Stormwater Management

for Lakeshore and "Near" Lakeshore Homeowners

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Historically, stormwater management has focused on "end-of-the-pipe" structures like nutrient detention ponds, infiltration basins, wetland treatment systems, etc. Although construction of stormwater BMPs, has been ongoing for many years, documented water quality improvements resulting from this construction activity are rare, possibly because these BMPs have a phosphorus removal efficiency of 50% or less (Osgood 1999). Successful water quality management will, therefore, require additional nutrient loading reductions. This article will address practices that can be implemented by individual homeowners to reduce nutrient loading to lakes through on-lot source reduction.

Although this article focuses mainly on lakeshore homeowners, I would argue that the stormwater conveyance systems installed, along with urban developments, have made everyone in a drainage area a lakeshore homeowner, at least in terms of the impact of residential lot runoff on adjacent lakes and streams. Water flowing off of a typical urban lot, for instance, flows to the street and then almost immediately into a storm sewer pipe, in which it is conveyed to a waterbody with very little attenuation of the pollutant load, regardless of how long the pipe is. It makes little difference to pollutant loading if properties are adjacent to the shoreline, or if they are located a few blocks or even a few miles from the lake. Thus, "near" lakeshore homeowners have as great of an impact on lakes as do true lakeshore homeowners.

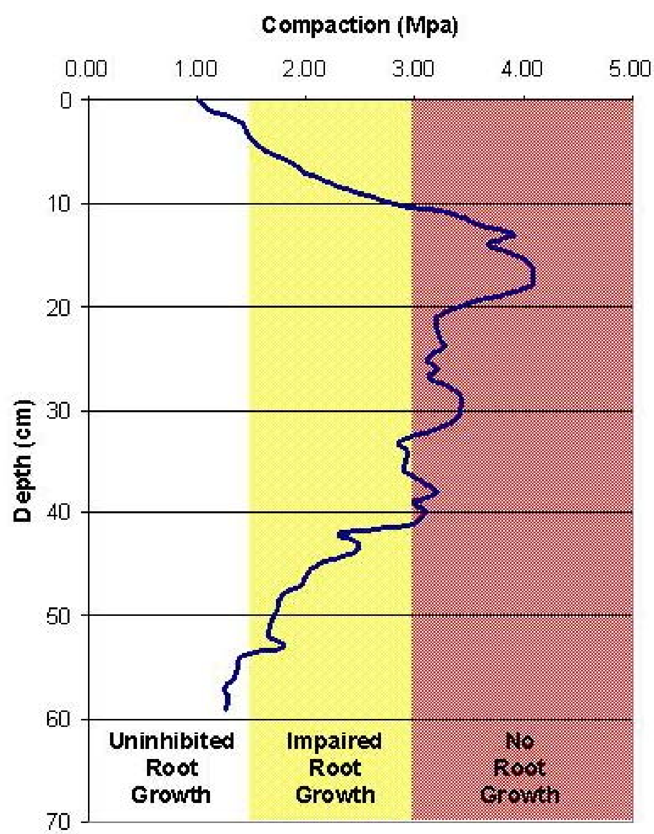
Runoff Quantity

Runoff from residential lots comes from two sources, impervious areas (roofs, driveways, streets), and pervious surfaces, typically lawns, and both of these surfaces contribute pollutants to the runoff stream. There are many actions that individual homeowners can take that collectively will reduce the quantity and improve the quality of stormwater runoff from residential lots. Because very little can be done about the quantity or quality of runoff from impervious surfaces, the focus of residential homeowner stormwater management needs to be on pervious surfaces, mainly lawns.

A large part of the runoff quantity problem results from the way most turf areas are established. During the residential development process, heavy equipment is repeatedly driven over the land surface as hills are cut down to create depressions and depressions are filled in to create hills (why do they do that?). Following site grading, individual building foundations are dug and the excavated material piled on the surrounding soil. Then, the concrete truck, the rafter delivery truck, the drywall delivery truck, the roofing material delivery truck, the plumber, the electrician, and the carpenter all drive around the structure, each in a different place, effectively compacting the entire lot to the hardness of asphalt. After construction, the ground is leveled, a few inches of black dirt spread over the site, and the lawn area is covered with seed or sod. Cone penetrometer readings obtained from lawns established in this manner in Plymouth and Maple Grove, Minnesota in 2002, show significant compaction of the upper soil layers (Figure 1). (Note: although I frequently refer to the ground under urban lawns as "soil," this is actually a misnomer. Following the home construction process, the ground under suburban lawns bears virtually no resemblance to a true soil.)

