Effect of a Phosphorus Fertilizer Ordinance on Runoff Water Quality

Image courtesy of the Washington State Water Quality Consortium

EMPACT: Lake Access 2

***Three Rivers Park District** (formerly Hennepin Parks)*

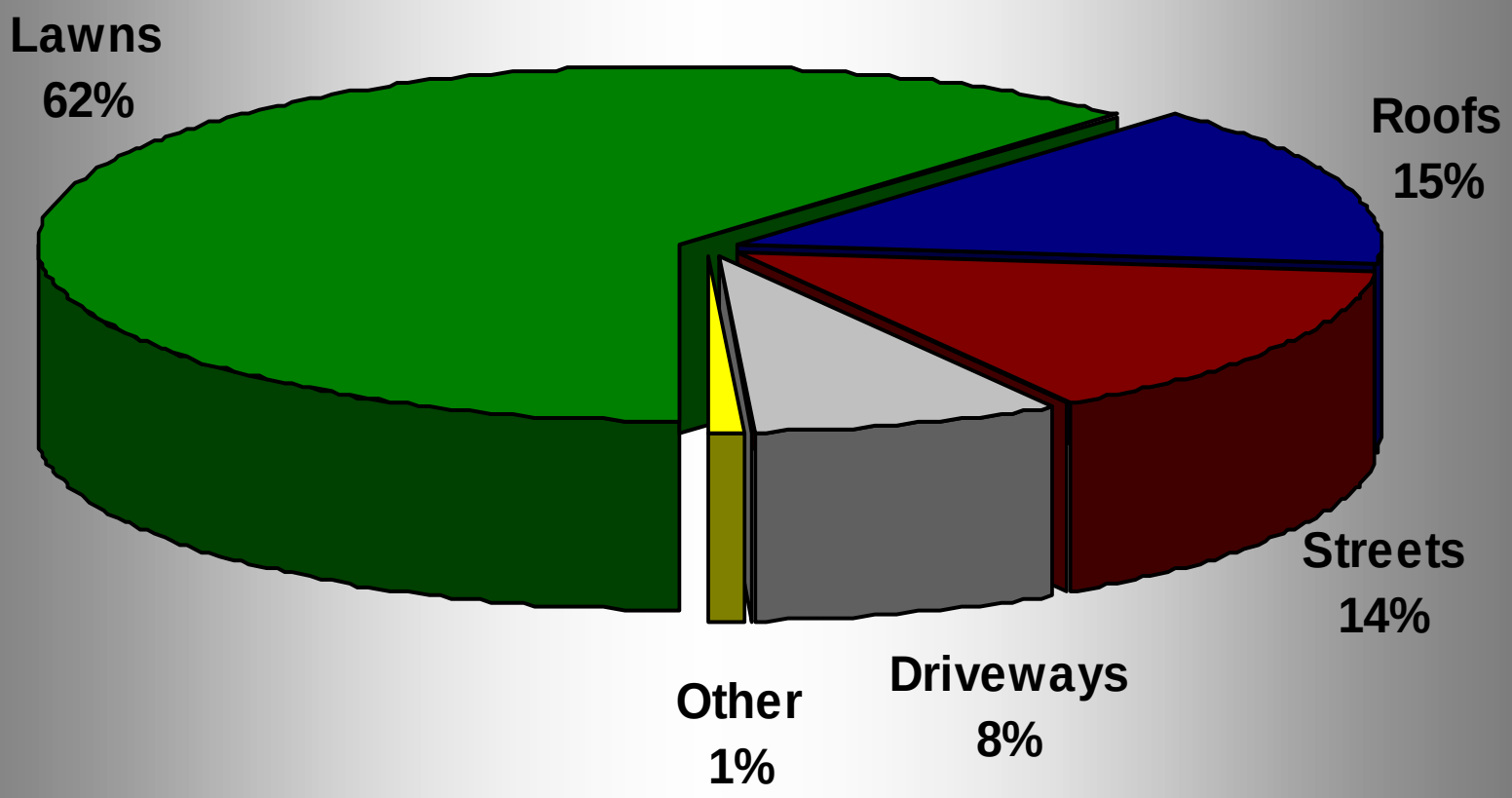
University of Minnesota: Natural Resources Research Institute

Minnesota Sea Grant

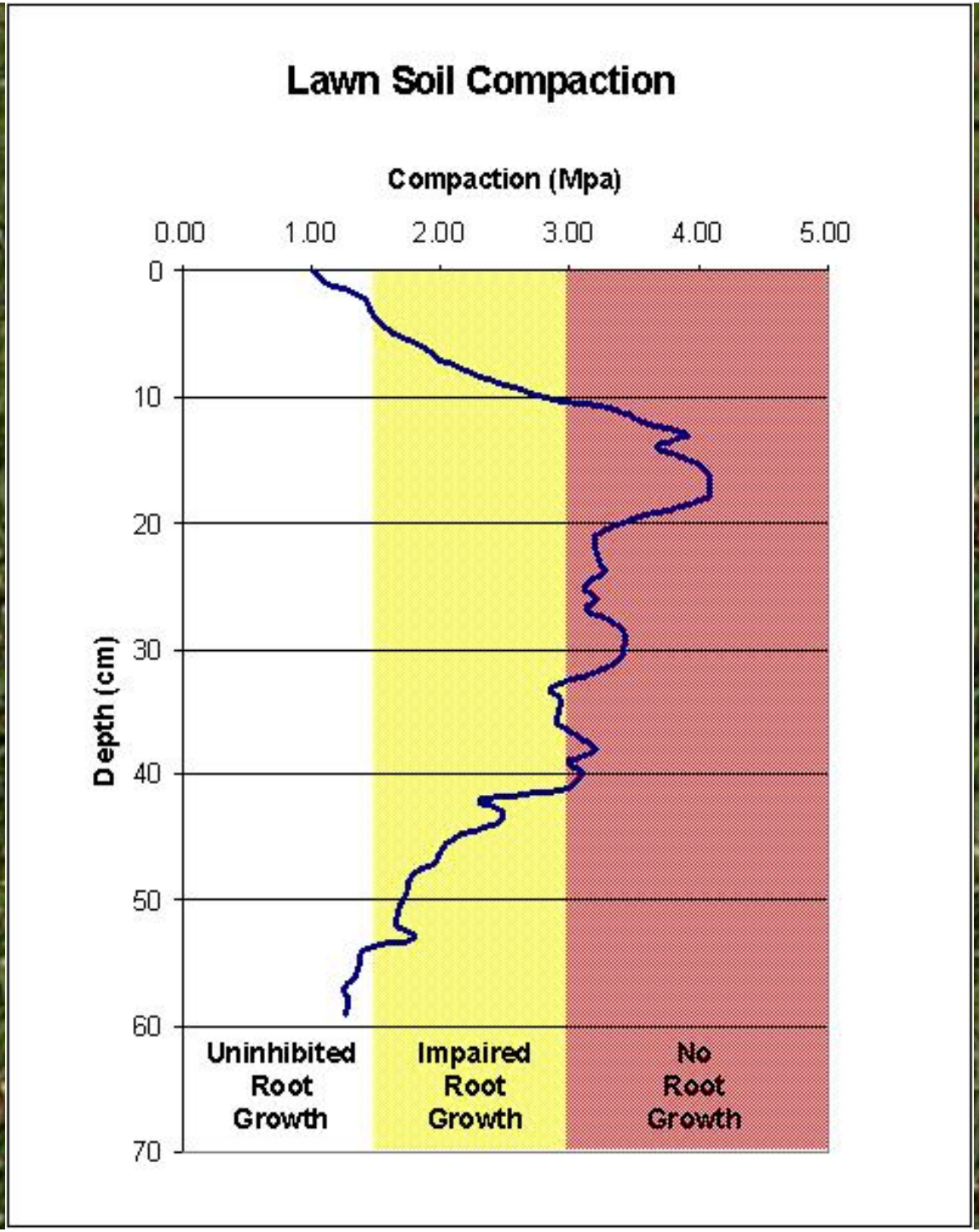
Minnehaha Creek Watershed District

Elm Creek
Crow-Hassan
Coon Rapids Dam
Clifton E. French
Lake Rebecca
Baker
MINNEAPOLIS
Mississippi River
Bryant Lake
Carver
Hyland Lake
Minnesota River
Murphy-Hanrehan
Cleary Lake
10
169
94
19
1
55
694
494
12
18
7
5
494
42
35 W

Residential Land Surfaces

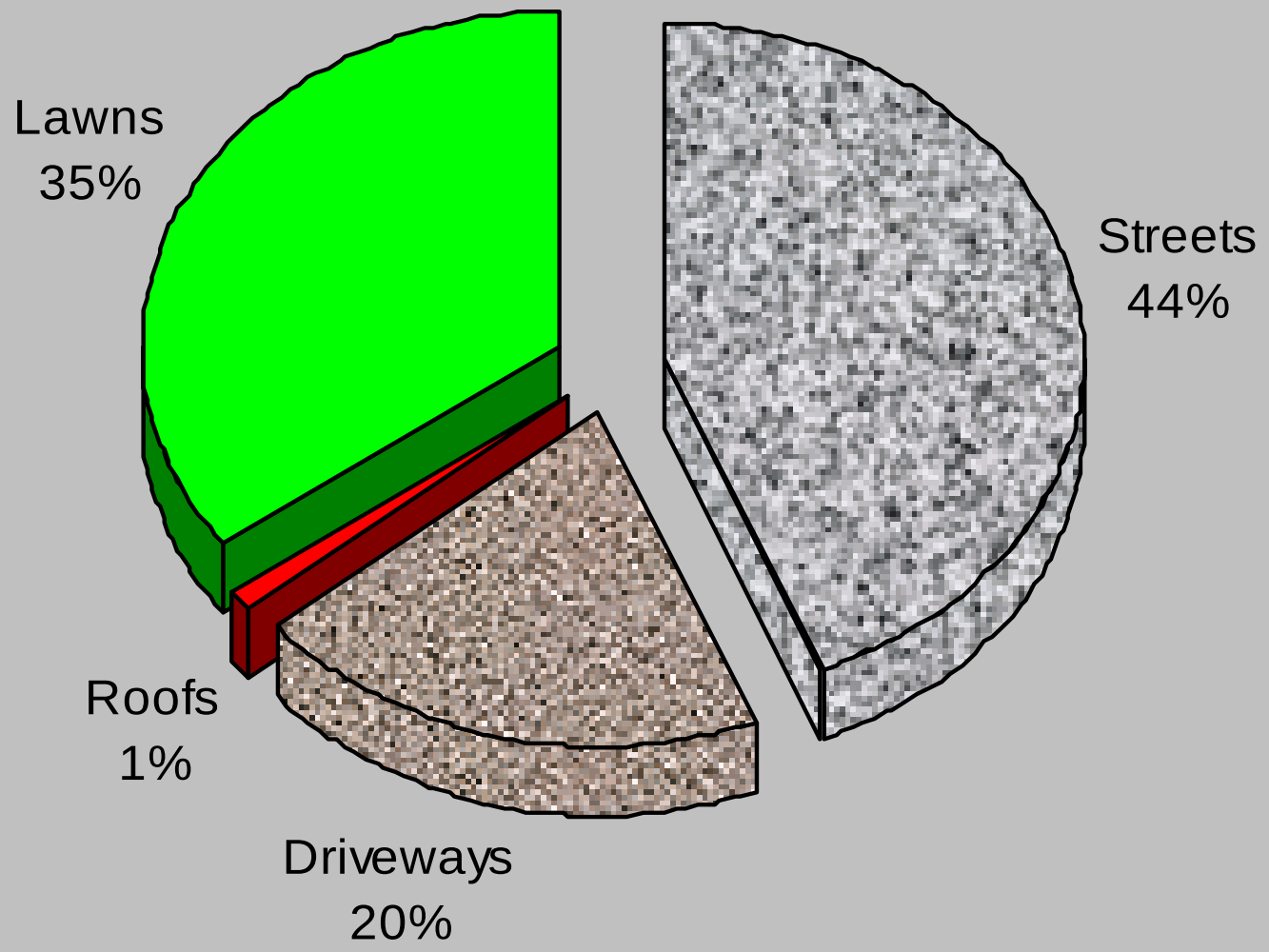


CAT
CAT

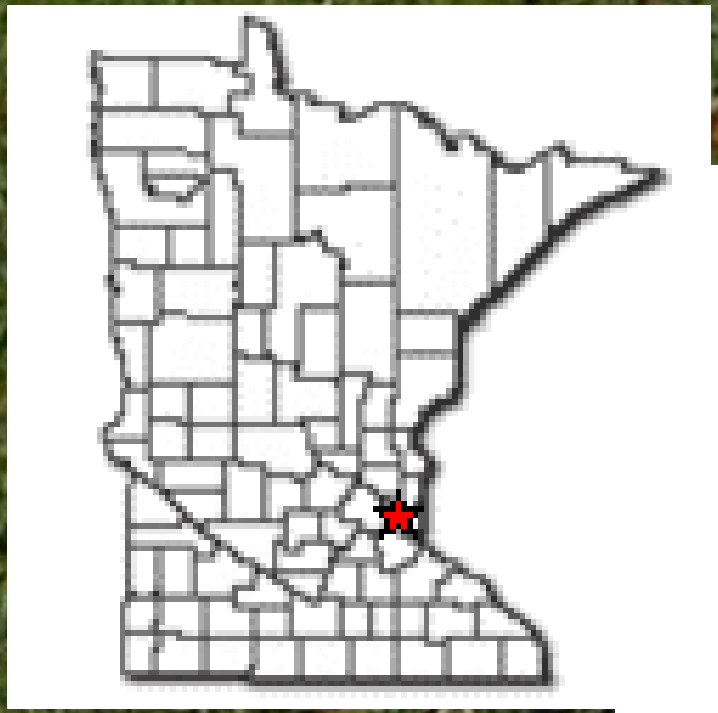

Lawn Soil Compaction
Compaction (Mpa)
0.00
1.00
2.00
3.00
4.00
5.00
Depth (cm)
0
10
20
30
40
50
60
70
Uninhibited Root Growth
Impaired Root Growth
No Root Growth

