

A Model for Phosphorus from Shoreland Development

Paul McGinley

Stormwater Workshop
Waukesha Co & WI Land & Water
April, 2025

Lakes & Phosphorus

- Add a little P, and you can make a lot of algae:

1 lb P
→
500 lbs Algae*



*p 275 in *Limnology*, Robert Wetzel, Academic Press, 2001

Healthy Lakes & Rivers

ABOUT ▾ BEST PRACTICES ▾ GRANTS ▾ RESULTS ▾ RESOURCES ▾ SCORE MY SHORE ▾

I own shoreland property.
This can make a difference. Learn about Healthy Lakes & Rivers best practices for your property and how to find help.
[Get Started](#)

I'm a Partner Organization.
From technology to lakes or river organizations, municipalities, or local government, you can help make Healthy Lakes & Rivers a better place.
[Get Started](#)

Healthy Lakes & Rivers

RAIN GARDEN
PART 1001 SERIES

PLANTING

COSTS
* Average \$1000 - \$1500 (average = \$1250)
Healthy Lakes & Rivers grant funding available: \$1000 per acre garden.

PURPOSE
Rain gardens capture and filter rain runoff along streets, driveways, and roofs to prevent the immediate flow of water into waterways. Rain gardens absorb pollutants and excess nutrients before they reach waterways.

<https://healthylakeswi.com>

Objective

Develop a tool to help shoreland property owners and organizations evaluate the benefits of lot-scale stormwater management



Collaborators

- Dave Ferris, Burnett Co
- Cheryl Clemens, Harmony Environmental
- Carolyn Scholl, Vilas Co
- Emily Moore and Shawn O'Connell, Burnett Co
- We appreciate John Panuska's comments about this project, and the discussions about lakes, development and related modeling with many DNR and Extension Colleagues.

Outline

- Shorelands & Phosphorus
- Model Development
- Example



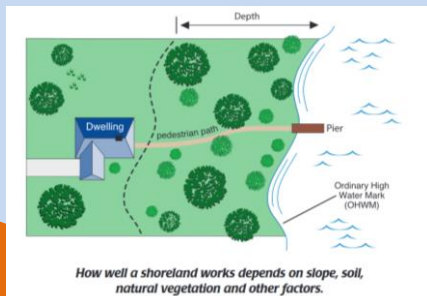
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Shorelands & Phosphorus



Shorelands & Phosphorus



Lakes Partnership Shoreland Stewardship Series Cooperative Extension Publications 877944-7827, Carmen Wagner, John Haack, and Robert Korth

Shorelands & Phosphorus

Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives: A Literature Review with Policy Implications



Dams, Floodplain & Shoreland Section
Bureau of Watershed Management

Prepared by Thomas W. Benesh
Edited by John R. Barrett

FD-87-88-87



The modeling results and empirical studiesdemonstrate that phosphorus levels can increase with even small levels of residential development around lakes.

WDNR, 1997

Shorelands & Phosphorus

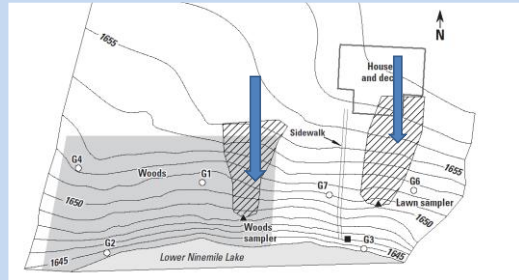


In cooperation with the Wisconsin Department of Natural Resources

Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999–2001

By David J. Graczyk¹, Randall J. Hunt¹, Steven R. Greb², Cheryl A. Buchwald¹, and James T. Krohelski¹

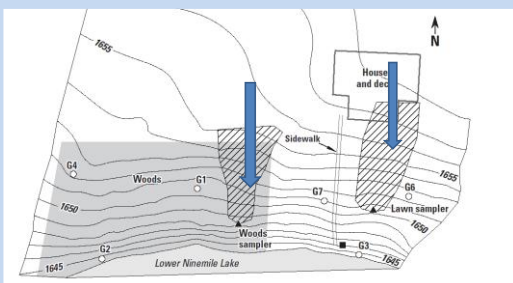
Water-Resources Investigations Report 03-4144



By David J. Graczyk¹, Randall J. Hunt¹, Steven R. Greb², Cheryl A. Buchwald¹, and James T. Krohelski¹

In cooperation with the Wisconsin Department of Natural Resources

Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999–2001



Quantity of phosphorus transported was related to the volume of runoff



By David J. Graczyk¹, Randall J. Hunt¹, Steven R. Greb², Cheryl A. Buchwald¹, and James T. Krohelski¹