Not surprisingly, the infiltration rate of these compacted soils is significantly

Figure 1. Soil compaction levels (in micro-Pascal) in suburban Minnesota lawns, 2003.



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reduced relative to typical native soils. Pitt et al. (1999), found that the infiltration rate averaged 13 inches/hour and 1.4 inches/hour, respectively, for non-compacted and compacted sandy soils. For dry clayey soils, the infiltration rate averaged 9.8 inches/hour and 0.2 inches/hour, respectively, for non-compacted and compacted soils.

Reducing soil compaction on residential lots, therefore, needs to be a first step in stormwater management for individual homeowners. Fortunately, numerous tools exist to accomplish this. Prior to establishing a new lawn, or when reseeding an established lawn, the underlying compacted soil needs to be ripped with a subsoiler, and then tilled to a depth of 18 inches with a rototiller or a spading machine. Spading machines are preferable, because the motion of the spades prevents development of a hard pan at the bottom of the tilled soil. In addition, spading machines do a superior job of mixing compost into the soil to improve tilth and structure. Not only will this increase the infiltration rate, it will also result in better growing conditions for the grass and other plants. Municipal ordinances requiring tilling of lawns will probably need to be adopted to reduce soil compaction on a watershed scale, so NALMS members need to attend City Council meetings and advocate for this BMP.

Soils under established lawns can be loosened with core aerators, spike aerators or better, with an aero-vator machine that actually vibrates the soil, causing soil clumps to fracture. Three Rivers Park District has been using this piece of equipment for a number of years with excellent results. Soil aerators can be rented at many garden supply stores. Operation of these machines can be difficult in severely compacted soils, but becomes progressively easier as the soil loosens. All lawns need to be aerated annually to maximize rainfall infiltration.

Turf Management

Increasing the organic matter of lawns will also help increase the infiltration rate and moisture holding capacity of the soil. The previously described construction process frequently eliminates soil organic matter. Samples from 181 lawns in Minnesota suburbs in 1997 showed that 26 of 42 lawns had low organic matter (less than 2% as determined by the University of Minnesota soils testing laboratory), and the remainder had only medium levels (less than 3.5%). At a minimum, soils should have 5% organic matter. Mulching leaves and grass clippings on lawns with a mower or adding compost to lawns will increase soil organic matter. Turf management professionals call adding compost “top dressing,” and it is routinely done on golf coursees.

Raising the cut height of lawn mowers is also an easy, painless way to improve infiltration (and also improve turf quality). Turf grass rooting depth is generally proportional to the above ground height of the plant. Thus, raising the cut height will increase the rooting depth, enhancing both infiltration and the moisture-holding capacity of the soil. Many horticulturists recommend cutting grass at a height of two to three inches to provide good quality turf. Added benefits of longer grass and deeper roots are increased drought resistance and reduced weed seed germination.

Alternative Landscaping

Well-managed and maintained turf grass has been shown to be fairly efficient at infiltrating rainfall (Barten 1995). However, turf grass has very shallow root systems (two to three inches deep) and, therefore, has a limited potential to infiltrate water. Conversely, native plants have rooting depths of two to three feet, and have greater capacity to infiltrate water. *Replacing turf with shrub beds, gardens, and flowerbeds*, will increase rainwater infiltration. In particular, planting native grasses, shrubs, or other plants along curbs will capture and infiltrate runoff water before it reaches the street and the storm sewer system. Establishing alternative plantings along curbs is similar to establishing shoreline buffer zones along lakes and wetlands.

A specific type of alternative landscape planting that has become very popular in Minnesota is the construction of *rain gardens*. Rain gardens are small depressions in lawns that capture runoff from roofs and driveways and significantly reduce the quantity of stormwater leaving residential lots. A network of rain gardens installed in a 14-lot neighborhood in Bloomington, Minnesota reduced stormwater runoff by over 90% from a 0.75-inch rainfall (Barr Engineering 2004). Installation of rain gardens in a yard in Madison, Wisconsin, almost eliminated the discharge of runoff from a house roof (Roger Bannerman, Pers. Comm.). Rain gardens are planted with a variety of native species to both infiltrate roof runoff and provide an aesthetic amenity to homes.