Urban Residential Runoff

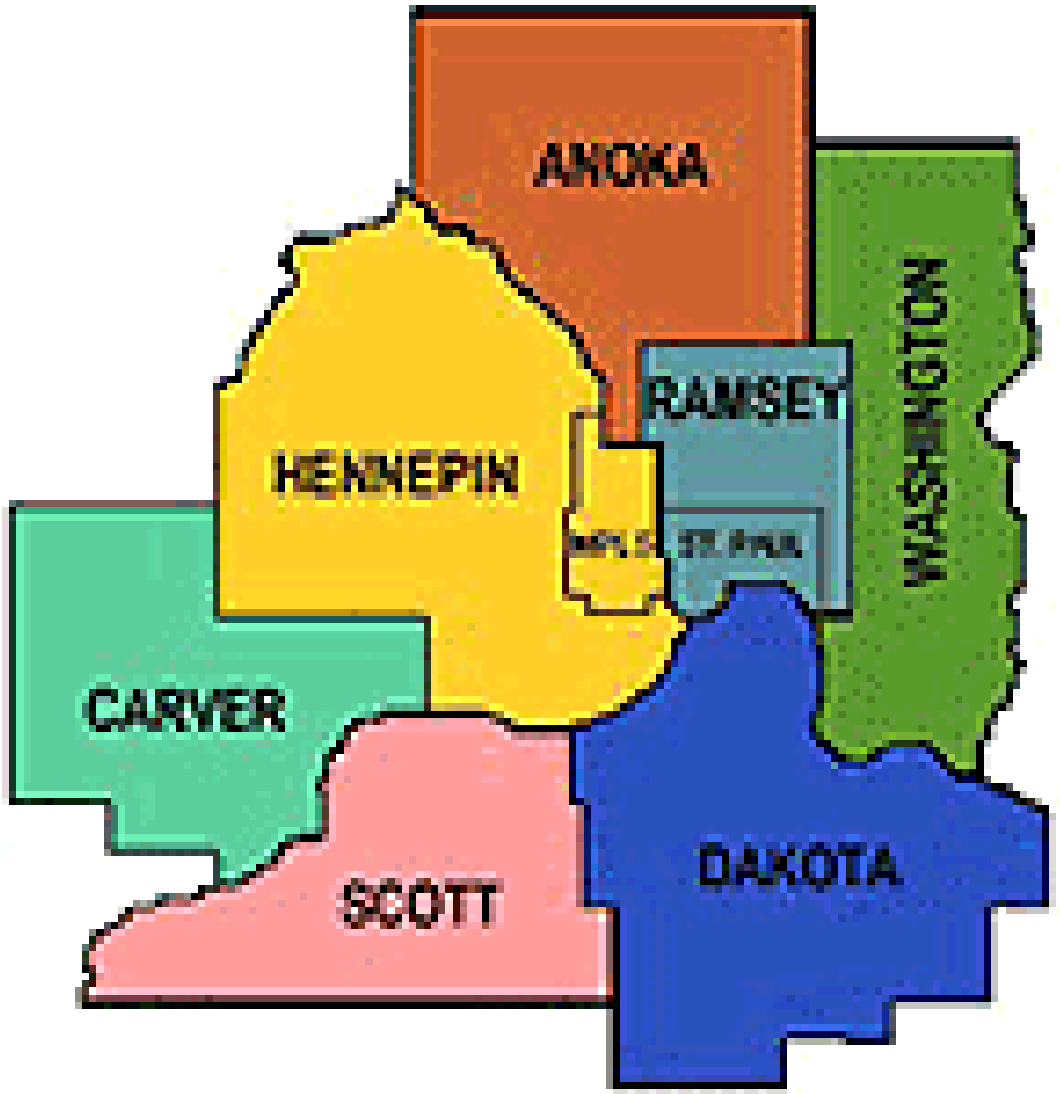
Total Phosphorus Sources



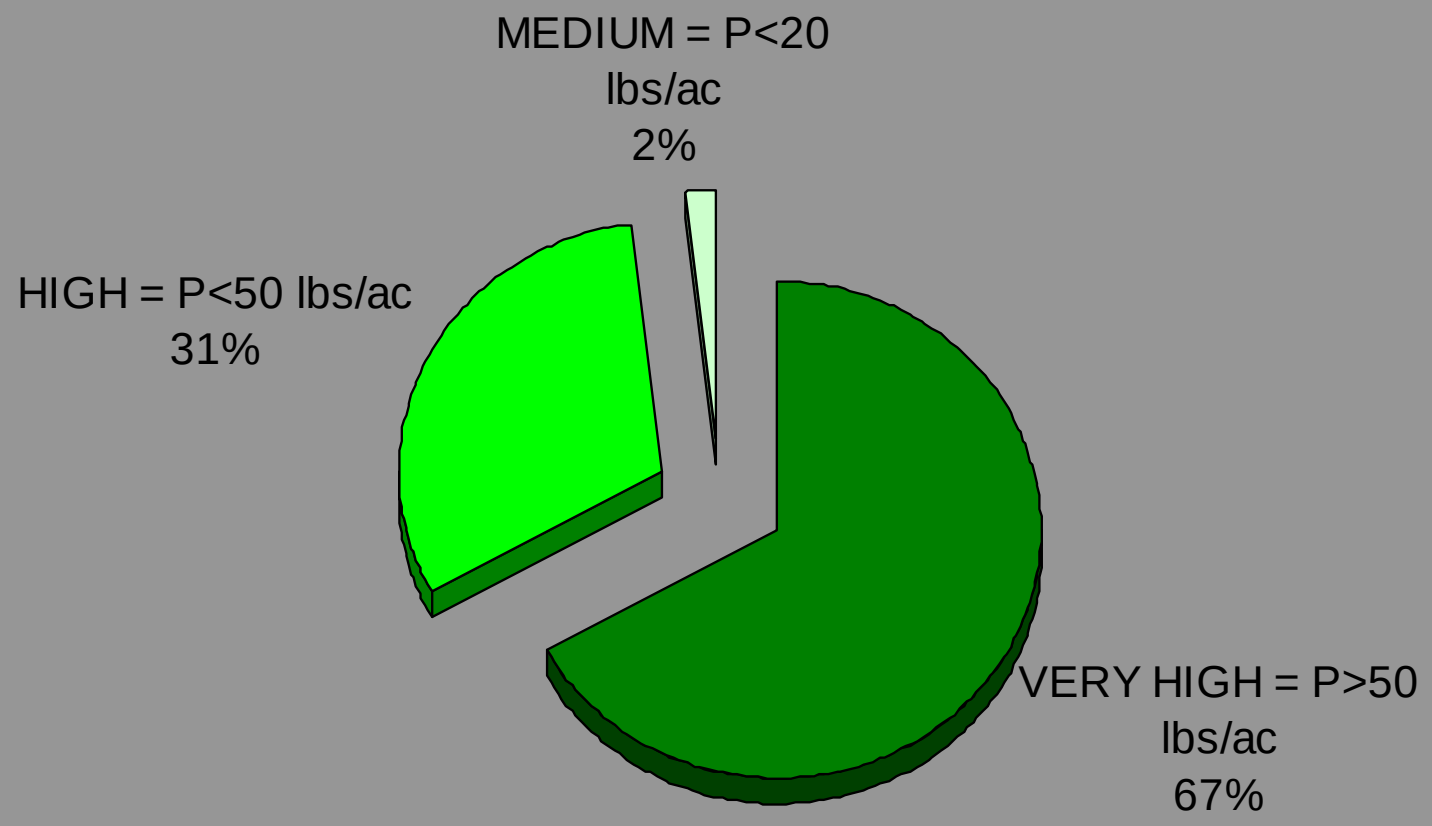
From Bannerman et. al. 1992



Seven County Metropolitan Area



SOIL PHOSPHORUS FERTILITY LEVEL



181 lawns in 4 suburban communities, 1994

PLYMOUTH, MN 55441

Laboratory No. 919
Date Received 05/2
Date Reported 06/0

Soil Test Results

Sample Designation	Soil Texture	Soil pH	Buffer Index	Organic Matter	P Phosphorus (ppm)	K Potassium (ppm)	Soluble Salts (mmhos)
PL 32	MEDIUM	7.6		MEDIUM	(OLSEN) 46 PPM X 2 = LB/ACRE	74	

INTERPRETATION OF SOIL TESTS

Phosphorus (P) — LOW · MEDIUM · HIGH · V. HIGH

Potassium (K)

pH — 3.0 · 4.0 Acid · 5.0 · 6.0 Optimum · 7.0

Soluble Salts — 0 · 1.0 · 2.0 Satisfactory · 3.0 · 4.0 · 5.0 · 6.0 Possible Problem · 7.0

RECOMMENDATIONS FOR: HOME LAWN

LIME RECOMMENDATION: 0 LBS/1,000 SQ.FT. GRASS NOT WATERED CLIPPINGS N

TOTAL AMOUNT OF EACH NUTRIENT TO APPLY PER YEAR: *

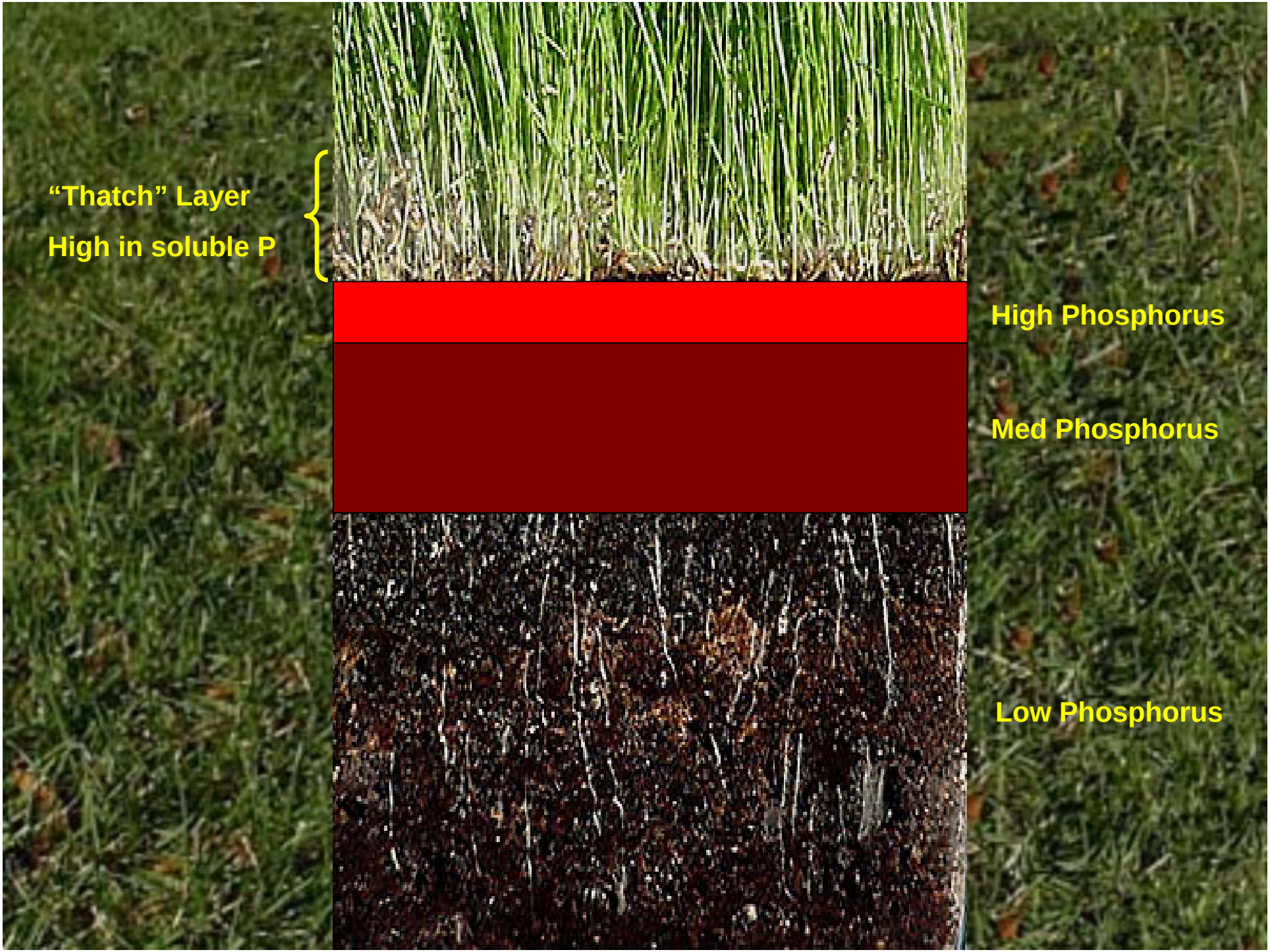
NITROGEN	PHOSPHATE	POTASH
1 LB/1000 SQ.FT.	0 LB/1000 SQ.FT.	1 LB/1000

