Friends of Lake Wingra

Promoting a healthy Lake Wingra
through an active watershed

Lake Wingra Watershed Management Plan – Storm Water
August 2003

Contents:

Friends of Lake Wingra – Storm Water Committee

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Watershed Management Plan - Storm Water
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Purpose of the Storm Water Management Plan

This plan is submitted in partial fulfillment of a Wisconsin Department of Natural Resources (DNR) Lake Management Planning Grant awarded to the Friends of Lake Wingra (FOLW). The plan is intended to address a critical need for widespread participation of citizen and partner groups in the development of a comprehensive, integrated plan for managing storm water throughout the Lake Wingra Watershed.

Over the last two years, FOLW has worked closely with the surrounding community to develop this plan for improving the ecological quality of the Lake Wingra Watershed. Storm water, because of its fundamental role in both terrestrial and aquatic ecosystems, is a primary component of the Watershed management plan. This document describes the importance of good storm water management practices, identifies existing critical management problems, and suggests short and long term solutions that can be implemented by the municipalities and residents of the Watershed. It is our hope, that after reading this storm water management plan, the need for action to correct and improve storm water management practices in the Lake Wingra Watershed will be obvious.

<u>Our Watershed Vision</u>

The Friends of the Lake Wingra value Lake Wingra and its surrounding uplands as a natural and community resource;

All who live, work and play in the Lake Wingra Watershed will understand the lake's ecology and are aware of how their actions affect the lake;

We will protect and restore the aquatic wetland, savanna and woodland communities of Lake Wingra;

We will effectively manage the storm water runoff and its associated pollutants in order to make Lake Wingra habitable for our native wildlife, and safe for fishing, swimming, and other recreation;

Watershed residents, businesses, interest groups, schools and government will collaborate to maintain this balanced ecosystem approach.

Friends of Lake Wingra - Storm Water Management Values

Storm water affects the topography, hydrology and ecology of the Lake Wingra Watershed, and the habitat and water quality of Lake Wingra itself. Historically, storm water has been managed exclusively in regards to erosion and flooding, with the preferred method being conveyance to the closest water body. Recent research, along with the historical record of continued degradation of the of Lake Wingra and its surrounding watershed, shows that this approach is not sustainable. FOLW strongly believes that trend can be reversed if Watershed residents, businesses and municipalities adopt the following storm water management values:

Ecosystem Health - Storm water management in the Watershed should promote a healthy watershed ecosystem by intentionally managing storm water with the purpose of enhancing the subsurface hydrology, terrestrial ecosystem, and Lake water quality.

Management at the Source - Infiltrating and treating rainfall runoff where it occurs has many advantages: it places responsibility in the hands of owners of land where runoff originates, the size and scope of source management and reduction options are more manageable and less costly, demands on down-gradient conveyance and treatment systems are reduced, and it fosters stewardship by municipalities businesses and residents.

Infiltrating Rainfall - Traditional methods of conveying rainfall directly to Lake Wingra have: depleted local groundwater, eliminating or and reducing spring flows; increased surface water temperature; carried nutrients, chlorides and sediments to the Lake; and facilitated the establishment of invasive species. Infiltrating rain where it falls, or as far upland as is feasible, is the preferred approach to managing storm water, and reversing ecosystem degradation .

Eliminating Erosion - Significant land-form degradation is being caused by storm water erosion at various sites throughout the Watershed. Together, the sediment and nutrients carried to Lake Wingra from these sites constitute the Watershed’s most serious threat to water quality. Immediate steps should be taken to eliminate erosion by reducing the volume and velocity of overland storm water flow, and to stabilize erosion sites with natural vegetation.

Collecting Nutrients and Sediments - Impermeable surfaces throughout the Watershed allow nutrients, sediments, chlorides and other pollutants to be carried directly to the Lake by storm water. Where possible, the flow of untreated storm water to the Lake should be eliminated. Improved management of impervious surfaces to collect leaves, litter and dirt before they are transported by storm water, is the preferred approach to accomplishing this. When necessary, storm water treatment using engineered systems may also be employed to achieve the maximum removal that is practical for nutrients, sediments, chlorides and other pollutants.

Understanding the Lake Wingra Watershed

The Lake Wingra Watershed has a total area of 5,000 acres (21 sq km) with about 75% of that area being urban. Although located in an urban setting with well-established residential and commercial development, almost all of the Lake Wingra shoreline is undeveloped, and 30% of the watershed area is green space, occupied by urban parks, golf courses, and the University of Wisconsin Arboretum. The Lake Wingra Watershed has been dramatically changed by urbanization. Dredging and filling associated with the construction of Vilas Park, Wingra Creek, and Arboretum Drive have permanently altered the size and level of the lake and surrounding wetlands.