Even if rain gardens are not desired, rooftop runoff quantity reaching streets can be reduced by *disconnecting downspouts from impervious surfaces*, and conveying runoff as sheetflow across turf or native plant beds. This can easily be accomplished simply by relocating roof gutter downspouts away from driveways and sidewalks.

Runoff Quality

Regardless of how much on-site infiltration can be improved, some runoff water from residential lots will reach the street and the stormwater conveyance system, or flow directly into lakes from adjacent homes. The quality of this runoff water can be improved by individual homeowners.

Establishing *shoreline buffers* along lakes and streams will improve runoff water quality. The natural vegetation in shoreline buffers act to slow down runoff water, allowing it to infiltrate into the soil and for pollutants to be removed through deposition or plant uptake. Buffers can be formal and planted with native species to enhance the aesthetics of a residence, or established by simply allowing existing vegetation to grow unimpeded. Many communities in Minnesota require natural vegetation buffers around wetlands, lakes, ponds, and along streams. Buffer widths vary from 25 to 50 feet depending on the nature of the adjacent water body.

As discussed above, the shoreline buffer concept can be expanded to include curbside areas. Runoff from driveways, lawns, and rooftops enters streets along curbs, where it is collected by the storm water conveyance system.

Establishing a natural vegetation buffer along curbs will reduce the quantity of stormwater reaching the street, and also improve the quality of water collected by the storm water conveyance system.

Many homeowners carelessly blow *grass clippings* into the streets while mowing their lawn. A visual survey of six neighborhoods in Plymouth and Maple Grove, Minnesota in 2003 found that almost 50% of homeowners had some clippings in the streets adjacent to their lots. Fortunately, the quantity of clippings collected from the streets was small (approximately 416 g/Ha of residential development). Nevertheless, elimination of these grass clippings from the stormwater stream could remove an estimated 0.04 g/Ha of phosphorus by simply sweeping the clipping off the street after mowing.

Fall leaf drop can add significant quantities of phosphorus to the stormwater stream. A mature tree can produce from 15 to 25 kg of organic leaf litter containing significant amounts of nutrients each year (Novotny et. al. 1985). Removal of leaves from streets is relatively easy and cheap if done by individual homeowners. The leaves can simply be raked from the street onto lawns and then mulched or bagged (this is really easy if teenagers are living in the household). Leaves can be disposed of by mulching directly onto lawns, composting on-site in a homemade compost facility, or at a municipal compost site. Personal experience shows that six to eight inches of leaves can be mulched into a lawn in the fall with a mower, and be completely decomposed by spring, even during a cold Minnesota winter. Leaves should *never* be blown or raked directly into a lake from a shoreland property.

Phosphorus Free Fertilizer

Phosphorus in runoff water can be reduced by eliminating the use of phosphorus fertilizer on lawns without compromising turf quality. Soil tests done on lawns in the Twin Cities Metropolitan Area of Minneapolis and St. Paul, Minnesota (TCMA) found that approximately 75% of lawns had high to very high phosphorus concentrations and additions of phosphorus fertilizer did not improve turf growth (Figure 2). High soil phosphorus levels are not unique to Minnesota. Approximately 90 percent of soil tests collected from 15 northern tier states by Cenex/Land-O-Lakes, Inc. had high to excessive (their rating) levels of phosphorus (Al Czapski, Pers. Comm.).

Despite high natural fertility, homeowners in the TCMA apply approximately six million pounds of phosphorus fertilizer annually to lawns (Creason and Runge 1992). When phosphorus fertilizer is applied to lawns with high phosphorus concentrations, some of the phosphorus is carried into adjacent lakes and streams with runoff water. Runoff collected from fertilized lawns with very high (VH) phosphorus levels had significantly higher phosphorus concentrations than runoff from unfertilized medium (M) and high (H) fertility lawns (Figure 3, from Barten and Jahnke 1997). Similar results were found in runoff from Lauderdale Lakes, WI shoreline lawns (Garn 2002).