THE APPROXIMATE RATIO OR PROPORTION OF THESE NUTRIENTS IS: 5- 0- 5 OR 10- 0-10

USE A FERTILIZER WITH THE PERCENTAGE OF NUTRIENTS CLOSEST TO THE ABOVE RATIO. APPLY ACCORDING TO THE INSTRUCTIONS ON THE FERTILIZER BAG OR CONTAINER, OR DETERMINE THE REQUIRED FROM THE INSTRUCTIONS GIVEN ON THE BACK SIDE OF THIS REPORT. SINCE MEETING THE AMOUNT REQUIRED FOR EACH NUTRIENT WILL NOT BE POSSIBLE IN MOST CASES, IT'S MORE IMPORTAN THE AMOUNT OF NITROGEN REQUIRED AND COMPROMISE SOME FOR PHOSPHATE AND/POTASH.

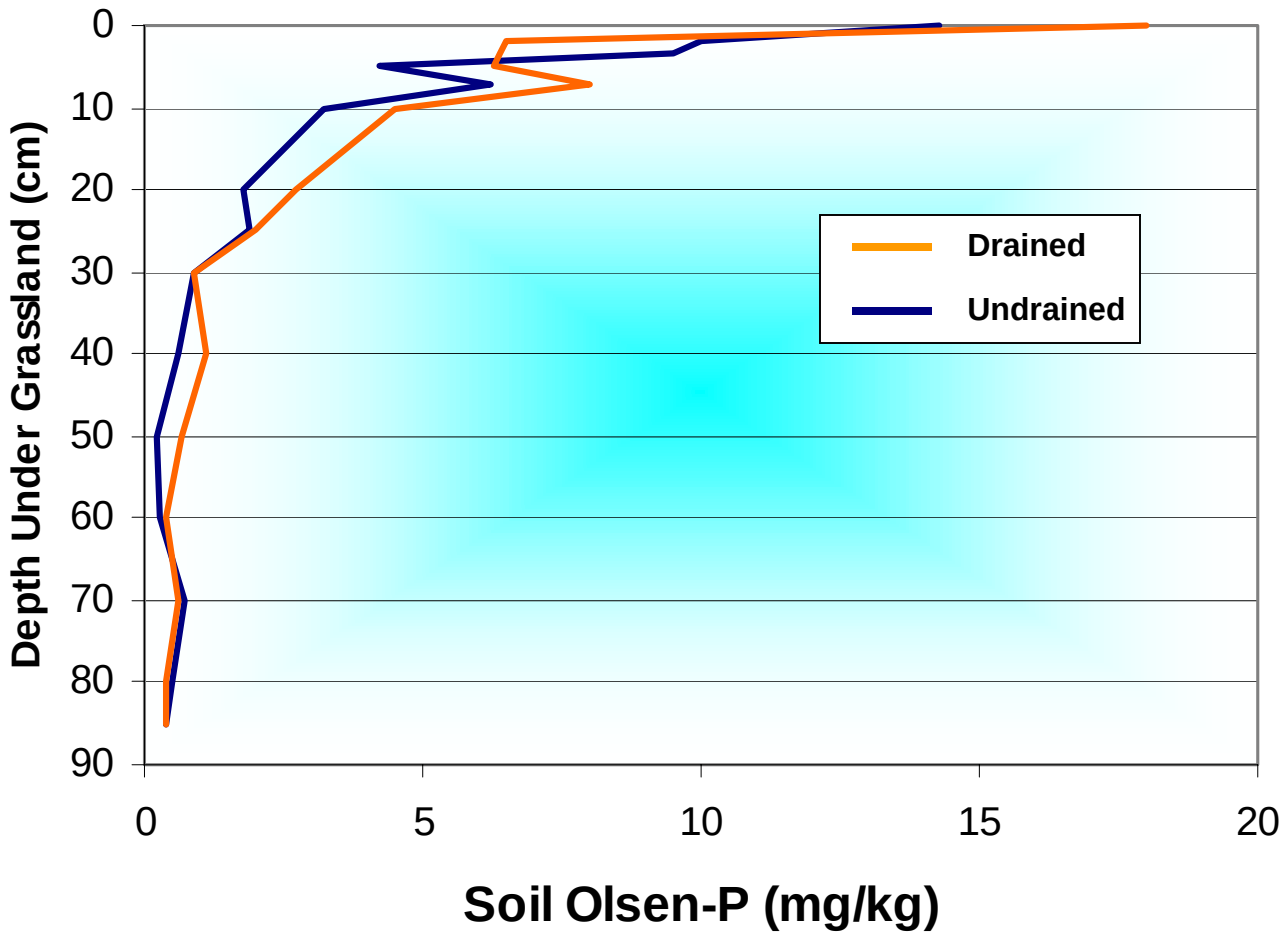
APPLY TOTAL AMOUNT AT ONE TIME IN SEPTEMBER.

* CAUTION DO NOT APPLY MORE THAN 1 LB NITROGEN PER 1000 SQ.FT. IN ONE APPLICATION TO A BURNING THE GRASS UNLESS A SLOW RELEASE FORM OR ORGANIC FERTILIZER IS USED. IT IS RECOMM