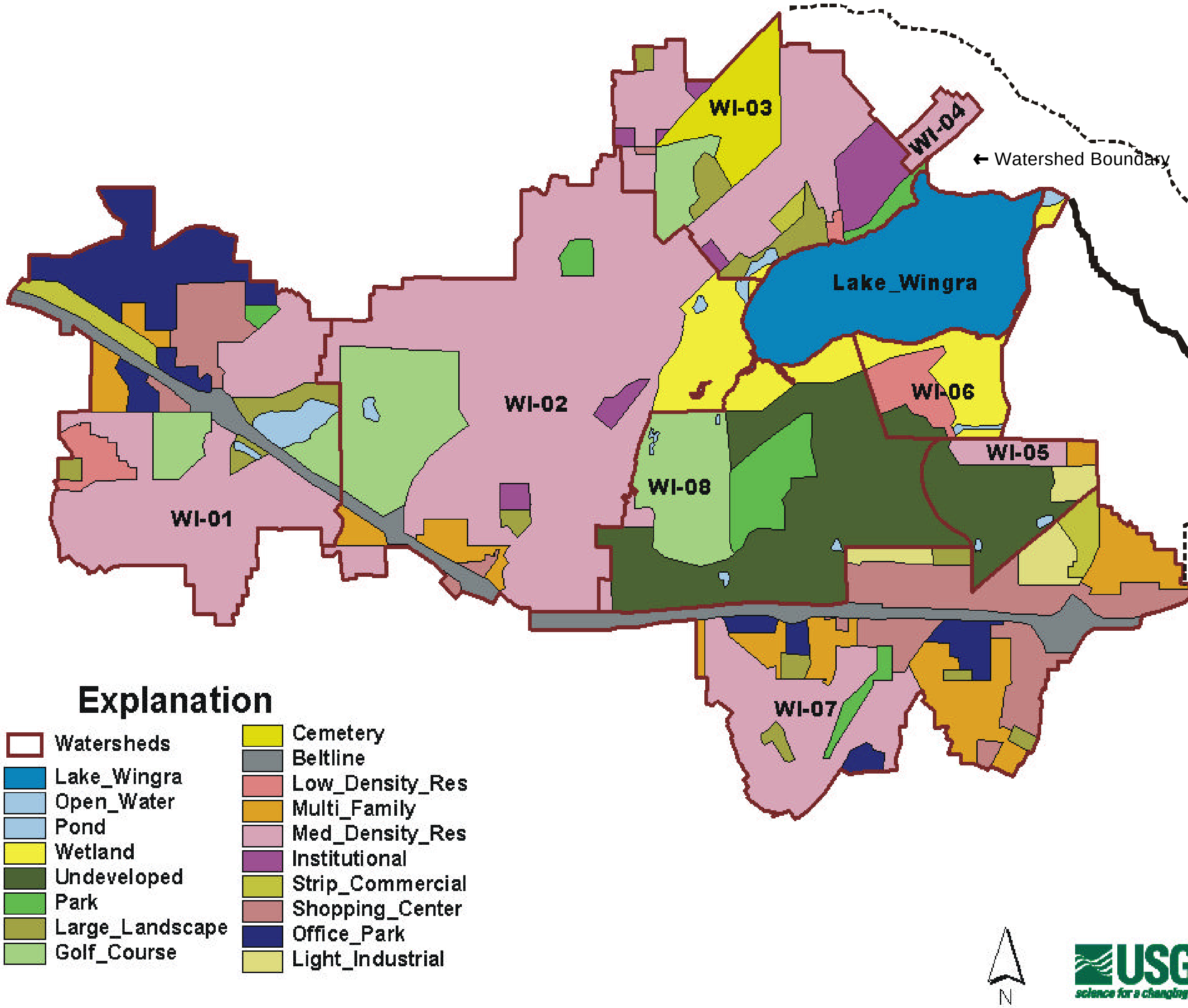
Pre-settlement Lake Wingra drained to Lake Monona through a meandering wetland flowage. The original boundary between the two watersheds was probably not precise (since the difference in elevation very small), and the direction of flow could reverse in response to varying hydrologic conditions. The United States Geological Survey has determined that the eastern boundary of the Wingra watershed is at Beld Street.