In response to these concerns, a number of municipalities adopted ordinances that prohibited the application of phosphorus fertilizer to lawns unless a soil test indicted a need for this nutrient. In 2003, the state of Minnesota adopted legislation prohibiting the application of phosphorus fertilizer to lawns in the seven county TCMA, unless a soil test indicated a need for it. In 2004, the legislation was expanded to include the entire state. Preliminary data from a four-year monitoring program comparing phosphorus export from municipalities with and without fertilizer ordinances indicate that reducing phosphorus fertilizer applications could reduce phosphorus export by approximately 20%. No decrease in turf quality was observed in lawns not receiving annual phosphorus applications.

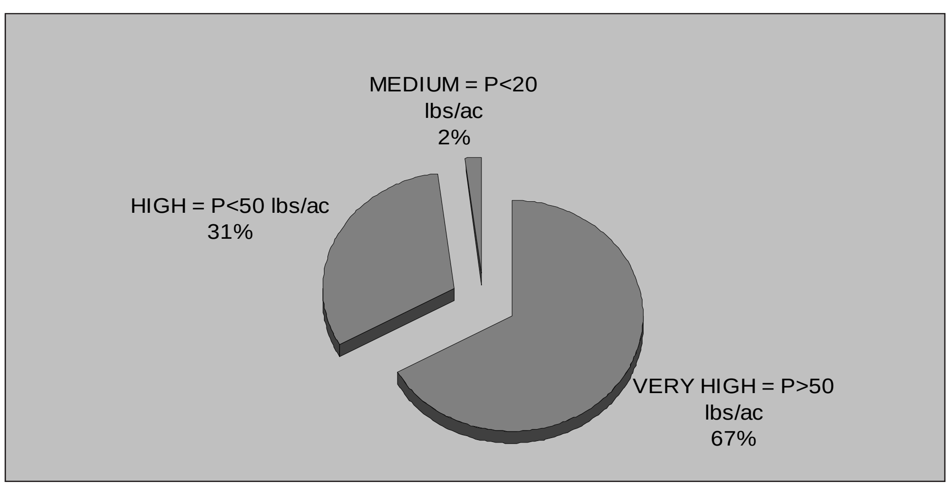
Summary

Stormwater management by individual homeowners has the potential to significantly reduce the quantity and improve the quality of runoff water entering lakes and streams. By definition, non-point source nutrient loading (which is the main threat to our lakes and streams) is a result of many individuals each contributing a small amount of pollution. A part of the solution, therefore, is to have each individual homeowner reduce the nutrient export from his/her lot.

Source reduction by individual homeowners can play a significant role in reducing nutrient loading from residential areas to improve the quality of lakes. Parkers Lake, Plymouth, Minnesota, for example, saw a significant reduction in phosphorus concentrations that coincided with the adoption of the fertilizer ordinance in 1995 (Figure 4).

Economically, source reduction is significantly less costly than engineered stormwater treatment structures such as nutrient detention basins or alum injection systems. The cost factor was one of the main drivers behind the decision of a citizen's advisory group in Plymouth, Minnesota (the Medicine

Figure 2. Soil Fertility Levels in 181 Suburban Minnesota Lawns, 1994.



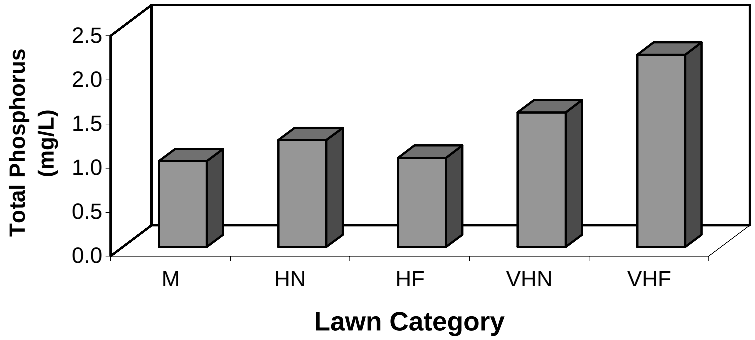


Figure 3. Mean total phosphorus concentration in runoff from lawns with medium fertility fertilized with phosphorus (M), high fertility lawns fertilized (HF) and non-fertilized (HN), and very high gertility lawns fertilized (VHF) and non-fertilized (VHN).