"Thatch" Layer
High in soluble P
High Phosphorus
Med Phosphorus
Low Phosphorus

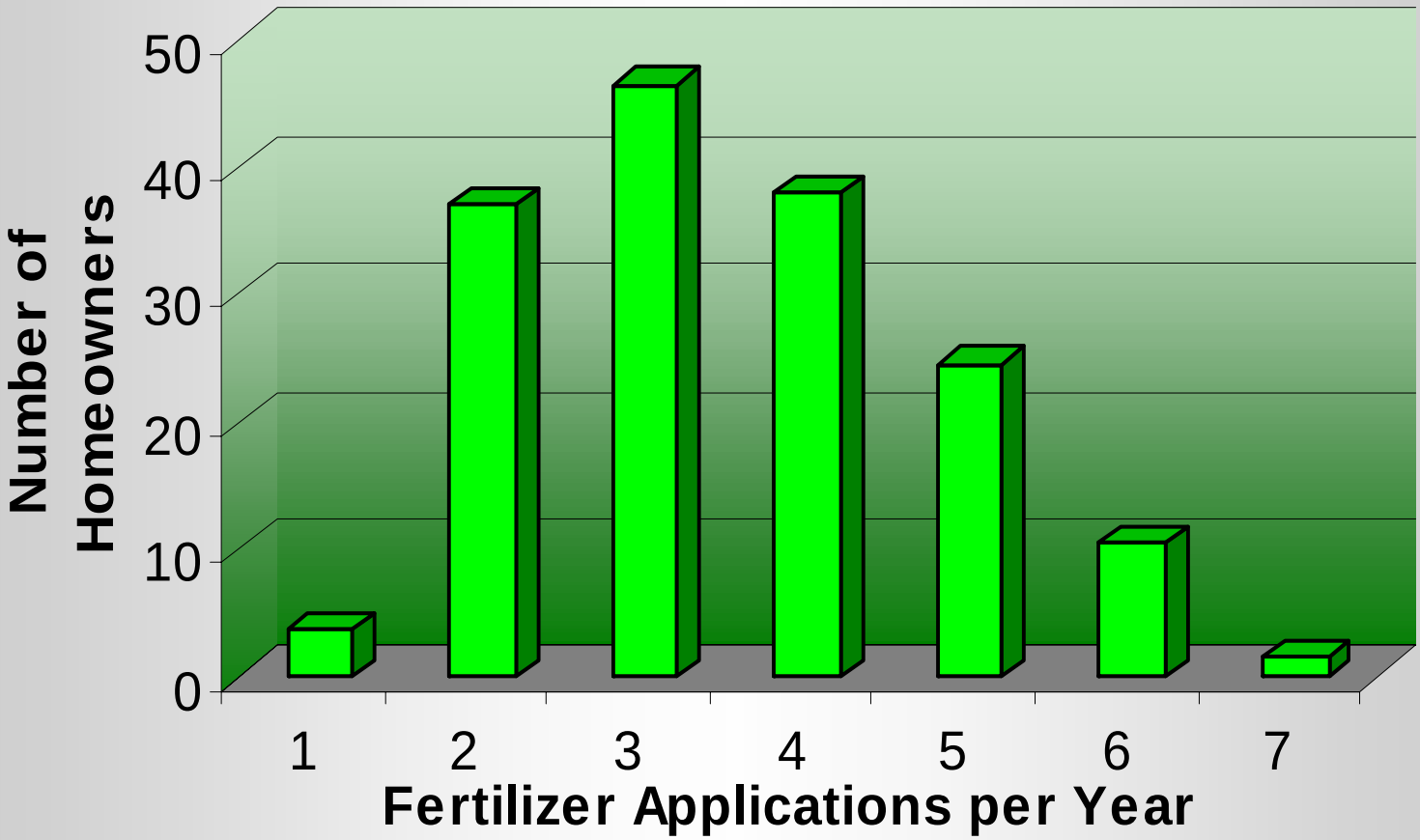
Olsen-P vs. Depth

After 15 Years of Fertilizing and Grazing



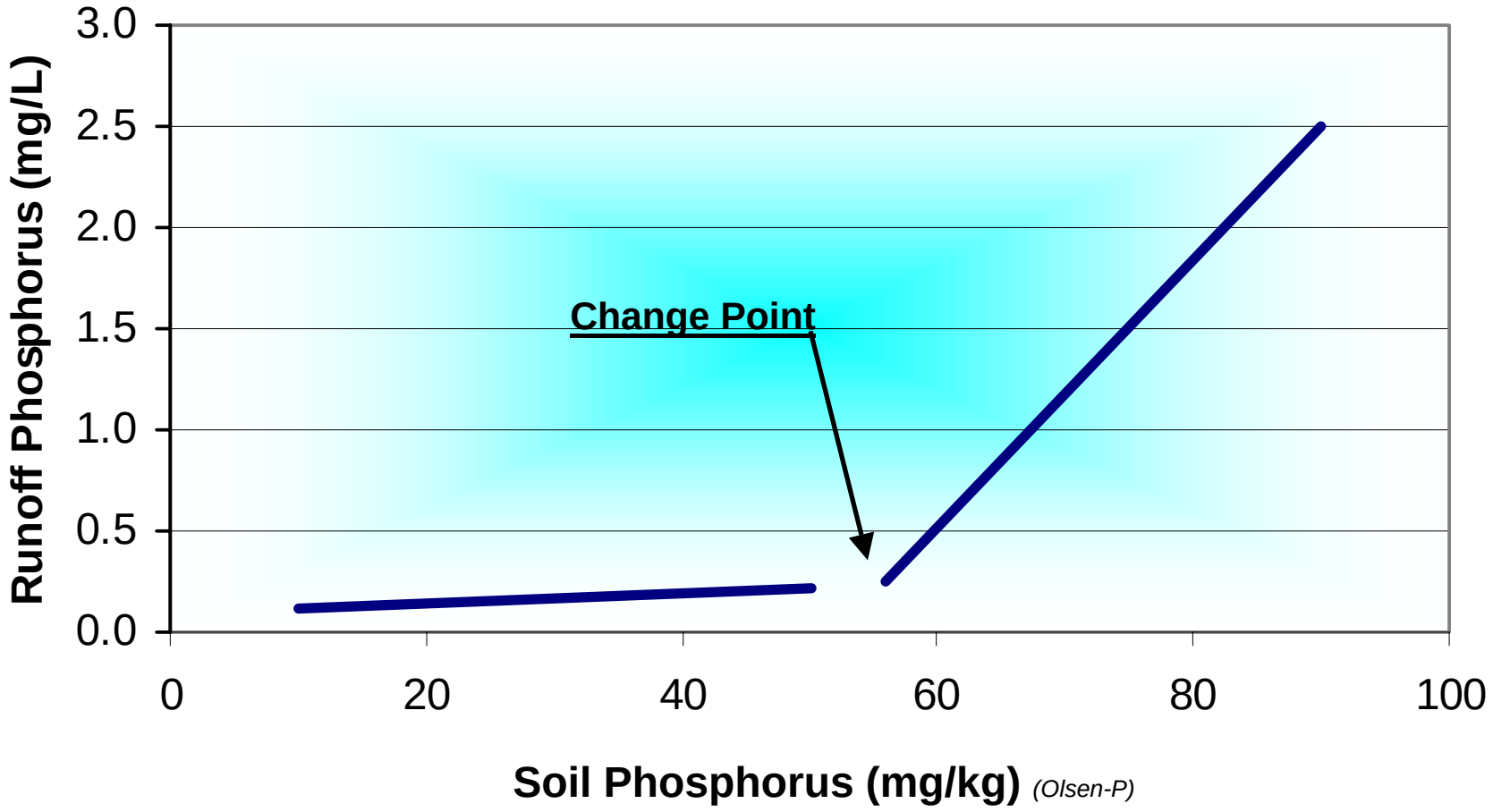
Lawn Fertilizer Application Frequency

1994 - Twin Cities Suburbs



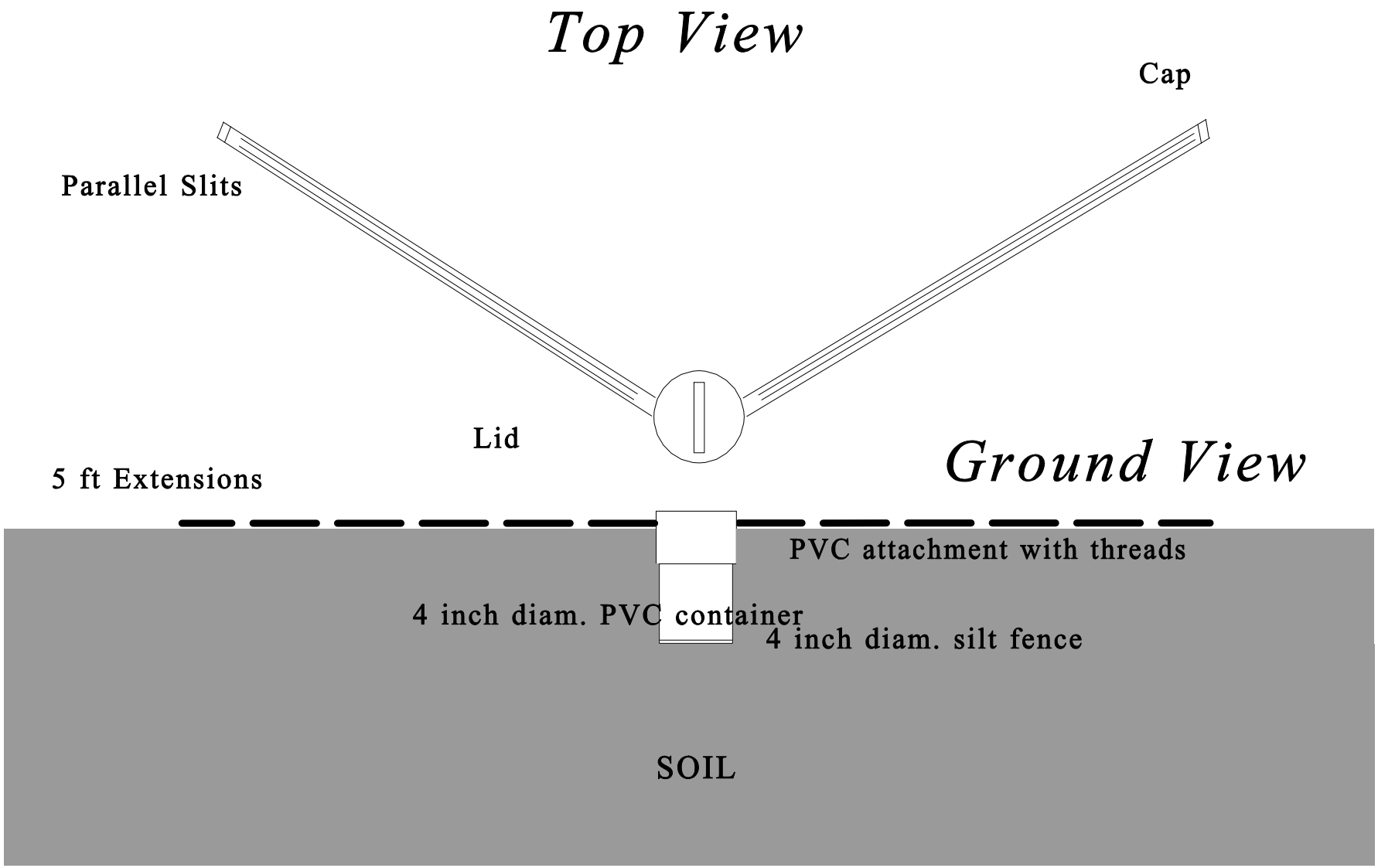
Barten, 1997

Relationship of Soil-P Level to Runoff-P Concentration

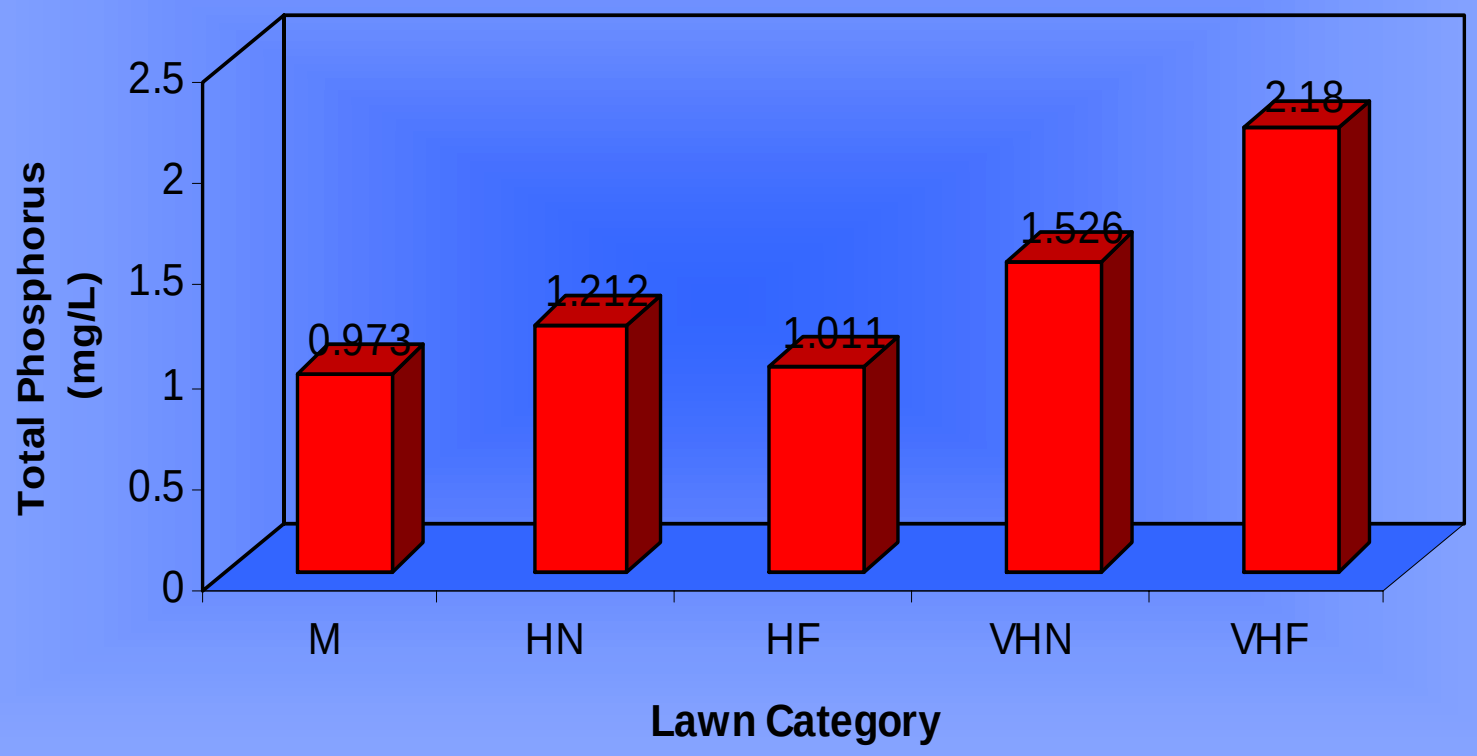


Heckrath et al., 1995

LAWN SAMPLER



Average Phosphorus Levels in Lawn Runoff



Plymouth P-fertilizer Ordinance

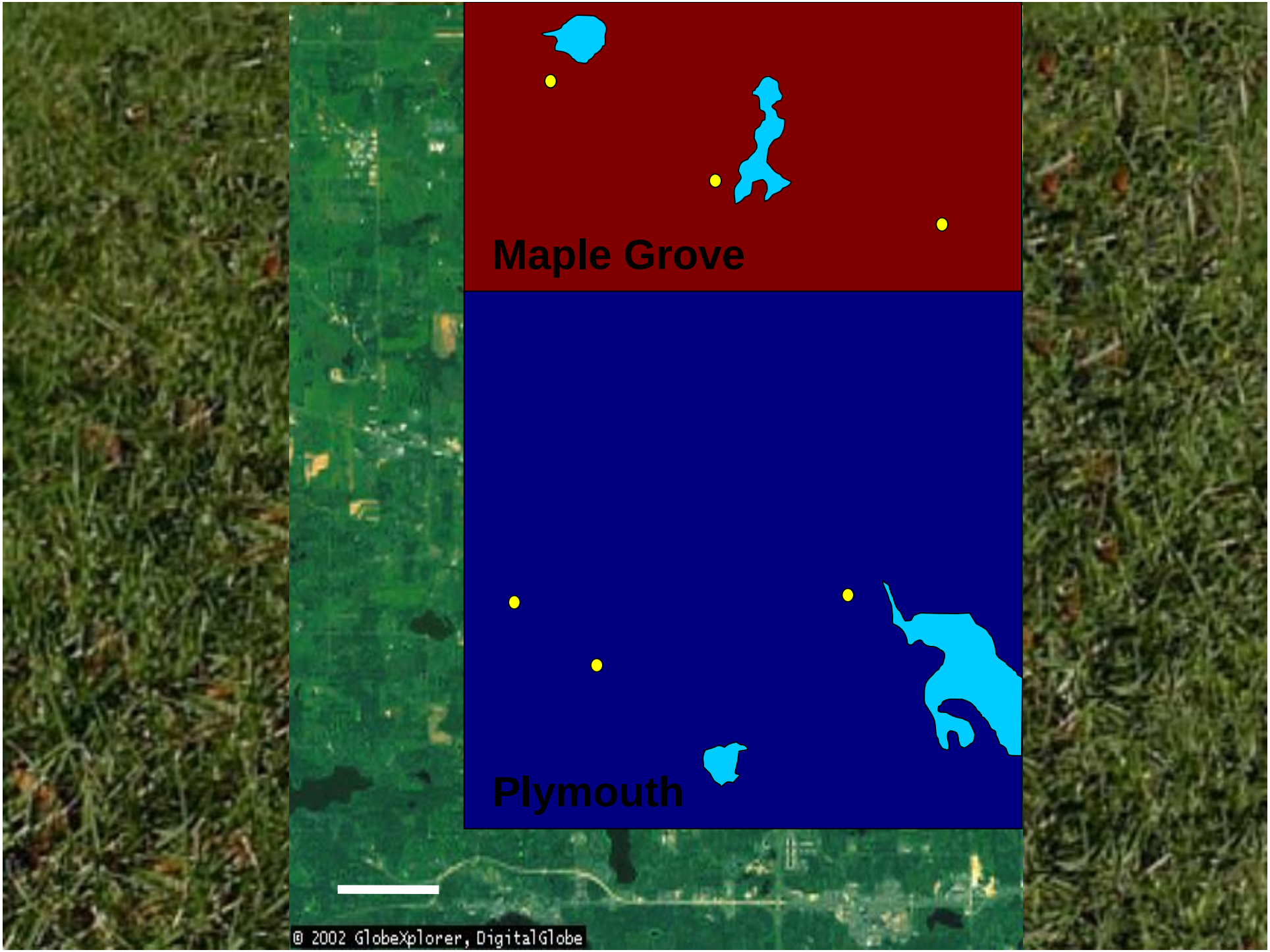
- 1996: Commercial applicators restricted
  - Use only P-free fertilizer (some exceptions)
  - Require license to apply in Plymouth
  - Education of self-applicators

- 2000: Home-owner application restricted
  - Use only P-free fertilizer (some exceptions)
  - Additional rules prohibit application to impervious areas, waterways, and shorelines.