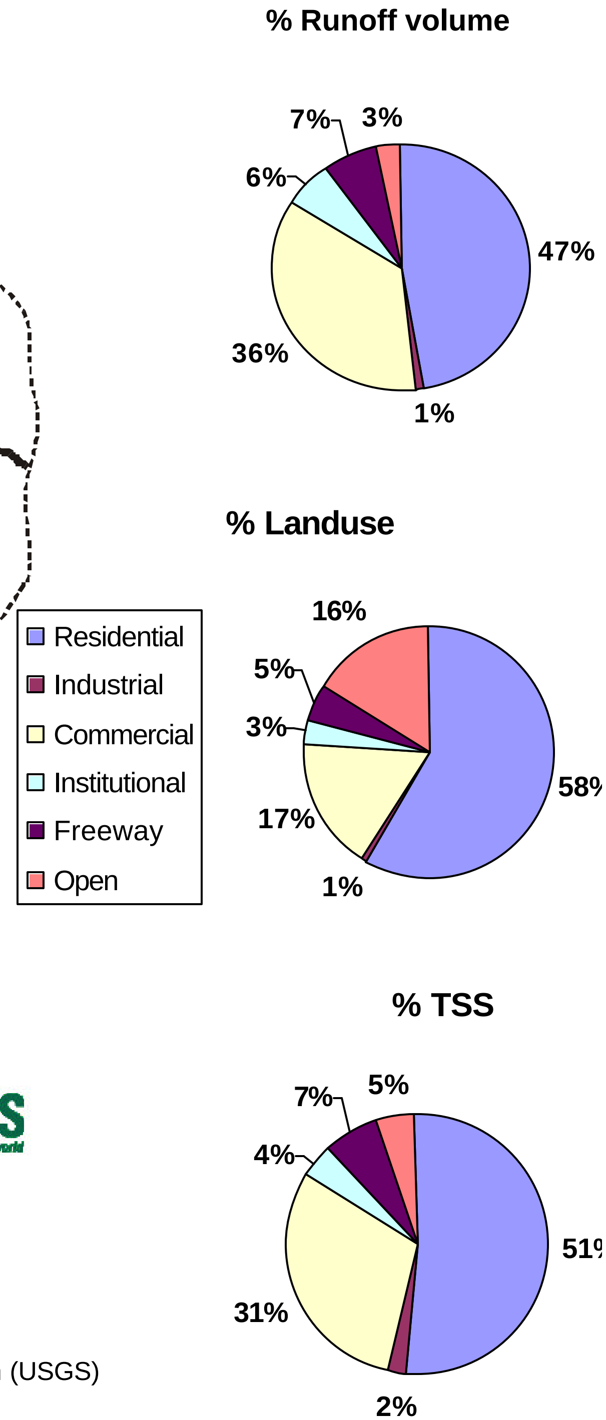
Today, Lake Wingra has a mean depth of 14 feet (4.3m), a maximum depth of 22 feet (6.7m), and an elevation of 848 feet (258.5m) . As a result of the construction of the spillway at the current outlet of Lake Wingra (near the south end of Orchard Street) and of Arboretum Drive (that serves as a levee separating Gardner Marsh from the lake), one-third of Wingra Watershed runoff now drains directly into Wingra Creek, rather than into the Lake. Pre-settlement and present characteristics of the lake and watershed are summarized in Table 1.

Characteristic	**Pre-Settlement** (estimates)	**Present**
Lake surface area	650 acres (2.6 sq km)	325 acres (1.3 sq km)
Watershed area	5140 acres (20.8 sq km)	4525 acres (18.3 sq km)
Wetland area	1500 acres (6 sq km)	210 acres (0.8 sq km)
% Permeable surface	100%	54%
Runoff volume	very low	110 million cu ft/year
Contribution of runoff to lake (% of total input)	8%	16%
Sediment loading	100 tons/year	500 tons/year
Phosphorus loading	300 lbs/year	3,300 lbs/year
Phosphorus concentration (Lake)	?	40 µg/liter
Chloride concentration (Lake)	<5 mg/liter	~75 mg/liter
Lake Trophic Status	?	~65 (eutrophic)

Table 1. Overview of the Lake Wingra Watershed[1]

[1] Pre-settlement watershed boundaries from USGS; present boundary from sewersheds of City of Madison Engineering; lake surface and wetland areas from Bauman et al 1974; estimates of runoff volume, phosphorus and sediment loading from Bannerman et al., 2003; see “Lake Wingra Water Quality Analysis” (Appendix) for sources of data on lake phosphorus concentration and trophic index; see “Road Salt and Lake Wingra Water Quality” (Appendix) for sources of chloride data.





The Lake Wingra Watershed at a Glance

Source: *Reducing Phosphorus and Sediment Inputs to Lake Wingra,* Roger Bannerman (WDNR), Judy Horwatich (USGS)

Lake Wingra Storm Water Management Problems

The water quality of Lake Wingra has been under study for several decades (see: *Lake Wingra Watershed: A New Management Approach*). Today, storm water runoff from the densely developed urban areas carries sediment and chemicals (e.g. nitrogen, phosphorus, chloride) into the lake. Specific concerns identified by the Yahara-Monona Priority Watershed Project include: excessive nutrient loading, increasing levels of chloride and heavy metals from storm water runoff, and bacterial levels that sometimes interfere with safe swimming.

