

Using GIS and Predictive Modeling for Analysis of Shoreline Development

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Background
Shawano Lake is the 4th largest water body in Wisconsin which has a surface area of 6178 acres located within a 62 square mile watershed. The shoreline of Shawano Lake is almost completely developed as high density residential housing (Figure 1). As the shoreline development of Shawano Lake continues further from the lake, impacts associated with development will increase. The amount of runoff draining to Shawano lake is directly linked to landuse, amount of impervious surfaces, and how connected the impervious surfaces are to the lake. The proximity of the impervious surfaces will determine the of impact on the lake. As the impervious surfaces get closer and are more connected to the lakeshore, runoff has less time to slowdown and percolate into the soil (Figure 2).
Native vegetated buffers, rain gardens, and retention ponds slow the rate of runoff which allows the sediment to settle out onto the buffer area. The majority of sediments, nutrients, and other pollutants are taken out of the water before they reach the lake or stream.

Abstract:
The first step toward making effective management decisions is quantifying the phosphorus contribution from the identified problem areas. GIS, the Source Loading and Management Model (WinSLAMM), an urban model, and other models were used to evaluate runoff and inputs of nutrients. WinSLAMM is a tool to evaluate compliance to Wisconsin's runoff management plan (NR151). Present shoreline conditions were evaluated along with other scenarios including the use of vegetative buffers and low impact development (Figure 3).
This analysis is an early step in our exploration of the percent connection of impervious surfaces within the lakeshore zone. An understanding of how the amount of runoff and nutrient loading from impervious surfaces changes as a result of implementing management options will enable an increased accuracy in predicting annual runoff and nutrient export to the lake. This can be used to guide decisions in lake management.

Objectives

- Determine percent impervious cover of Shawano Lake shoreline
- Quantify runoff and nutrient loading at present percent imperviousness
- Evaluate changes in runoff and nutrient loading between conventional and low impact development

Figure 1. Development of Shawano Lake Shoreline and Present % Imperviousness

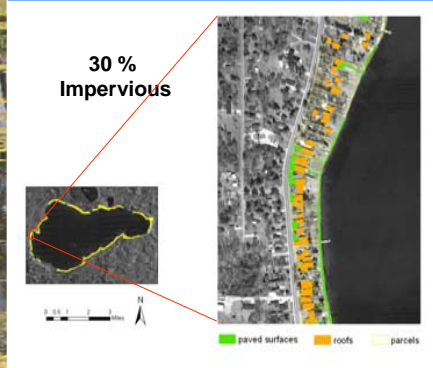
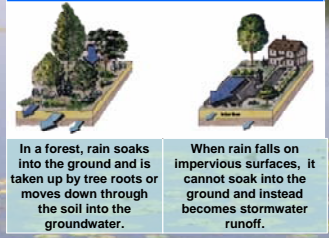


Figure 2. More Impervious Surfaces = More runoff



Methods
Delineation of the Shawano Lake shoreline was accomplished by using a GIS program, ArcMap. Any impervious cover within 100 meters of the shoreline was digitized. Three layers were created for streets, homes, and driveways / sidewalks. A Shawano County landuse coverage was used to calculate the acreage of landscaped, undeveloped, and cropland for use in WinSLAMM, along with acres of impervious cover. WinSLAMM uses these values and precipitation data, runoff coefficients, particulate size, and concentrations to model the impacts of urban development. Variables included the degree of connection between impervious surfaces and Shawano Lake, and the addition of runoff retention or drainage structures. Runoff, calculated by WinSLAMM, was used to calculate phosphorus loading. Other methods of calculating phosphorus loading were compared against the WinSLAMM method. Phosphorus loading and runoff were calculated using The Simple Method (TSM), which uses empirical runoff and phosphorus coefficients specific to land cover. The Phosphorus Export Coefficient Method (P_e) uses empirical phosphorus coefficients to predict phosphorus loading.

Figure 3. Conventional vs. Low impact



Results & Discussion
WinSLAMM, TSM, and P_e all produced different phosphorus loading quantities (Figure 4). WinSLAMM's calculated phosphorus loading and runoff exhibit a linear relationship. For each incremental increase in disconnection, phosphorus loading decreases by 3.7 lbs per year (Figure 5). The Simple Method estimated a relatively large phosphorus load. When comparing WinSLAMM to TSM, the loading calculated by TSM was larger than the WinSLAMM loading at 100% disconnection. TSM appears to assume 100% connection in the calculation; any precipitation that falls on the impervious surface will be transported directly to Shawano Lake. When comparing WinSLAMM to P_e, phosphorus loading was approximately equivalent to 35% disconnection in WinSLAMM.
These comparisons are made assuming WinSLAMM accurately calculates runoff and phosphorus loading. This assumption is highly questionable based on the extreme runoff reduction at 100% disconnection, and variability in results from the three methods. The questionable accountability of WinSLAMM raises concern of its use as a management tool in NR151. This study has prompted additional research into the impacts of impervious surfaces and connection of those impervious surfaces to receiving waters.

Figure 4. WinSLAMM, The Simple Method, and Export Coefficient Method Phosphorus loading

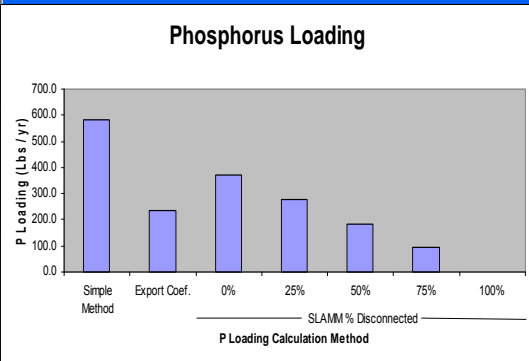
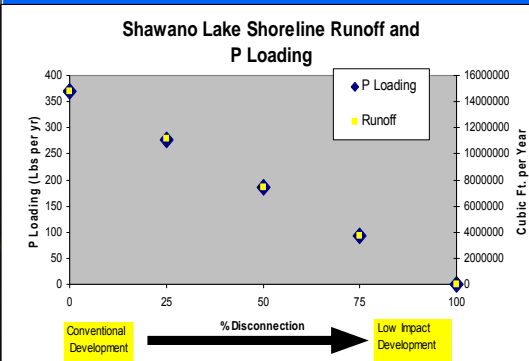


Figure 5. WinSLAMM Runoff and Phosphorus Loading



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