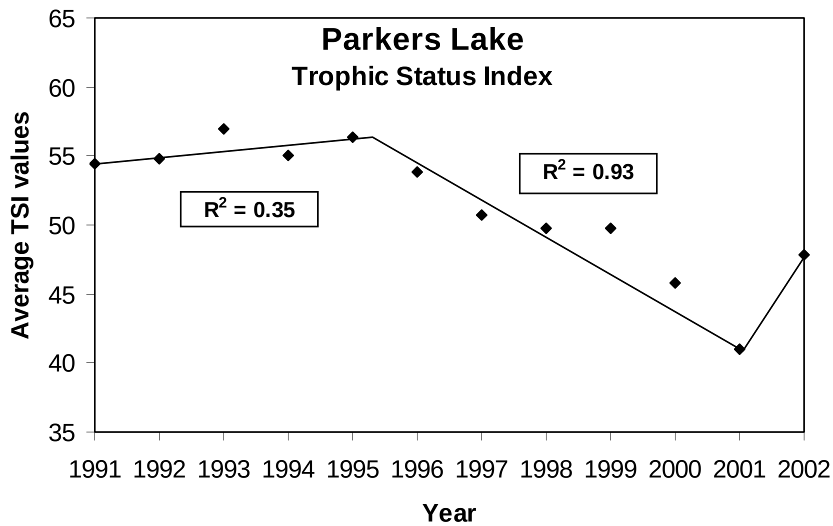


Figure 4. Parkers Lake, Minnesota, mean TSI values 1991–2002.

Lake Advisory Committee) to attempt to improve Medicine Lake quality through installation of rain gardens, shoreline buffers, street sweeping and adoption of a phosphorus fertilizer ordinance. Although no definitive conclusions can be drawn at this early stage of the project as to the effectiveness of individual lot source reductions, homeowner support for changing their management practices is very high. The City of Plymouth has a waiting list of homeowners requesting assistance with installing rain gardens and shoreline buffers. The experiences in Plymouth suggest that the potential of individual homeowners to improve runoff water quality is high and bodes well for the health of our lake resources.

Literature Cited

Barr Engineering Company. 2004. Burnesville Rainwater Gardens. *Land and Water Conservation.* September/October 2004. Pp 47-51.

Barten, J.M. 1995. Quantity and Quality of Runoff from Four Golf Courses in the Twin Cities Metropolitan Area. Report to the Legislative Commission on Minnesota Resources. 53 p.

Barten, J.M. and E. Jahnke. 1997. Suburban Lawn Runoff Water Quality in the Twin Cities Metropolitan Area, 1996 and 1997: Suburban Hennepin Regional Park District, Water Quality Management Report, Maple Plain, MN., 17 p.

Creason, J.R. and C.F. Runge. 1992. Use of lawn chemicals in the Twin Cities. Public Report Series #7. Water Resources Research Center, University of Minnesota. 21pp.

Garn, H.S. 2002. Effects of Lawn Fertilizer on Nutrient Content of Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin. U.S. Geologic Survey Water-Resources Investigations Report 02-4130. 6 p.

Novotny, V., H-M. Sung, R. Bannerman, and K. Baum. 1985. Estimating Nonpoint Pollution from Small Urban Watersheds. *Journal of the Water Pollution Control Federation*. 57: 339-348.

Osgood, R.A. 1999. The Phosphorus Paradigm: Or if I had a hammer…. *LakeLine*. 22: 52-54.

Pitt, R., B. Robertson, P. Barron, A. Ayyoubi, and S. Clark. 1999. *Stormwater Treatment at Critical Areas: The Multi-Chambered Treatment Train(MCTT).* EPA Report No. EPA/600/R-99/017. U.S. Environmental Protection Agency, National Risk Management Laboratory, Cincinnati, OH. 505 pages.

*For the past 15 years, **John Barten** has been employed as the water resources manager for Three Rivers Park District, where he works with municipalities and WMO's to mitigate the impacts of development on the quality of lakes in the Park system. He is esponsible for the management of 20 lakes, nine swimming beaches, and 56 water supply wells. John is involved in research on the quality of runoff water from lawns and golf courses and has been a member of NALMS since 1980.*