Since settlement, the hydrology of Lake Wingra has also been extensively affected by urbanization, including: a shift from a hydrological system dominated by groundwater and spring flow inputs to one greatly impacted by storm water runoff, a 3-6 meter reduction in the upper groundwater aquifer, disappearance of at least 28 springs once feeding the lake, reduction in Lake Wingra surface area by about 50%, and reduction in wetlands to about 30% of their original extent.

While the Watershed hydrology and water quality cannot be restored completely to a "natural" state, FOLW believes that there is abundant opportunity to minimize the impact of urban development. Listed below are the primary problems that have been identified through our planning process.

Erosion -Today's storm water management practice of collecting and conveying rainfall directly to the Lake have drastically increased the volume and intensity of surface runoff flows around the Watershed. This has led to significant erosion of the landscape at Westmorland Park, Glenway/SW Bike Path, Manitou Way and Curtis Prairie, moving thousands of cubic yards of soil and nutrients to the lake.

Manitou Way Storm Sewer Outfall

Sedimentation - Sedimentation degrades habitat and water quality. Annual contributions to the Lake of suspended solids have increased by a factor of between 2 and 6 from pre-settlement estimates. Upland erosion carried into the Lake is a primary source of phosphorus. Sediments accumulating at storm water outfalls to Lake Wingra and Wingra Creek are beginning to restrict access by Lake users, and support invasive species.

Wingra Park Outfall Delta

Ground Water Depletion - One third of the 3,500 acre watershed is now impermeable to rain water infiltration, while one-half the Watershed is planted in turf-grass (lawns, parks and golf courses) which has low infiltration capacity. This reduction in ground water recharge has resulted in the loss of 28 springs that once replenished the Lake, leading to increased Lake water temperatures and dramatically changing aquatic habitat.

Council Springs Near Monroe Street

E. coli - Feces from pets, wildfowl, and Vilas Zoo have washed directly into Lake Wingra and Wingra Creek. Unsafe levels of E. coli have led to nine beach closings and health advisories since 1966. In July and August of 2003, Vilas Beach on Lake Wingra was closed for several weeks due to detection of E. coli 0157:H7, a strain of E. coli that can cause severe human illness

Nutrients - Annual contributions of nutrients to Lake Wingra have increased by a factor of between 5 and10 compared to pre-settlement estimates. Excess nutrients (especially phosphorus) contribute to lake eutrophication, and support invasive species. In addition to eroded soils, these nutrients come from leaf litter, lawn fertilization, and street runoff.

Non-Point Pollution

Degradation of Natural Areas- Urban storm water management practices have severely damaged the Watershed's unique natural areas, especially the UW-Arboretum. Previous attempts to control sediments have left the landscape blighted with storm water detention ponds and erosion channels. Nutrients, chlorides, sediments and invasive species that are transported by storm water continue to degrade natural areas throughout the Lake Wingra Watershed.

Erosional Sediment Accumulation

Road Salt - Before Madison began regular road salting in the 1950s, chloride levels in Lake Wingra were 5 mg/liter. In recent years, the average chloride level in Lake Wingra has been 75 mg/liter, or at least 15 times the original level, the highest concentrations of any Madison lake. Elevated NaCl in soils create osmotic imbalances in plants, inhibiting water absorption and seed germination, reducing root growth and root growth rates for grasses and wild flowers, and degrading native wetlands by favoring salt-tolerant plant species.

Road Salt and Sand Accumulation

Goals for Improving Storm Water Management

This storm water management plan sets specific goals for storm water management practices in the Lake Wingra Watershed. While all these goals are clearly achievable, most will take time and community involvement if they are to be implemented. However, when these goals have been met, we expect significant and sustainable improvements in the Lake Wingra Watershed ecosystem.

1) Limiting Surface Flows and Preventing Erosion

✓The existing storm water management infrastructure will be modified to minimize high storm water runoff volume and intensity, and to improve infiltration along the conveyance system. As a result;

✓ Erosion of the surrounding topography will be substantially eliminated, and erosion cuts will be repaired

2) Restoring Sub-Surface Hydrology Through Infiltration

✓ To the extent feasible, all residential properties in the Watershed will implement storm water infiltration of roof drain water.

✓ All new commercial and residential construction or re-construction will infiltrate storm water.

✓ Existing commercial and municipal facilities will be encouraged to retrofit to pre-treat and infiltrate storm water.

✓ Parks, golf courses, streets and other open spaces will be retrofitted to improve infiltration of storm water.

3) Reducing Sediment and Nutrient Transport to Lake Wingra

- ✓ Management practices and storm water treatment will be implemented to reduce the contribution of phosphorus, nitrogen, suspended solids and chlorides by at least 40%.
- ✓ Sediment accumulation at storm sewer outfalls to Lake Wingra and Wingra Creek will be removed to restore natural bottom contours.