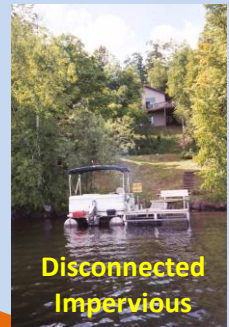
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Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999–2001

Model Development



Directly Connected Impervious



Disconnected Impervious

Model Development

Disconnection



Foster, K.M. 2008. The role of the residential shoreline lawn as a hydrologic connection between the downspout and lake. M.S. Thesis, College of Natural Resource, University of Wisconsin-Stevens Point. (available on 9/13/2023 at <https://minds.wisconsin.edu/bitstream/handle/1793/81198/Foster.pdf>)

Related Research

EVALUATION OF HYDROLOGIC BENEFITS OF INFILTRATION BASED URBAN STORM WATER MANAGEMENT¹ 2003

Jennifer K. Holman-Dodds, A. Allen Bradley, and Kenneth W. Potter²

Infiltration Through Disturbed Urban Soils and Compost-Amended Soil Effects on Runoff Quality and Quantity

By 1999
Robert D.
Bennett III
Birmingham, AL 35226

PHOSPHORUS RUNOFF FROM TURFGRASS - RESEARCH UPDATE

Carl Rosen, Brian Horgan, Andrew Holliman, Matt McNearney and Peter Bierman
Department of Soil
University of Minnesota

Effect of urban soil compaction on infiltration rate 2006

J.H. Gregory, M.B. Dukes, P.H. Jones, and G.L. Miller

THE ABILITY OF URBAN RESIDENTIAL LAWNS TO DISCONNECT IMPERVIOUS AREA FROM MUNICIPAL SEWER SYSTEMS¹ 2009

Gregory D. Mueller and Anita M. Thompson²

Urban Residential Surface and Subsurface Hydrology: Synergistic Effects of Low-Impact Features at the Parcel Scale

C. B. Venter¹ and S. P. Loheide II²

¹Department of Civil and Environmental Engineering, Unk

Field Monitoring of Downspout Disconnections to Reduce Runoff Volume and Improve Water Quality along the North Carolina Coast 2019

Enikou J. Tagatz, B.M.A.S.C.E.¹, Erin S. Casey², and William F. Hunt III, Ph.D., P.E., D.WPE, M.A.S.C.E.³

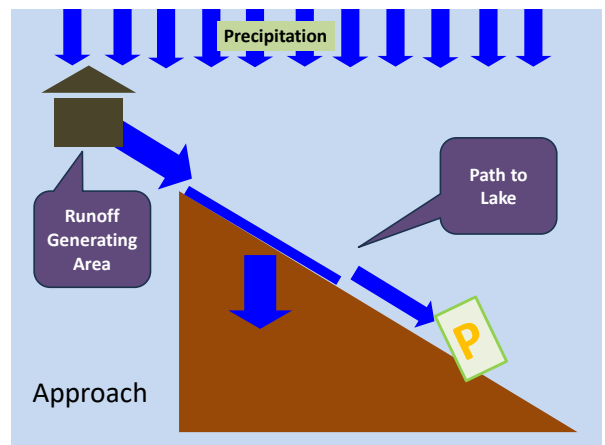
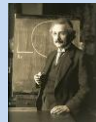
Enhancement and Application of the Minnesota Dry Swale Calculator

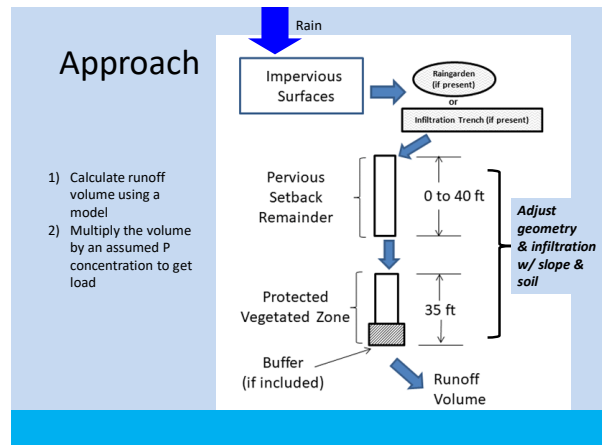
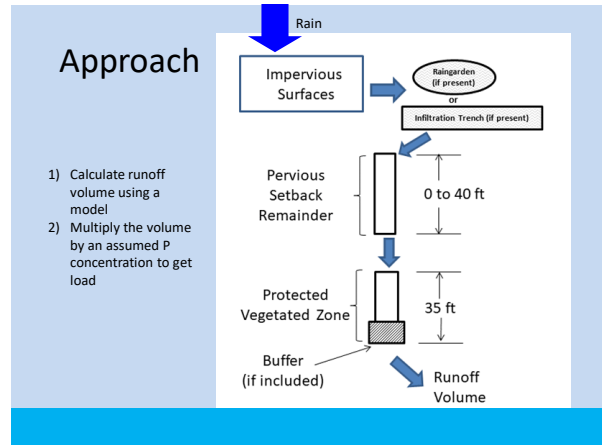
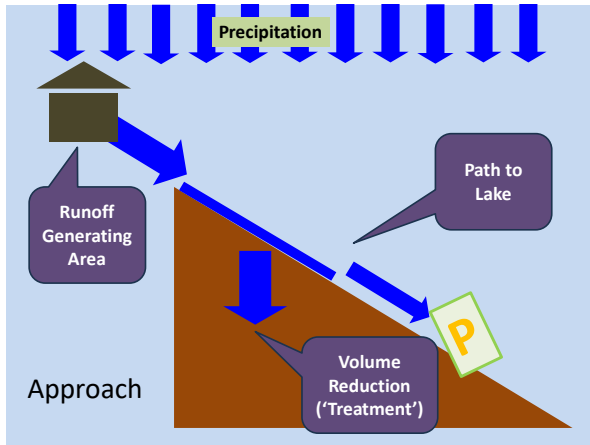
John S. Gulliver, Principal Investigator
Department of Civil, Environmental and Geo-Engineering
University of Minnesota