* 2002: Sales Restriction

- Sell only P-free fertilizer unless soil test indicates a need for phosphorus

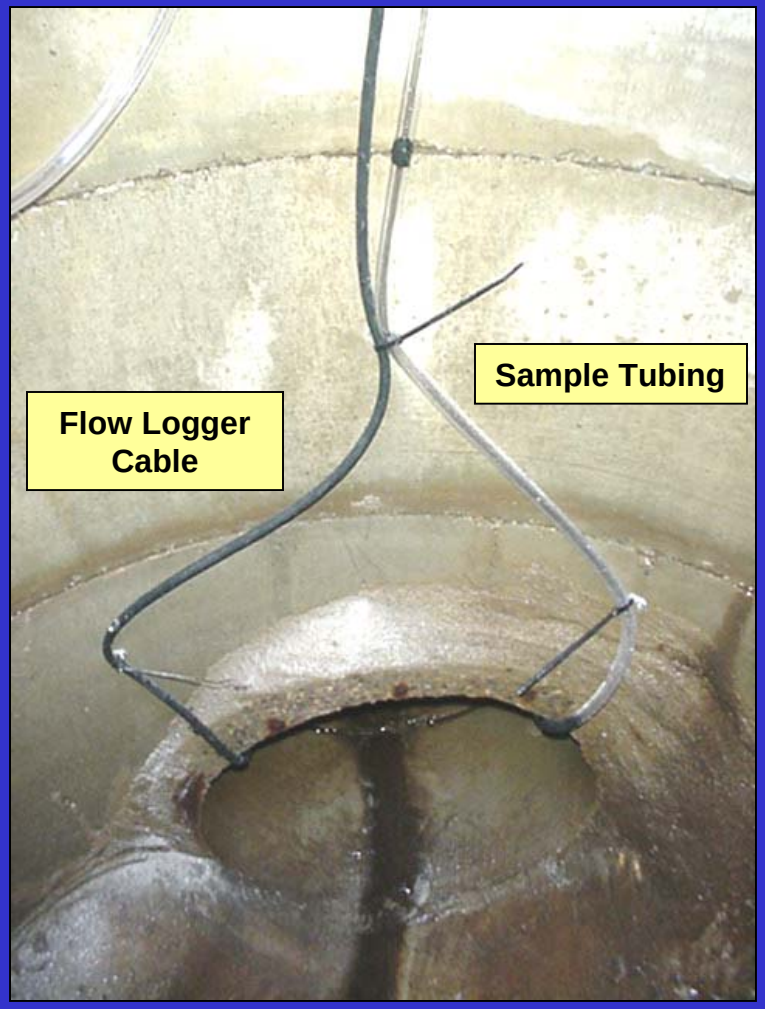
For lakes' sake!
Another
PHOSPHORUS-
Free
Lawn!
A water quality program of the City of Plymouth

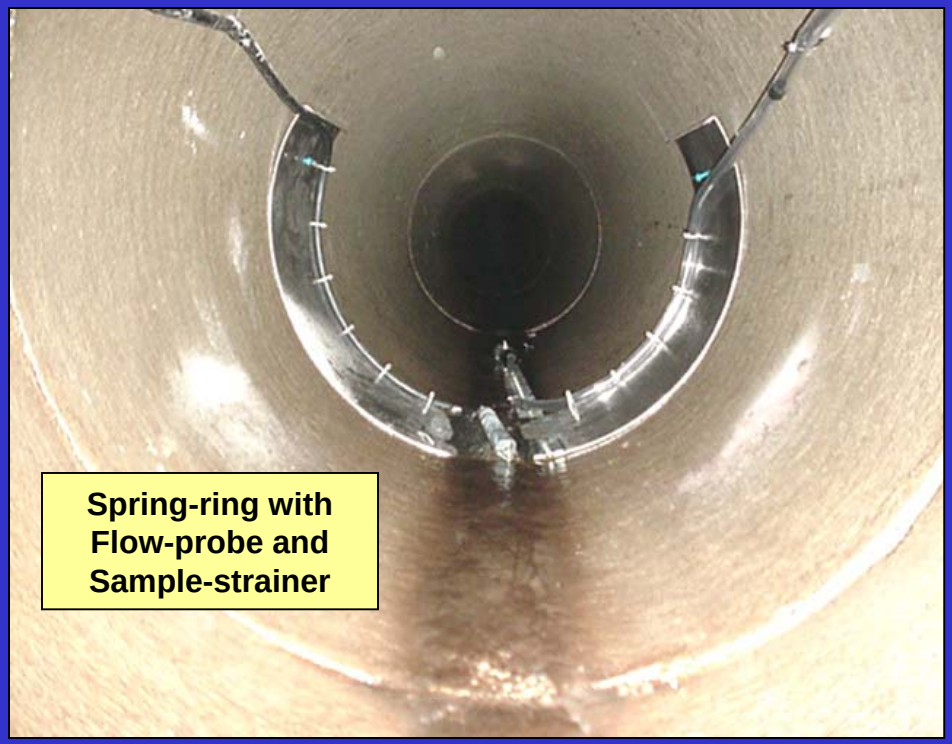

Maple Grove
Plymouth
© 2002 GlobeXplorer, DigitalGlobe

Automated Sampler
Flow Logger

Under the Street

Monitoring Urban Stormwater





STOP

	Watershed Characteristics		
Site	Area (ha)	Impervious Area (%)	# Homes
MG1	5.5	43%	49
MG2	3.5	40.40%	36
MG3	16	35.20%	108
P1	5.1	44.60%	43
P2	6.8	43.50%	47
P3	5.6	28.40%	37

Paired Watersheds

Rainfall - *No Significant Difference*

Runoff - *Significantly Correlated*

Impervious Area - *MG 4-5% More*

Soil P - *Variable (majority H or VH)*

Soil Compaction - *Little Difference*

Fertilizer Use - *Some Differences*

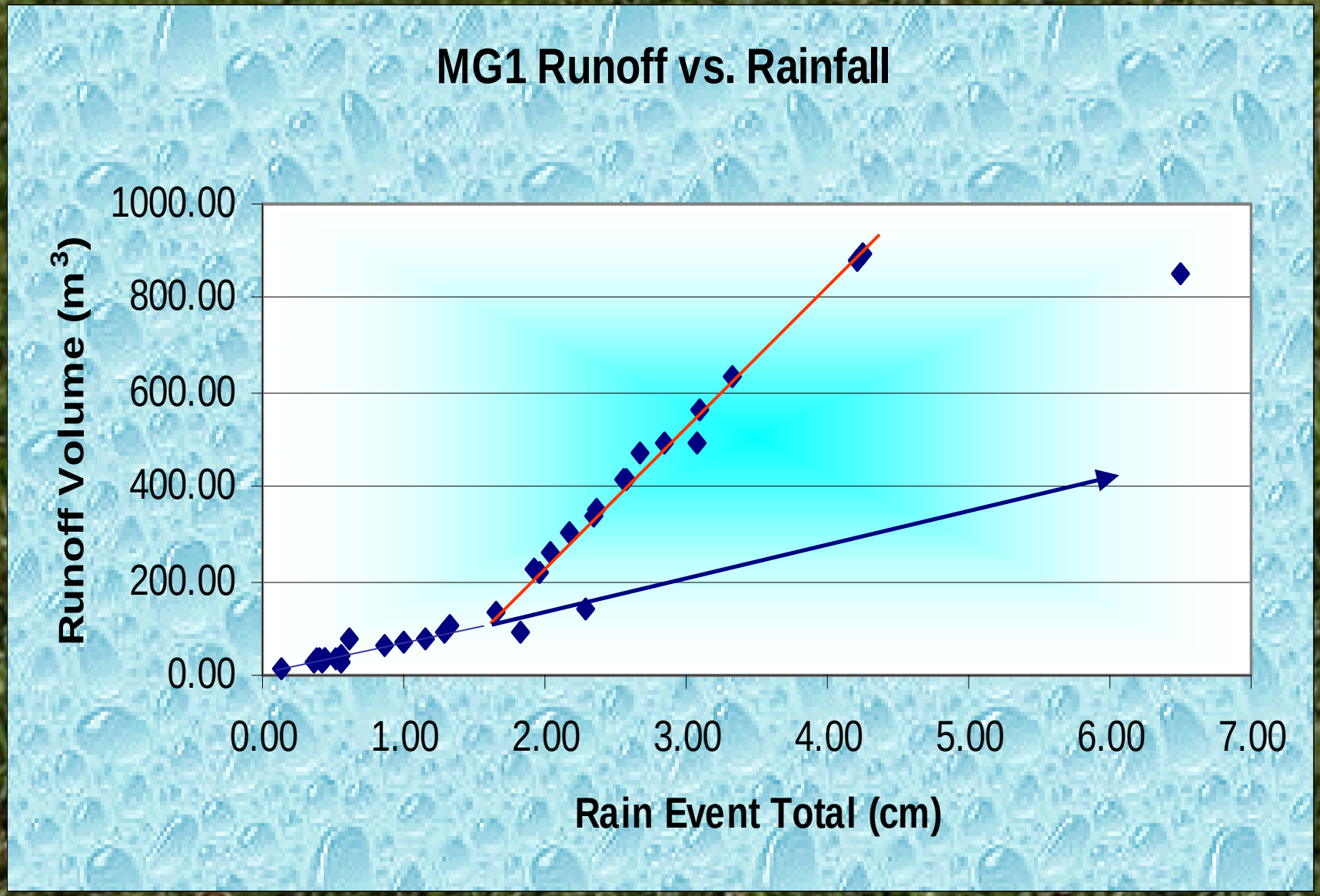
P-Application - *Large Differences*

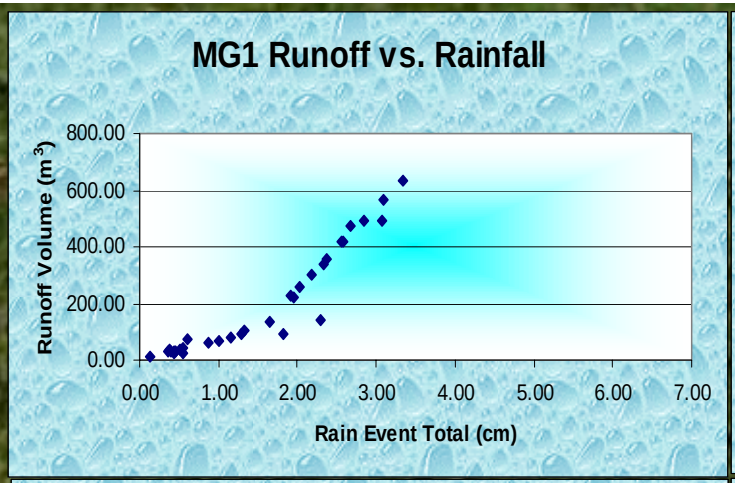
	New Developments		Middle-aged Developments		Older Developments	
	P1	*MG1*	*P2*	*MG2*	*P3*	*MG3*
Rainfall *(cm)*						
Mean	2.22	2.17	2.32	2.20	2.29	2.23
Median	1.33	1.30	1.21	1.18	1.14	1.35
Max	11.43	10.54	13.59	13.84	13.59	12.07
Min	0.04	0.03	0.04	0.05	0.03	0.10
N	64	64	64	62	63	63
% Impervious Area						
%	38.0%	42.5%	35.1%	39.4%	27.3%	34.2%
Hectares	1.92	2.35	2.39	1.39	1.54	5.42
% Connected Impervious Area						
%	23.9%	26.2%	22.9%	25.9%	17.8%	21.1%
Hectares	1.20	1.45	1.56	0.91	1.00	3.34
Soil Compaction 0-10 cm *(MPa)*						
Mean	1.09	1.38	1.09	1.19	0.98	1.13
Median	1.10	1.33	1.06	1.15	1.02	1.12
Max	1.33	1.77	1.35	1.39	1.15	1.43
Min	0.86	1.09	0.76	1.06	0.75	0.89
N	6	10	7	4	6	13
Zone of Maximum Compaction 0-10 cm *(MPa)*						
Mean Depth of Max *(cm)*	6.69	7.66	6.54	6.73	7.71	8.58
Mean Compaction at Max	1.61	2.06	1.39	1.74	1.30	1.70
SD of Max Compaction	0.137	0.149	0.141	0.189	0.104	0.124
Max Compaction Value	4.79	6.64	3.56	5.43	3.19	6.23
N	60	100	70	40	60	130
Soil P Fertility 0-10cm *(study watersheds only)*						
% Very High	36%	92%	90%	78%	89%	43%
% High	57%	8%	10%	22%	11%	26%
% Low-Medium	7%	0%	0%	0%	0%	30%
N	14	12	10	9	9	23