4) Fostering Citizen Stewardship for Storm Water

- ✓ Neighborhood associations will endorse and participate in storm water management strategies.
- ✓ The City, County, Town and UW Arboretum will adopt the recommendations of the FOLW storm water management plan.
- ✓ Citizens will support allocation of public funds for improved storm water management.

Storm Water Management Techniques

The engineering of storm water management is in transition. Traditional methods of conveying untreated storm water directly to streams and lakes is being abandoned, in favor of new methods that reduce the negative environmental impacts of storm water. In addition to well established storm water retention ponds, these new approaches offer the possibility of helping to restore the surface ecosystem and subsurface hydrology of the Watershed, further minimizing the impact of urbanization.

Point of Origin Management - Treating runoff where it falls, rather than through collection to a pond or other structure has many advantages. Nutrients and solids retention, and storm water infiltration, are easiest when flows and volumes are minimal. Once water moves off-site and accumulates in a conveyance system, expensive infrastructure must be employed to achieve the same efficiencies.

Infiltration - Promoting the infiltration of rainfall accomplishes several things. At the point of origin, infiltration of the “first flush” from a storm event can prevent the majority of nutrients from entering the runoff conveyance system (and ultimately Lake Wingra). Infiltration can also reduce the volume of water that is conveyed to the Lake, and help to recharge the subsurface hydrology. Infiltration is easiest to implement at point of origin (e.g. residential rain gardens, good turf grass management, permeable parking lots), though in some case engineered infiltration basins are possible.

Storm Water Detention - Storm events commonly discharge high volumes of water over short periods of time. Uncontrolled, flows from these events lead to erosion (which carries nutrients directly to the Lake), and overwhelm the storm water conveyance infrastructure (leading to flooding). Designing the conveyance system to temporarily detain water in the uplands, and gradually release it over a number of hours, can eliminate the problems caused by these strong flows.

End-of-Pipe Treatment - While storm water retention ponds are a good example of end-of-pipe treatment, new technologies are becoming available for removing solids and nutrients from the storm water conveyance system. Carefully designed systems of absorbent materials and small settling basins can remove significant amounts of contaminants from low flows.

Watershed-Wide Management Recommendations
Fulfilling the vision of the FOLW storm water management plan will require many years of concerted effort by citizens, businesses and government. FOLW believes that building citizen stewardship is the only way to transform these planning efforts into sustainable action. The following watershed-wide recommendations will require education and organization to succeed. Our longer-term goals include:

Reducing or Eliminating Storm Water Problems at the Source - by promoting residential, commercial, and municipal rain gardens and other infiltration techniques; discouraging unnecessary application of lawn fertilizer, pesticide and road salt to reduce pollutant loading to the Lake; and implementing more effective leaf collection and street sweeping practices to collect solids before they enter the storm water conveyance system.

Mitigating the Impacts of Existing Storm Water Management Practice - by controlling storm water runoff flows to reduce volume and velocity; redesigning street drainage systems to promote curbside infiltration; and restoring the subsurface hydrology of the area with engineered upland storm water infiltration.

Treating Storm Water Before it Reaches the Lake - by maintaining and improving detention basins to ensure effective solids removal; redesigning storm water outfalls to reduce their impact upon Lake Wingra and Wingra Creek wildlife habitat; and adding storm water treatment technologies to the Watershed infrastructure as needed to remove residual solids, nutrients and other contaminants.

Key Steps to Implementing the Recommendations
Over the past year FOLW has worked to document sites of storm water related ecosystem degradation in the Watershed, and identify specific opportunities for improving storm water management. We have also prioritized management recommendations to guide their implementation over the next several years. We believe that our long-term vision for the Watershed will be met though the development of community stewardship. To meet our goal to "*effectively manage the storm water runoff and its associated pollutants in order to make Lake Wingra habitable for our native wildlife, and safe for fishing, swimming, and other recreation*", we see taking the following steps:

✓ Creating education and outreach programs that will educate stakeholders about FOLW recommendations, and encourage voluntary changes in behavior that do not require substantial financial investment (e.g. residential rain gardens, leaf and litter handling).

✓ Initiating demonstration projects at specific sites, for education, information and an immediate impact on water and habitat quality (e.g., street-scape or large-scale rain garden).

✓ Promoting watershed-wide practices that can result in significant reductions in nutrients, sediments, chloride, etc. For example, street sweeping, leaf collection, lawn care practices (including composting and use of pesticides and fertilizers), gutter disconnection and dispersed infiltration practices (including rain gardens).

✓ Promoting volunteerism to improve sites that have specific problems and/or opportunities, and where such changes will have significant positive impacts upon water and habitat quality (e.g., Odana ponds outflow; Manitou Way; runoff onto Curtis prairie).

✓ Encouraging continued research on effective approaches to increasing rainfall infiltration, and reducing inputs of solids and nutrients through street sweeping and leaf collection.