Model Development

"Everything should be made as simple as possible, but no simpler"
A. Einstein

"All models are wrong but some are useful"
G. Box



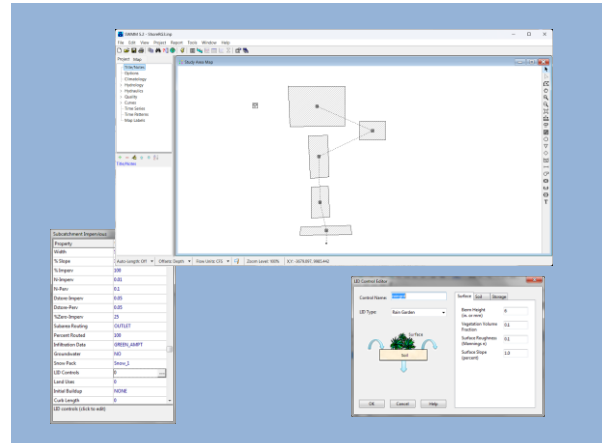


US EPA Storm Water Management Model (SWMM)



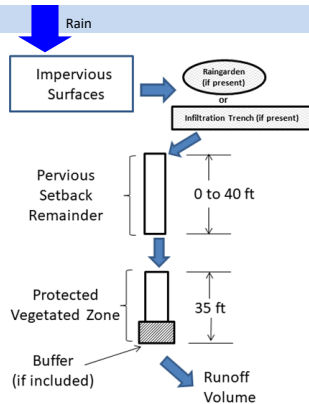
Release	Details
5.0.0.0	SWMM 5.0.0.0 Manual (SWMM 5.0.0.0 Manual)
5.0.0.0	SWMM 5.0.0.0 Manual (SWMM 5.0.0.0 Manual)
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- Continuous simulation model
- Flexible, open-source model
- Adapted Wisconsin's hourly rainfall files
- Can be automated with python packages



Approach

- 1) Calculate runoff volume using a model
- 2) Multiply the volume by an assumed P concentration to get load
- 3) Run base-case models 1000s of the times and summarize the results



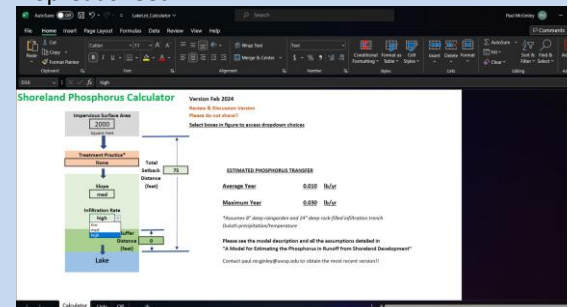
Model Application

email me at paul.mcginley at uwsp.edu

or

<https://pmcgwater.github.io/shorephos.html>

• Spreadsheet



The Spreadsheet: *Behind the scenes*

Related Resources

- Report
– 12 page overview

A Model for Estimating the Phosphorus in Runoff from Shoreland Development

- Appendices

APPENDICES

- A. Model Solution Tables for Base Simulation
- B. Model Parameters for Base Simulation
- C. Model Files Available
- D. Preliminary Regional Comparison
- E. Quick-Start Guide to SWMM
- F. Python Code for Repeated Simulations
- G. Experimental Evaluation of SWMM Pervious Runoff Simulation

Table R 1.1.2

RAIN GARDEN

Infiltration Rate	Infiltration Depth (mm)	Infiltration Area (mm)	Rain Garden Depth (mm)		Infiltration Rate	Infiltration Depth (mm)	Infiltration Area (mm)
			10 mm	15 mm			
100	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200
300	300	300	300	300	300	300	300
400	400	400	400	400	400	400	400
500	500	500	500	500	500	500	500

Related Resources

- SWMM Input Files



Input File. SWMM uses an input file with a suffix ".inp" that contains the information about impervious surfaces, runoff pathways, rainfall, and temperature files.