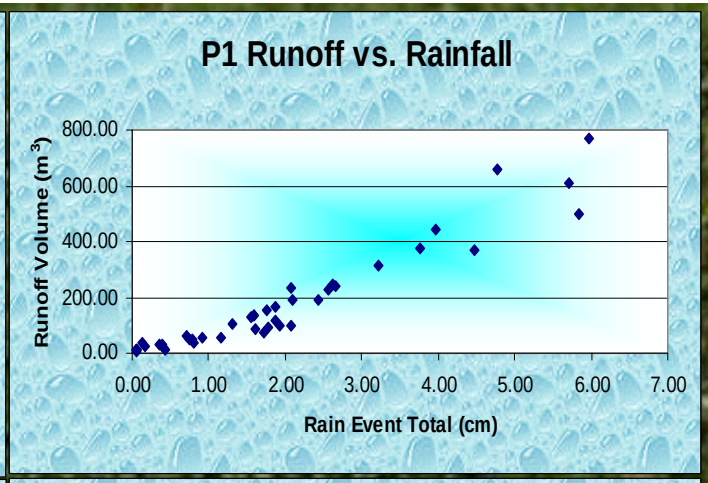
Soil P Fertility 0-10cm *(study watersheds and previous study data)*

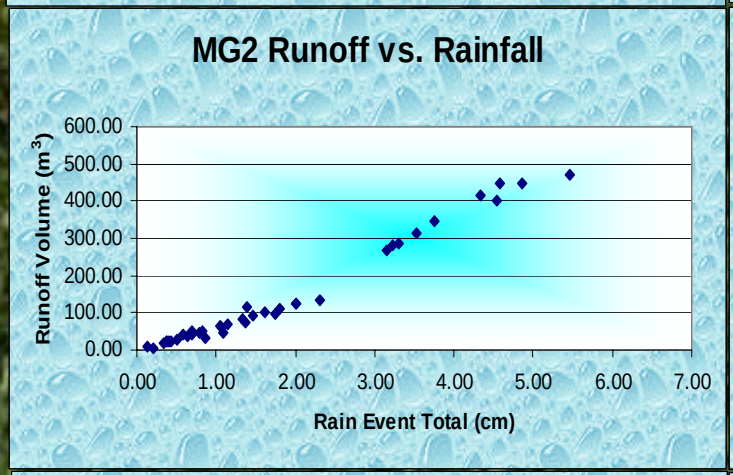
	Plymouth	Maple Grove
% Very High	75.6%	75.5%
% High	22.2%	16.0%
% Low-Medium	2.2%	8.5%
N	*90*	*94*

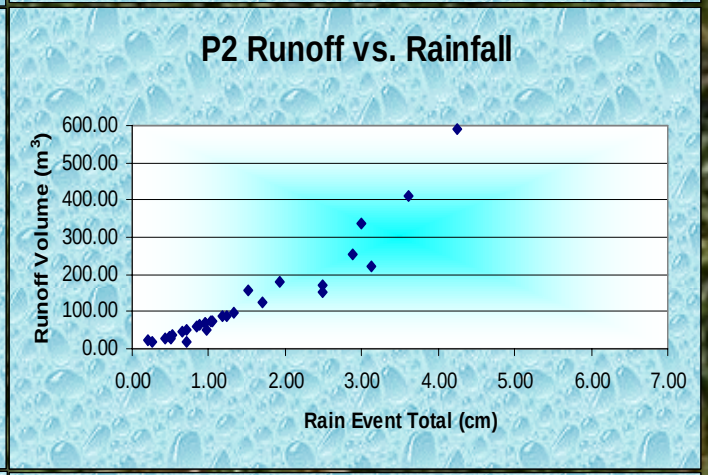
% Homeowners that Fertilize Lawn						
%	100%	100%	71.6%	88.9%	75.5%	91.7%
% Homeowners that Applied Phosphorus						
%	44.4 %	63.6%	20.0 %	83.3%	21.4 %	73.7%
N	18	14	55	9	42	24

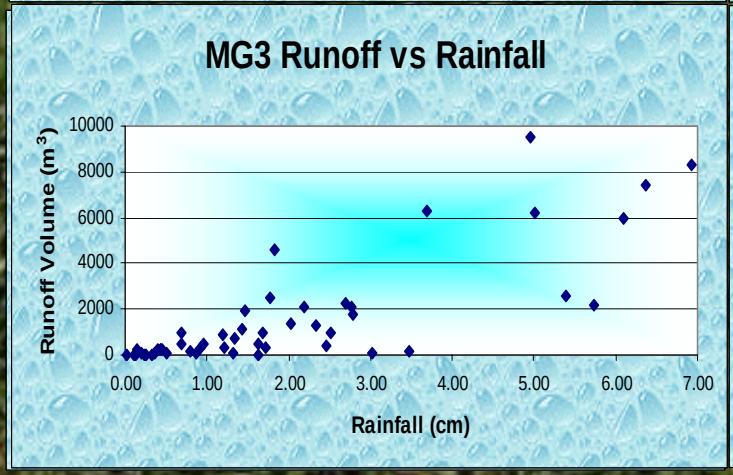

MG1 Runoff vs. Rainfall
Runoff Volume (m3)
1000.00
800.00
600.00
400.00
200.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)

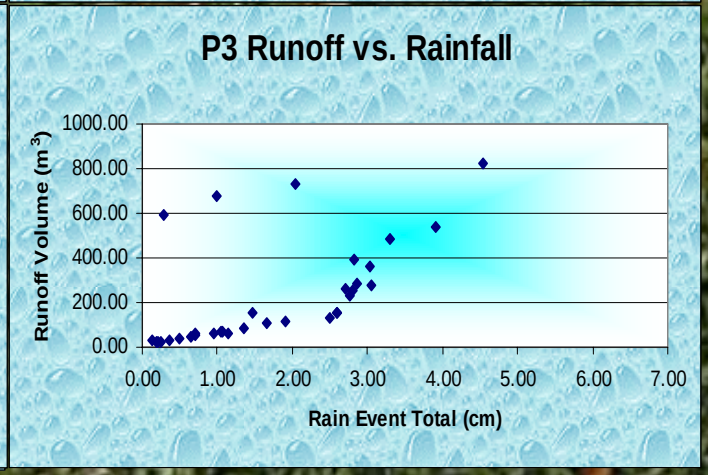

MG1 Runoff vs. Rainfall
Runoff Volume (m3)
800.00
600.00
400.00
200.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)


P1 Runoff vs. Rainfall
Runoff Volume (m3)
800.00
600.00
400.00
200.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)

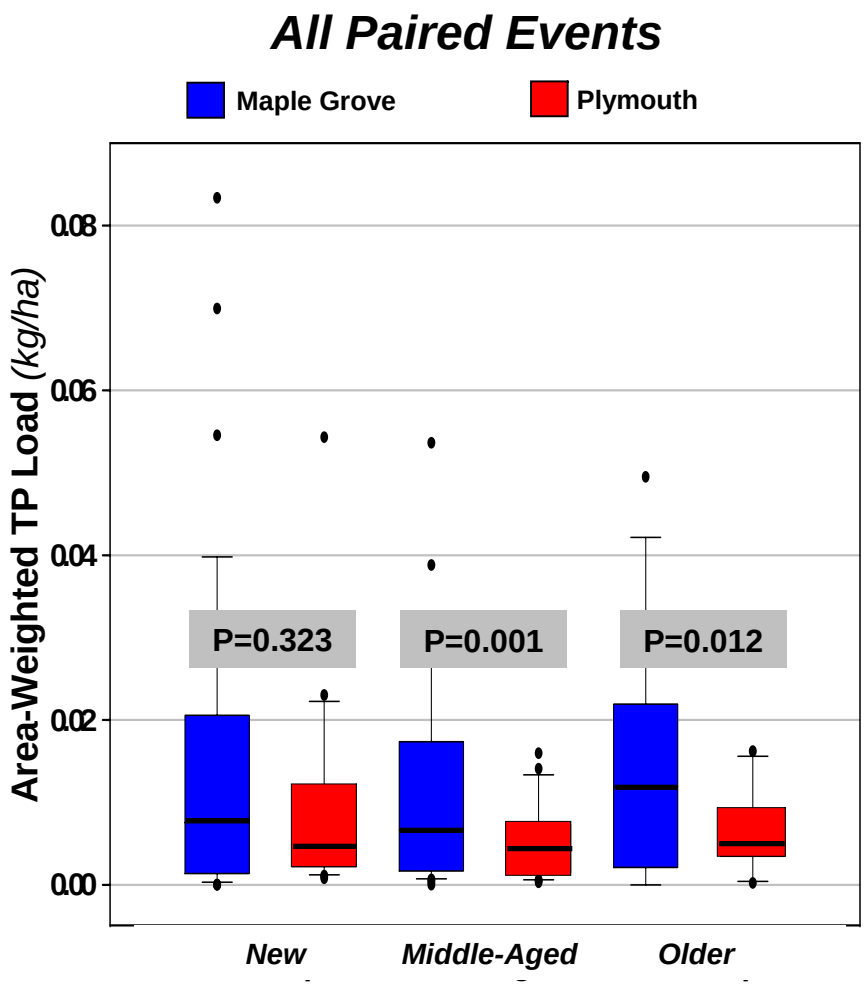

MG2 Runoff vs. Rainfall
Runoff Volume (m3)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)

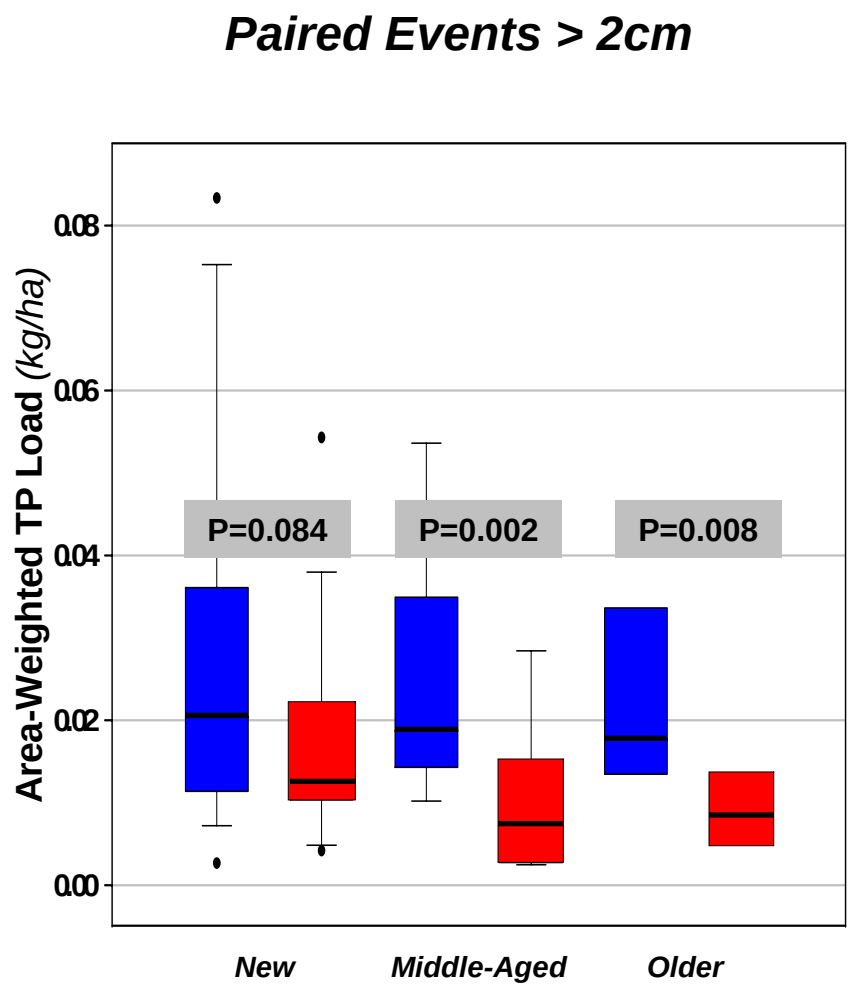

P2 Runoff vs. Rainfall
Runoff Volume (m3)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)