✓ Promoting coordination on storm water management issues between the Town of Madison, City of Madison, Dane County, University of Wisconsin and neighborhoods and businesses in the Watershed.

✓ Evaluating the effectiveness of citizen involvement in implementing specific storm water management recommendations, tracking changes in storm water management practices, and conducting ongoing monitoring of improvements in storm water quality.

Site - Specific Recommendations

The preceding sections identified the problems related to storm water management in the Lake Wingra Watershed, providing values and goals for improving the ecosystem. Following are specific sites that we assign high priority for immediate attention. Each year that these site-specific problems go unrepaired will result in significant and irreversible damage to both the Watershed and to Lake Wingra water quality.

Odana Ponds & Manitou Outfall - Significant erosion and habitat degradation in the West Wingra Marsh is caused by storm water flows originating in the far western Watershed. Use of Odana ponds for temporary detention of storm water flows can help to alleviate erosion causing peak flow volumes and velocity, and provide a more consistent flow of storm water from the Manitou outfall. FOLW recommends:

- ✓ Removing accumulated sediment from Odana Ponds to increase detention capacity.
- ✓ Controlling Odana Pod pool level to minimize outflow peak volume and velocity.
- ✓ Dispersing Manitou Way outfall effluent to eliminate channelization.
- ✓ Restoring the surface topography around the Manitou Way outfall.

South West Bike Path & Glenway Golf Course - Runoff from Westmorland Neighborhood, Glenway Golf Course and the northern Lake Wingra Watershed is conveyed along the SW Bike Path, severely eroding soils which are carried directly to the Lake. FOLW recommends:

- ✓ Promoting rainfall infiltration on up-gradient residential, commercial and municipal properties.
- ✓ Increasing permeability along up-gradient streets to reduce the volume of runoff conveyed to the Lake.
- ✓ Creating dry detention and infiltration capacity on Glenway Golf course to moderate flows and improve infiltration.
- ✓ Restoring native Oak Savannah in the Glenway woods to reduce erosion and promote infiltration.
- ✓ Installing check dams, rip-rap and native plantings to stabilize the existing erosional cut along the SW Bike Path.
- ✓ Creating a sedimentation basin above bike path culvert to prevent solids from entering the Lake.
- ✓ Removing storm water outfall sediment deltas in Ho-Nee-Um Pond and at Wingra Park.

Forest Hill Cemetery - Poor turf grass quality and road curbs have reduced infiltration capacity in this area, and promoted erosion. The resulting sediment is transported to the Lake at Wingra Park. FOLW recommends:

- ✓ Modifying or removing curbs to promote rainfall infiltration on adjoining turf.
- ✓ Managing cemetery turf grass to promote a healthy turf root system and increased infiltration.
- ✓ Stabilizing footpaths along SW Bike Path to stop erosion.

Vilas Park and Zoo - Storm water flows across the landscape are washing wildlife feces directly into the Lake and Creek. Shoreland erosion is being caused by the wild goose population and foot traffic. FOLW recommends:

- ✓ Restoring shoreline vegetation to create a runoff buffer, and to discourage geese.
- ✓ Experimenting with management/control strategies to reduce goose population.
- ✓ Managing wildlife feces to control runoff contamination.

UW-Arboretum - Maintenance and repair of storm water infrastructure in the Arboretum is needed to reduce habitat degradation and nutrient and sediment transport to the lake. The Arboretum Storm Water Committee is meeting to create a storm water management plan. FOLW recommends:

✓ Surrounding municipalities and landowners should coordinate with UW-Arboretum on the development and implementation of a storm water management plan.

Leyton Lane Check Dam

South Randall Ave. - Storm water runoff from upper Vilas Park is causing hillside erosion, and washing sediment into storm sewers and the Lake and Creek. FOLW recommends:

- ✓ Restoring natural vegetation on the hillside to hold soil and infiltrate water.
- ✓ Creating dry detention capacity in lower Vilas Parks to promote infiltration.

Westmorland Park - Up-gradient, impermeable surfaces create intense flows through the Park along Tokay Blvd., causing extensive erosion. This sediment contributes phosphorus to the runoff that is carried to the Marion Dunn detention pond, where it must be removed by dredging. FOLW recommends:

- ✓ Increasing up-gradient permeability on commercial, residential and city properties to promote infiltration.
- ✓ Installing check dams in the existing watercourse to moderate flow velocity.
- ✓ Installing a sill around the existing storm drain to encourage sediment removal and infiltration.
- ✓ Re-grading Westmorland Park above the conveyance channel to promote infiltration of surface flows.
- ✓ Restoring native plant communities along the conveyance channel and stabilize soils.