The SWMM input file "Shoreland.inp" is printed below and the view from the SWMM GUI is shown on the right. This input file describes an impervious area directed to a rain garden followed by a runoff control pathway with a buffer adjacent to the lake. The model layout was used for the rain garden tables in the report. Users can also read this into SWMM and adjust the sizes of the areas and soil properties. Note that the file names shown below can be changed by the user to other locations.

Rainfall Files. The shoreland impact and mitigation model was developed using hourly rainfall. A set of rainfall files was created from previously developed precipitation files provided by the Wisconsin DNR for shoreland runoff modeling (<https://www.wisconsin.gov/topic/Environment/landuse/landuse.htm>).

The rainfall files provide hourly rainfall from January 1, 1960 to December 31, 1995. They were converted to the SWMM file format from the format supplied in the SWMM download (PR format).

The files are:
D:\sho\PR\Rain (Shoat)
D:\sho\PR\Rain (Shoat)
D:\sho\PR\Rain (Shoat)

Related Resources

<https://pmcgwater.github.io/shorephos.html>

- Webpage

Fresh Water Research | **Model** | **Lake Eutrophication** | **Shoreland P Model** | **Septic Systems** | **Water Chemistry**

Model Inputs
Some Background
For Much More Information

Phosphorus, Lakes and Shoreland Development

Runoff containing natural organic material, lawn fertilizers, and soil particles can increase the growth of algae and aquatic plants by transferring phosphorus from nearby land to the water. The EPA SWMM Model and Wisconsin DNR's shoreland phosphorus model were adapted to create a model to estimate how much phosphorus might reach a lake if no efforts are made to slow runoff, and how a rain garden or infiltration area can help prevent runoff and phosphorus transfer to the lake.

This shoreland phosphorus model and the tables below continue to be refined. For more information, contact paul.mcginnis@wisc.edu.

Model Results
(Pounds P/Year)

Add Buffer | Add Rain Garden | Add Infiltration

Show 10 entries

Assumes no rain garden or infiltration trench. Select other options in forms below column labels

Impervious	Slope	Setback	Infiltrate	BufferDepth	Phosphorus
All	All	All	All	All	All
1000 sq ft	Low	75 ft	High	0 ft	0
1000 sq ft	Med	75 ft	High	0 ft	0.002

Shoreland Phosphorus Calculator

Version Feb
Review & Disc
Please do not
Select boxes i

Impervious Surface Area
2000
Square Feet

Treatment Practice*
None

Slope
med

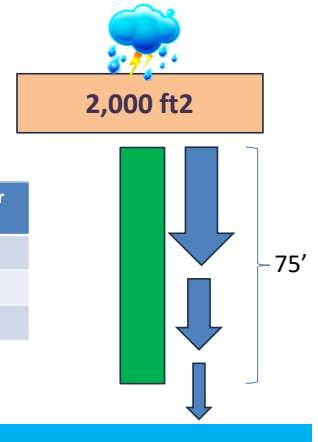
Infiltration Rate
high
low
med
high

Buffer Distance (feet)
0

Total Setback Distance (feet)
75

Lake

Infiltration Rate	P lb/year
High	0.010
Medium	0.063
Low	0.116



Add Raingarden

Shoreland Phosphorus Calculator

Impervious Surface Area
2000
Square Feet

Treatment Practice*
200 ft² Raingarden
150 ft² Raingarden
100 ft² Raingarden
50 ft² Raingarden
12.5 ft² Infi Trench
25 ft² Infi Trench
50 ft² Infi Trench
100 ft² Infi Trench

Infiltration Rate
low

Buffer Distance (feet)
0

Total Setback Distance (feet)
75

Lake

75'

Add Raingarden

Infiltration Rate	P lb/year	% Reduction
High	0.004	60%
Medium	0.018	71%
Low	0.057	51%

2,000 ft²

200 ft²

75'

Close /Summary /Discussion Ideas

- **Focusing on runoff generating areas**
 - Impervious surfaces
 - Other areas?
- **Not a 'worst case' model**
 - Assuming little sediment movement
 - Using an average annual (not highest year)
- **Goal should be zero**

Close /Summary /Discussion Ideas

- **What's next?**
 - Continuing to seek comments
 - Could revise with new information and better user guidance
 - Research ideas
 - Runoff from disturbed pervious areas
 - Saturation excess runoff
 - Site monitoring methods

Close /Summary /Discussion Ideas

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Thank you!

comments & questions:
paul.mcginley@uwsp.edu