MG3 Runoff vs Rainfall
Runoff Volume (m3)
10000
8000
6000
4000
2000
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rainfall (cm)

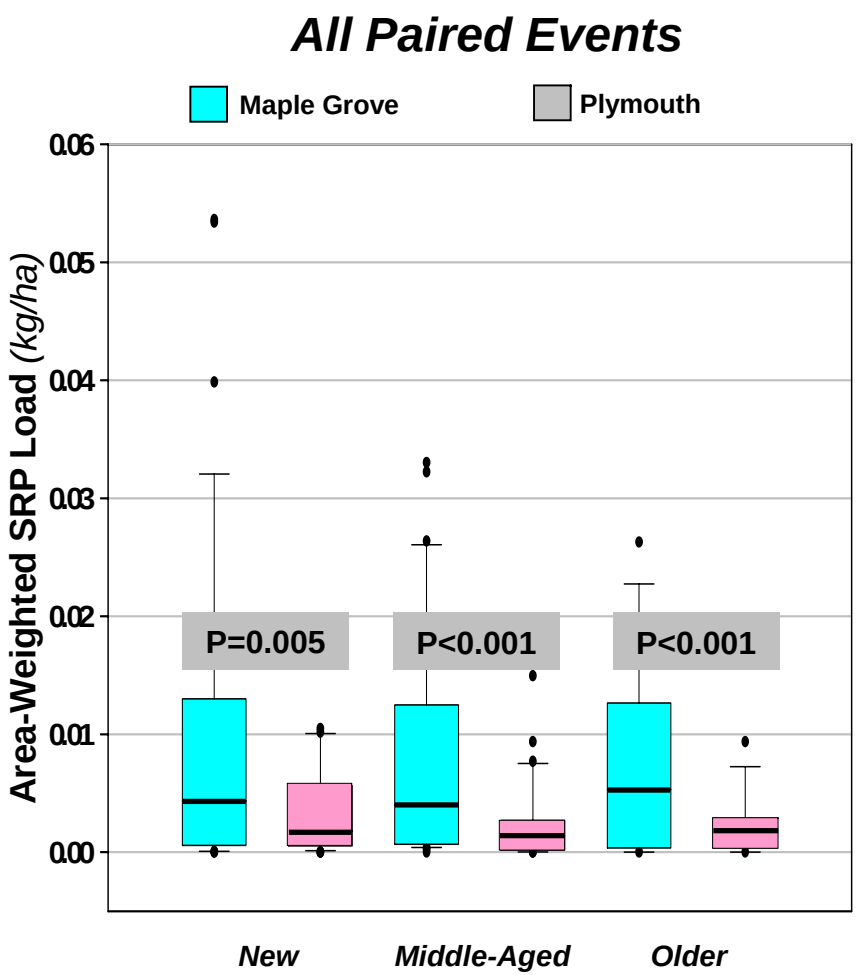

P3 Runoff vs. Rainfall
Runoff Volume (m3)
1000.00
800.00
600.00
400.00
200.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Rain Event Total (cm)