Wingra Creek - Shoreline erosion and the accumulation of sediment at outfalls are clogging Wingra Creek. This restricts access by boaters and reduces flows during low water levels. Recent public meetings have underscored the community value of Wingra Creek. FOLW recommends:

- ✓ Restoring the Wingra Creek shoreline to a more natural state to support native wildlife and fish.
- ✓ Removing sediment deltas in Wingra Creek to allow access by boaters.

Wingra Park - Shoreland erosion is being caused by foot traffic. FOLW recommends:

✓ Restoring shoreline slopes and vegetation where possible to create a runoff buffer.

✓ Stabilizing the bank where human use is common.

✓ Redirecting storm sewer outfalls into Ho-Nee-Um pond, and remove sediment deltas from Lake Wingra

Outcomes of Improved Watershed Storm Water Management

The Friends of Lake Wingra support the preceding recommendations because we believe that an informed and active watershed community can successfully reverse years of ecological damage caused by past storm water management practices. We believe that the outcomes of these efforts will be:

★Surface erosion caused by storm water conveyance will be eliminated, leading to a reduction of sedimentation at outfalls.

★ Nutrient, sediment and chloride loading to Lake Wingra will be substantially reduced, leading to improved water quality.

★ Increased infiltration will lead to a partial restoration of subsurface hydrology (groundwater), increasing spring flows, restoring the Watershed ecosystem, and reducing lake water temperatures.

★ Beach closings caused by E.coli from surface runoff of animal waste will cease.

★ Storm water facilitation of invasive species will cease to plague native plant communities.

Sources of Information

Baumann, Paul C., J.F. Kitchell, J.J. Magnuson, T.B. Kayes, *Lake Wingra, 1837-1973: A Case Study of Human Impact*, Transactions of the Wisconsin Academy of Arts and Letters, Vol. 62, 1974

Glass, Stephen B., D. S. Liebl, *A Concept for Investigating the Relation Between Community Storm Water Management & Restoration Ecology at the UW-Arboretum, UW-Arboretum, March 2003*

University, of Wisconsin - Institute of Environmental Studies, *Lake Wingra Watershed: A New Management Approach*, Madison, 1999

Appendix A.
Examples of sources of runoff in the Wingra watershed and practices for reducing pollution from those sources.

Source	Amount of watershed	Annual Runoff contribution	Recommended practices	Need for more information
Roofs	130 acres (4% of watershed)	Sediment: 23 tons (5% of total) Phosphorus:	**Disconnecting downspouts:** Specific arrangement of gutters & downspouts affects how much stormwater infiltrates on site versus enters the urban stormwater conveyance system; widespread "disconnection" of downspouts from impermeable surfaces can have significant effects on a watershed scale	What % of downspouts in watershed can be effectively disconnected?
			Rain gardens: Direct downspouts to depressions with vegetation that promotes infiltration rather than run-off; native plants are usually considered desirable because of their low maintenance requirements and their deep roots which promote infiltration	Site design and implementation standards. Storm water audit for residential properties.
Lawns	1070 acres (34% of watershed)	Sediment: 32 tons (7% of total) Phosphorus:	**Healthy turf or other vegetation cover**: Bare soil, especially associated with steep slopes, erodes and contributes sediment & nutrients to stormwater; healthy vegetation cover greatly reduces erosion	Approaches to improving infiltration of turf grasses.
			Reduced chemical use: Excessive or unnecessary use of lawn fertilizers and pesticides contributes to stormwater pollution, especially on newer or poorly maintained turf; most local soils have sufficient phosphorus	What % of local soils have phosphorus limitations? What is fate of pesticides used in watershed?
			On-site leaf composting: Many leaves raked from lawns and piled for pick-up end up in the lake, where they contribute unwanted nutrients; on-site (or neighborhood scale) composting directs those nutrients to areas (lawns & gardens) where they are desirable	What % of yards can be expected to implement composting or natural lawns?
			Rain gardens: (see "Roofs" above)	What % of properties in watershed have appropriate space and soil types?
Paved Parking	540 acres (17% of watershed)	Sediment: 119 tons (26% of total) Phosphorus:	**Reduced salt use**: private landowners apply an undetermined amount of salt as a de-icer on parking lots (see "Streets" below)	How much salt is applied in the watershed by private property owners?
			Sweeping: Use of regular broom sweepers or high efficiency sweepers removes much particulate pollution (see below under "Streets"), but little information is available on effectiveness on paved parking lots	What is the impact or permeable pavement on sweeping requirements?
			Filters: A variety of mechanical filters (many of them proprietary) are designed to filter out sediments and/or other stormwater pollutants from specific source areas such as parking lots; e.g., the Delaware Perimeter Sand Filter and the MCTT (Multi Chamber Treatment Tank) remove about 80% of sediments; all such devices require regular maintenance to avoid clogging	Up-gradient options may be more expensive than area-wide source reduction activities, Careful fiscal analysis is needed

