.00		Y	Raingauge frozen.
onday	January 6, 2003	0.00	0.00			
esday	January 7, 2003	0.00	0.00			
ednesday	January 8, 2003	0.68	0.00			
ursday	January 9, 2003	0.17	0.00		Y	Power out - reset. Raingauge cleared, level reset.
iday	January 10, 2003	0.01	0.01			
turday	January 11, 2003	0.00	0.00			
nday	January 12, 2003	0.00	0.00			
onday	January 13, 2003	0.00	0.00		Y	
esday	January 14, 2003	0.00	0.00			
ednesday	January 15, 2003	0.00	0.00			
ursday	January 16, 2003	0.00	0.00		Y	14" snow, icy. QC Raingauge reads 0". Level reset, samples taken.
iday	January 17, 2003	0.00	0.00			
aturday	January 18, 2003	0.00	0.00			
unday	January 19, 2003	0.00	0.00			
Monday	January 20, 2003	0.00	0.00		A	No flow - ice.
uesday	January 21, 2003	0.00	0.00			
Wednesday	January 22, 2003	0.00	0.00		A	No flow - ice.
hursday	January 23, 2003	0.00	0.00		A	No flow - ice.
riday	January 24, 2003	0.00	0.00			
aturday	January 25, 2003	0.00	0.00			
Sunday	January 26, 2003	0.00	0.00			
Monday	January 27, 2003	0.00	0.00		A	No flow - ice.
Tuesday	January 28, 2003	0.00	0.00			
Wednesday	January 29, 2003	0.02	0.01		A	No flow - ice.
Thursday	January 30, 2003	0.01	0.02			
Friday	January 31, 2003	0.05	0.02			

E-Mail: NELABSCT@AOL.COM www.NortheastLaboratories.com

REPORT TO:

LADA, P.C.
104 WEST STREET
SIMSBURY, CT 06070

FAX # (860) 651-6153

DATE SAMPLE COLLECTED: 1/3/2003
TIME COLLECTED: 10:49-17:49
COLLECTED BY: JASON BAJOR
DATE RECEIVED @ LAB: 1/3/2003
TESTED BY: LAB#11471
LAB I.D.#: LADA-301133-01
REPORT DATE: 1/13/2003

PRODUCT DESCRIPTION: THE HIGHLANDS
BREWSTER, NY

SAMPLE LOCATION: MS # = Monitoring Station #4
STORMWATER

SAMPLE #	TOTAL PHOSPHOROUS (per mg/L)	DISSOLVED PHOSPHOROUS	TOTAL SUSPENDED SO (per mg/L)
- 301133-01	-	-	-
A- 301133-02	0.07	0.02	-
- 301133-03	-	-	19
A- 301133-04	0.04	0.03	-
- 301133-05	-	-	<5
A- 301133-06	0.04	0.02	-
- 301133-07	-	-	23
A- 301133-08	0.06	0.02	-
- 301133-09	-	-	13
A- 301133-10	0.04	0.02	-
- 301133-11	-	-	14
A- 301133-12	0.04	0.02	-
- 301133-13	-	-	11
A- 301133-14	0.04	0.02	-
- 301133-15	-	-	18
A- 301133-16	0.06	0.02	-
- 301133-17	-	-	14
A- 301133-18	0.04	<0.01	-
10- 301133-19	-	-	17
10A- 301133-20	0.04	0.02	-
11- 301133-21	-	-	13
11A- 301133-22	0.06	0.02	-
12- 301133-23	-	-	5
12A- 301133-24	0.03	-	-

mg/L = milligrams per Liter

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L.A.D.

NOTE: All holding times were met.

Quality Control Officer

William W. Ellmann Ph.D
Laboratory Director

PHOSPHORUS REMOVAL

2003 Phosphorus Loads

2003	Gal/ Base flow	Avg. mg/l	Gal/Storm	Avg. mg/l	Total Phos. Discharge
Jan	2,153,600	0.023	679,500	0.47	0.7019 lbs
Feb	1,056,100	0.02	626,000	0.15	0.9660 lbs
Mar	3,585,800	0.036	1,442,600	0.14	2.9381 lbs
Apr	604,300	0.02	267,500	0.15	0.4210 lbs
May	745,700	0.01	582,400	0.04	0.2563 lbs
June	3,044,200	0.0275	1,328,700	0.09	1.7621 lbs

- 2002 Annual Phosphorus Load – 27.6 lbs
- 2003 Annual Phosphorus Load – 24 lbs*

*Estimated

EFFECTIVENESS of INDIVIDUAL BMPs

Baseflow Phosphorus Levels by BMP

Date	At MS #2 or WQB#1	At DB#1
1/13/03	0.05 mg/l	0.03mg/l
3/21/03	0.15 mg/l	0.07mg/l
5/22/03	0.01 mg/l	0.01 mg/l
5/27/03	0.03 mg/l	0.01 mg/l
6/5/03	0.01 mg/l	0.01 mg/l
6/12/03	0.03 mg/l	No flow
6/16/03	0.05 mg/l	0.01 mg/l
6/26/03	0.09 mg/l	0.01mg/l

CONCLUSIONS

- Using basins in series will reduce phosphorus - The “String of Pearls” is effective.
- The reduction in phosphorus levels are consistent with those assumed in the mathematical models
- Using basins in series offsets the seasonal inconsistencies of each individual BMP

- Conventional BMP’s can be easily modified to provide the maximum amount of treatment
- The longer the time stormwater is held within the system and the lower the rate of flow through each BMP, the more effective the system is as a whole

Other bits of wisdom

- Don’t try to monitor from a dry pipe
- If you want to keep geese out of your ponds, line the side of your pond – up to the high water mark with riprap.
- Good monitoring programs are very expensive – so spend the time to design both the system and the monitoring program before you start

THE END