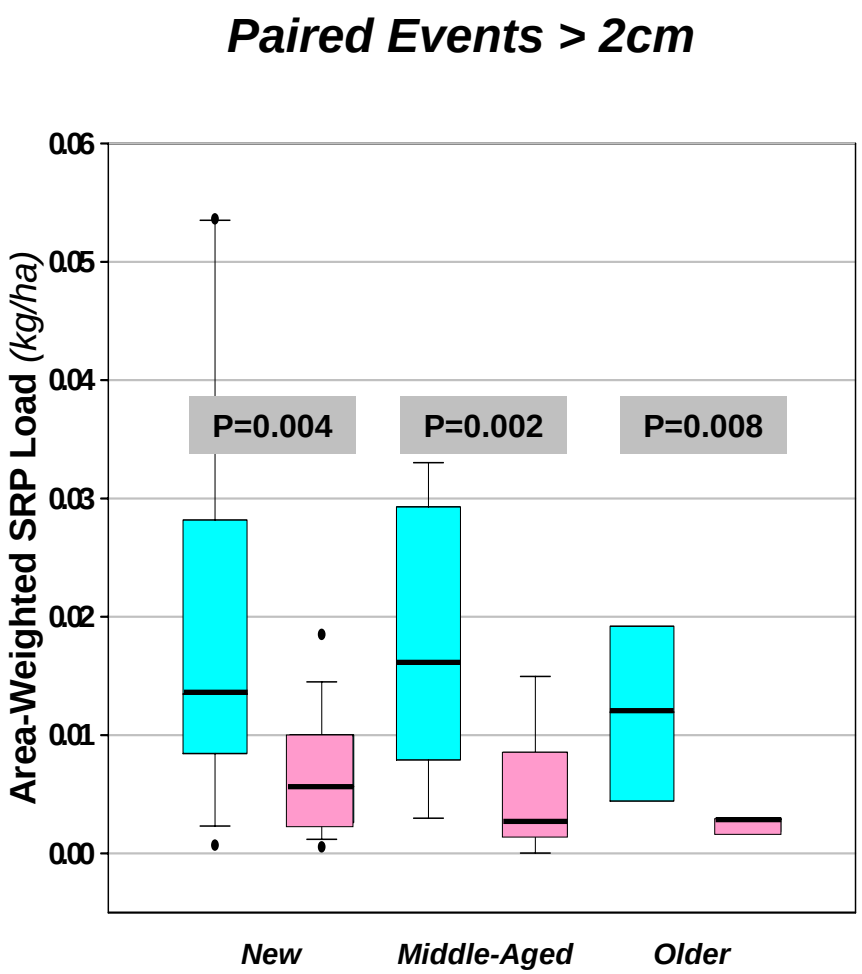
Area-Weighted Total Phosphorus Loading



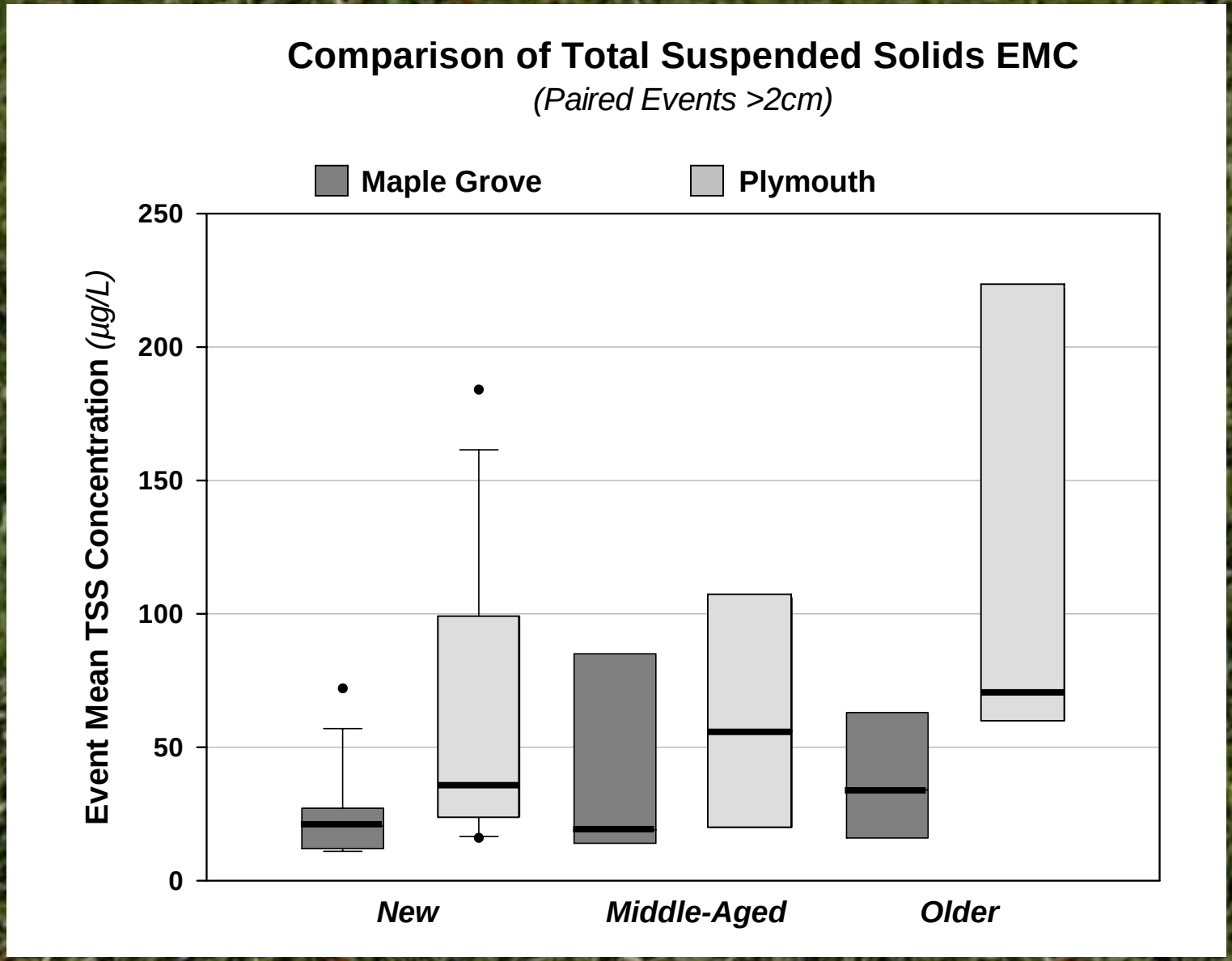


Area-Weighted Soluble Reactive P Loading





Suspended Solids

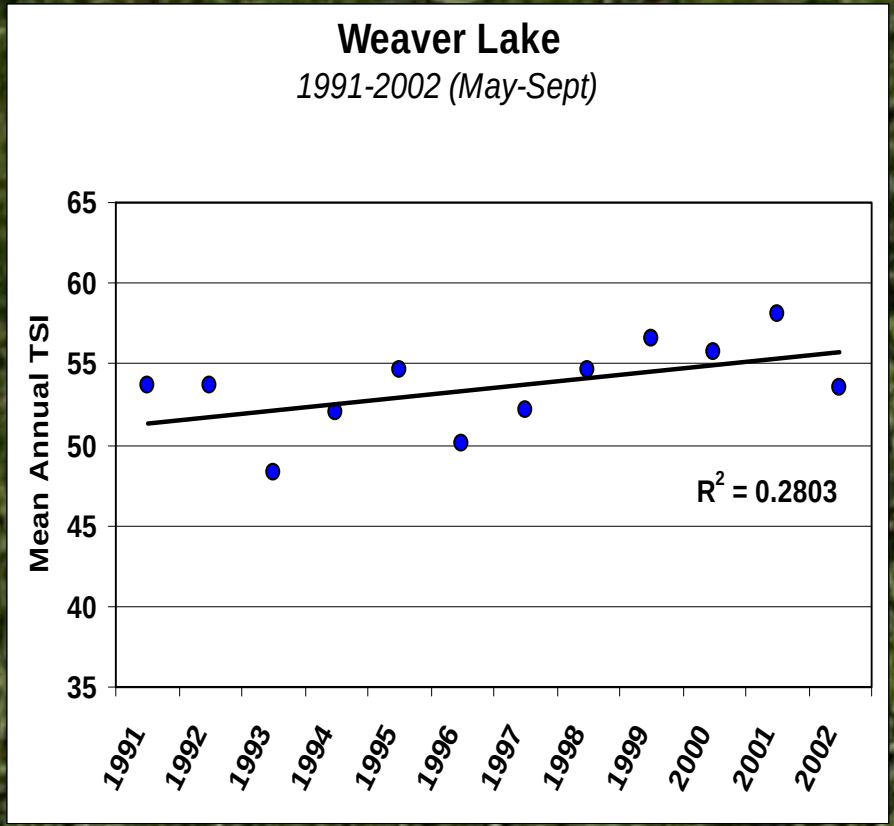


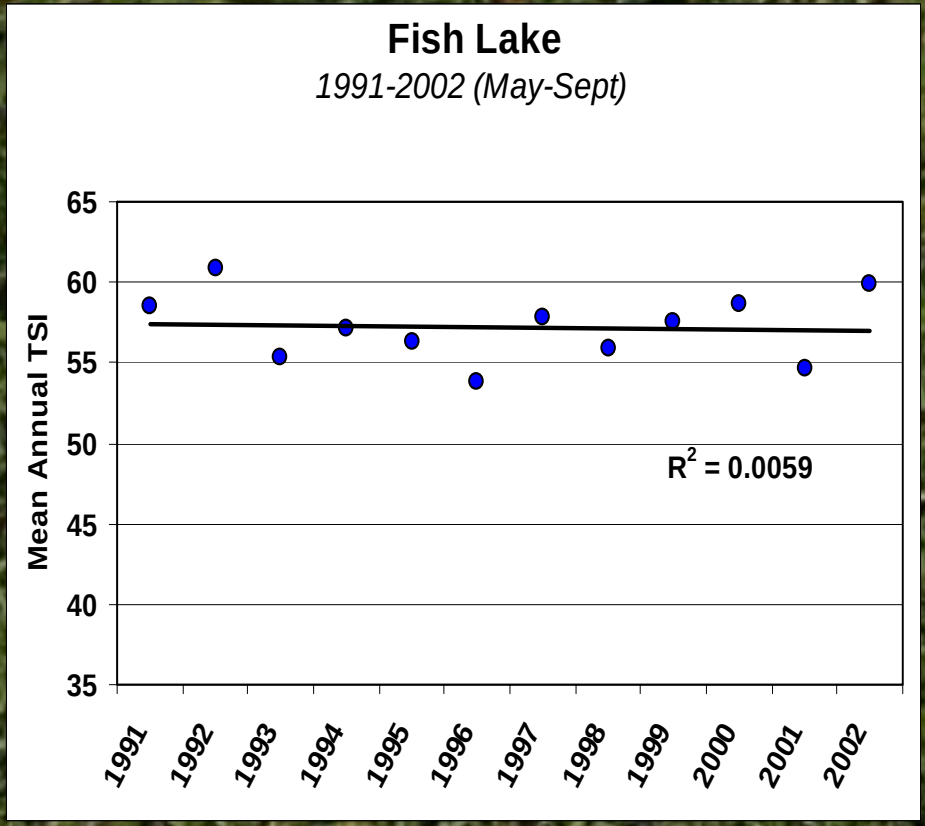
GISIN

Median Area-Weighted Loading for Paired Rain Events

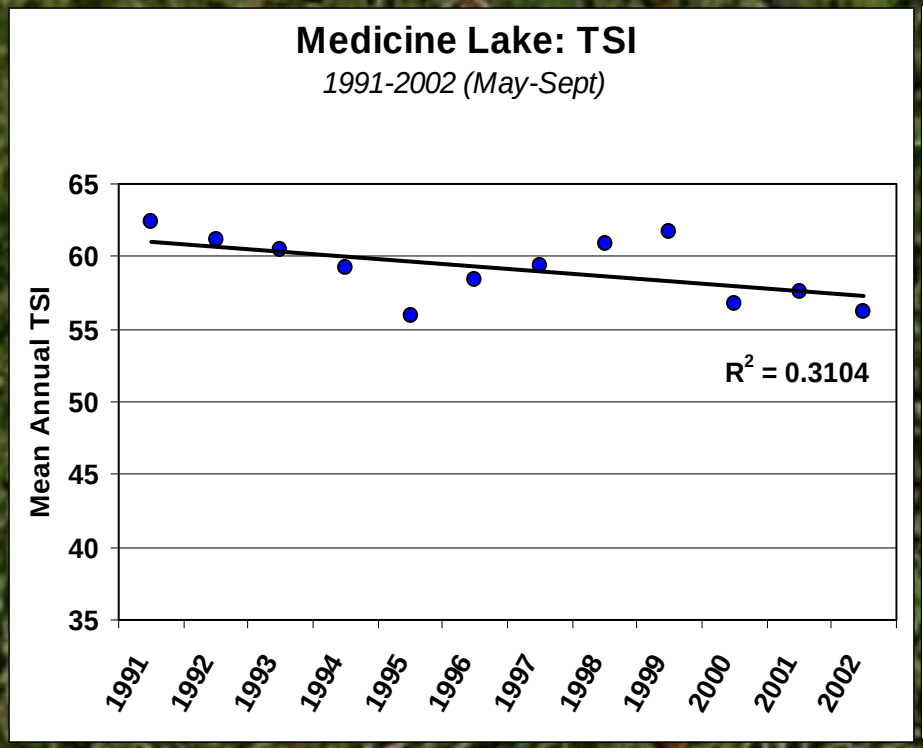
	TP			SRP		
	new	mid	old	new	mid	old
Maple Grove *(g/ha)*	7.58	6.69	12.0	4.34	3.99	5.31
Plymouth *(g/ha)*	4.89	4.12	4.75	1.77	1.38	1.88
Difference *(g/ha)*	2.69	2.57	7.25	2.57	2.61	3.43
% "Reduction"	35%	38%	60%	59%	65%	65%

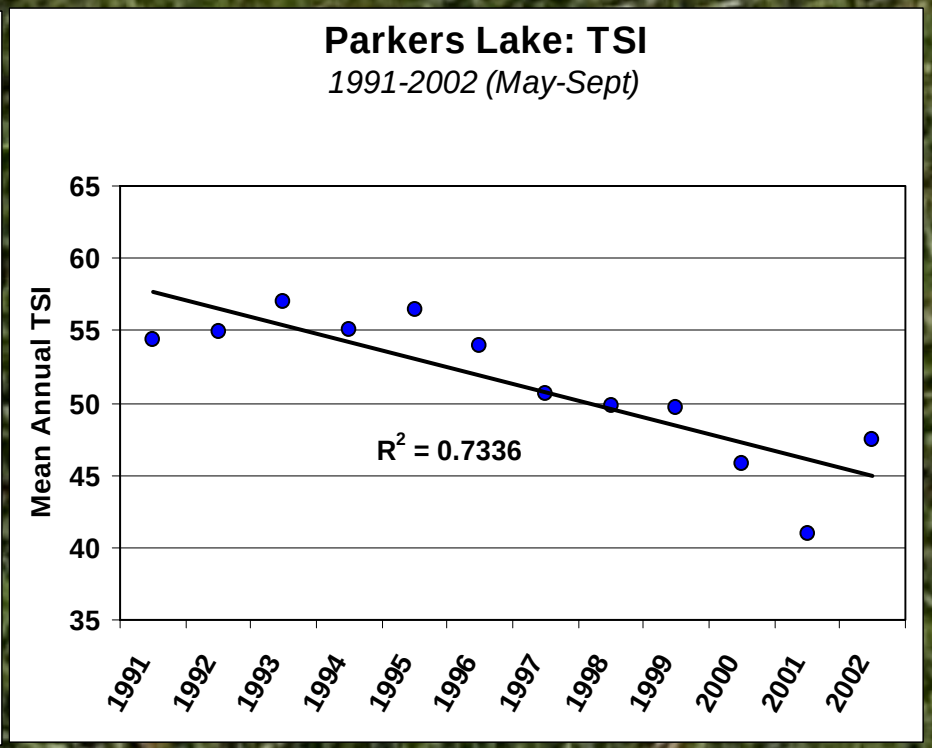
Maple Grove Lake Trends: 1991-2002

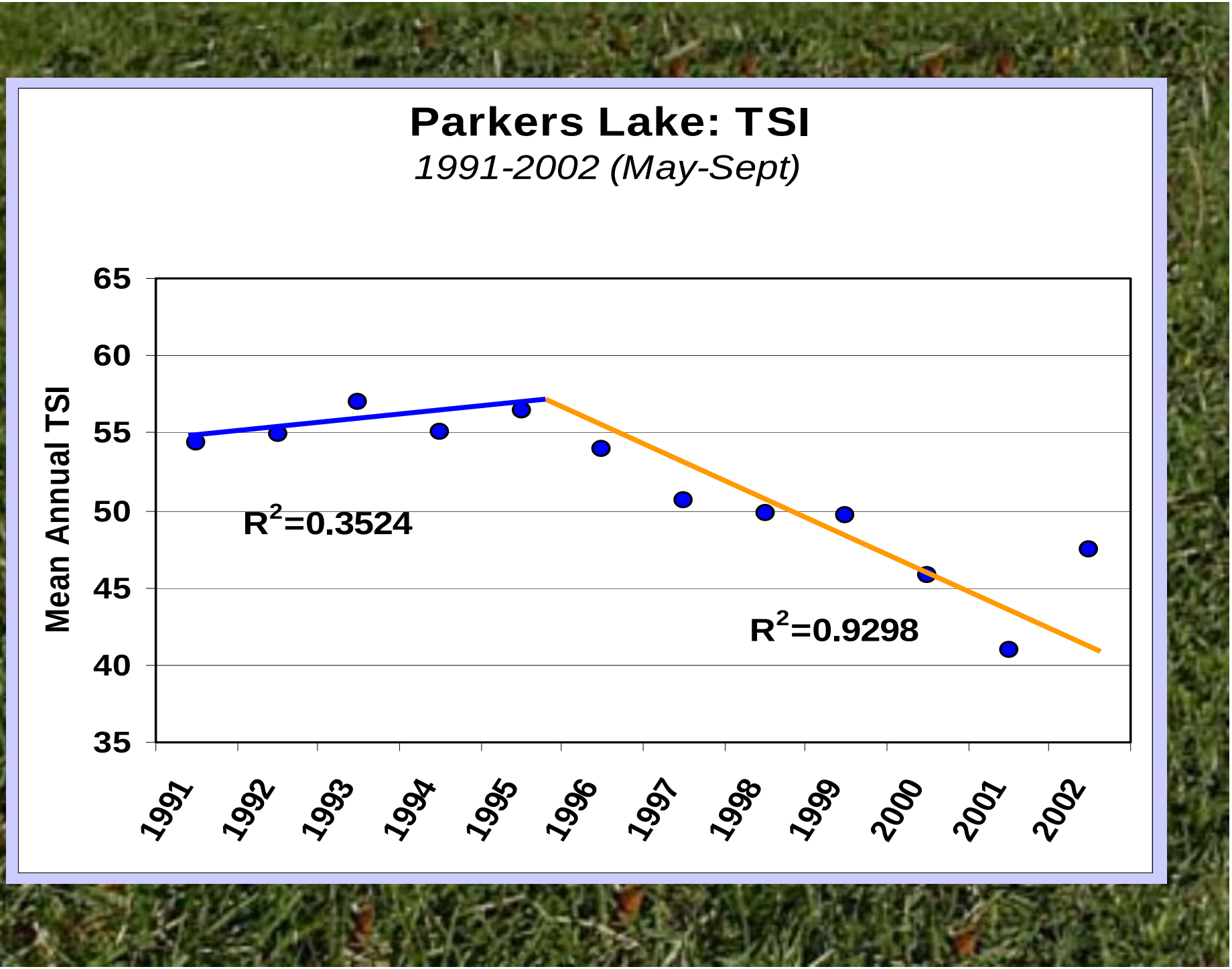




Plymouth Lake Trends: 1991-2002






Parkers Lake: TSI
1991-2002 (May-Sept)
Mean Annual TSI
65
60
55
50
45
40
35
R2=0.3524
R2=0.9298
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002

Summary of Findings

- **Runoff begins to occur from lawns in rain events > 2cm**

- **Watersheds with the fertilizer ordinance experienced:**
  - *Less P-fertilizer application (20% new / 50-60% older)*
  - *Fewer homes applying any fertilizer their lawns (15% less)*
  - *Significantly lower SRP loading (~65% less)*
  - *Significantly lower TP loading in all but newest watersheds (~40%)*

- **Higher TSS concentrations in Plymouth**
  - *may mask additional TP reduction attributable to the ordinance*

Conclusion:

Restricting use of P-fertilizer is an effective low cost BMP for reducing phosphorus in runoff from residential areas.