Source	Amount of watershed	Annual Runoff contribution	Recommended practices	Need for more information
Paved Parking	540 acres (17% of watershed	Sediment: 119 tons (26% of total) Phosphorus:	**Trench infiltration**: Stormwater run-off is directed to an excavated trench that is lined and backfilled with gravel; water infiltrates through trench then through native soil, filtering out sediments and other pollutants; however, salt and some other chemicals will not be removed and may contaminate groundwater	Where in the watershed is this approach likely to be successful?
			Bioinfiltration: Stormwater run-off is directed to shallow depressed vegetated areas, often underlain with formulated layers of gravel and soil; up to 100% of water infiltrates instead of continuing in the stormwater conveyance system; pollutants (e.g., 75% of sediments) are treated through sedimentation, filtration, adsorption, and microbial decay	Number of acres conducive to engineered bioinfiltration?
Streets & Freeways	380 acres (12% of watershed)	Sediment: 215 tons (47% of total) Phosphorus:	**Reduced salt use**: The City of Madison applies about 250 tons of salt annually in the Wingra watershed as part of it ice and snow removal program; salt (chloride) levels in the lake have increased by about 15 times since the 1950s; city policy (adopted 1973) set a goal of decreasing salt use by 50% in the watershed, but this goal has not often been met; undetermined quantities are also applied by the Town of Madison and private landowners	What is the least amount of salt that can be used to maintain reasonable traffic safety? Are there better alternatives? How much salt does the Town of Madison apply in the watershed?
			Sweeping: Weekly street sweeping by common broom sweepers remove 20% of sediments; high efficiency sweepers (with vacuum action assisted by broom and/or air jets) remove 60% on streets and 45% on freeways; efficiency can also be increased by alternate street parking	What are results of intensive street sweeping pilot in central Madison?
			Leaf removal: City Streets Division is responsible for establishing leaf pick-up schedule; cost-cutting efforts have eliminated regularly scheduled pick-ups and instead are done to maximize efficient use of street crews	Are more effective leaf removal technologies, or techniques available?
			Streetscaping: streets can be designed during construction or re-construction to employ bioinfiltration and/or rain gardens (see above) in addition to, or in place of, conventional storm sewers	How many streets have the potential for these management practices?
Large landscape	630 acres (20% of watershed)	Sediment: 13.5 tons (3% of total) Phosphorus:	**Reduced chemical use**: See “Lawns” above	
			Infiltration practices: See “Trench Infiltration” and “Bioinfiltration” above	Can municipalities afford to invest in engineered infiltration structures?
			Erosion control: Bare soil erodes and contributes sediment & nutrients to stormwater;; re-vegetation of bare soil on large landscapes greatly reduces erosion	Are there opportunities to reduce conveyance volumes?
			Vegetated shoreline buffers: Buffer of shoreline vegetation along creeks, ponds, and lakes reduces pollution entering water; also provides habitat diversity and discourages geese which contribute to water quality problems	Do shorelines need to be sloped or rip-rapped?

Appendix B.

Remediation of specific problem sites, and retrofit of existing stormwater conveyance infrastructure in the Wingra watershed.

General Problem	Specific Site Issues	Recommended Actions
Erosion: Bare soil, especially associated with construction sites and steep slopes, erodes and contributes sediment & nutrients to stormwater; construction site erosion practices are effective when used; re-vegetation of bare soil on lawns and parks greatly reduces erosion	Manitou outfall	Disperse outfall to alleviate channelization.
	Westmoreland Park	Create dry detention capacity and restore plantings.
	SW Bike Path & Glenway	Up-gradient infiltration, flow reduction, stabilization.
	Forest Hills Cemetery	Improved turf management and infiltration.
	Wingra Creek	Bank stabilization, outfall dredging.
	UW Arboretum	(See UW Arboretum Plan)
	South Randall Ave	Restore vegetation and infiltrate runoff.
	Vilas Park	Shoreline restoration.
	Wingra Park	Shoreline restoration and outfall(s) dredging.
Detention ponds: Permanent pools (wet retention) that are designed to allow sediments (up to 80% removal) and other pollutants to settle out before the water enters the lake; currently, the Wingra watershed has 8 detention ponds (Odana Golf Course, Marion Dunn pond on Monroe Street, 4 additional Arboretum ponds, and one on the Edgewood campus.	Odana ponds	Provide detention capacity and out-flow moderation.
	Marion Dunn (Monroe St)	Repair outfall and increase detention capacity.
	Arboretum ponds	Pond #1 – Infiltrate up=gradient of existing flume. Remove pond from Curtis Prairie Pond #2 – Control polluted runoff from commercial area. Pond # 3 – Repair outfall and convert to dry detention. Pond #4 – Repair breach and convert to dry detention.