Total Maximum Daily Load:
Mead Lake
Clark County, WI

Mead Lake, Clark County, WI
Report prepared by Ken Schreiber & Nicole Richmond
Revised Final September 25, 2008

Phosphorus and Sediment Total Maximum Daily Load (TMDL) for Mead Lake, Clark County, Wisconsin
Wisconsin Department of Natural Resources: West Central Region

August 13, 2008 Final
Revised September 25, 2008

INTRODUCTION

Mead Lake is a shallow, eutrophic impoundment of the South Fork Eau Claire River (Hydrologic Unit Code 07050006, Wisconsin Waterbody Identification Code 2137000). The Mead Lake watershed drains 248 km^2 (61,282 acres) of west central Wisconsin (Figure 1). Approximately 99 percent of the watershed is within Clark County, with the remaining one percent in Taylor County. The South Fork Eau Claire River is the primary source of surface water inflow to Mead Lake. The lake was placed on the Wisconsin 303(d) impaired waters list in 1998 due to sediment and phosphorus. In 2008, the 303(d) list was updated to reflect that the pollutants of sediment and phosphorus are leading to impairments of degraded habitat, pH criteria exceedances, and excess algal growth in summer which result in limited body contact recreational use (Table 1). The goal of this TMDL is to reduce phosphorus and sediment loadings to Mead Lake to address, pH criteria exceedances, decrease algal blooms in summer, and address degraded habitat so Mead Lake can be improved for recreational purposes.

Figure 1. *Location of Mead Lake watershed in west central Wisconsin.*

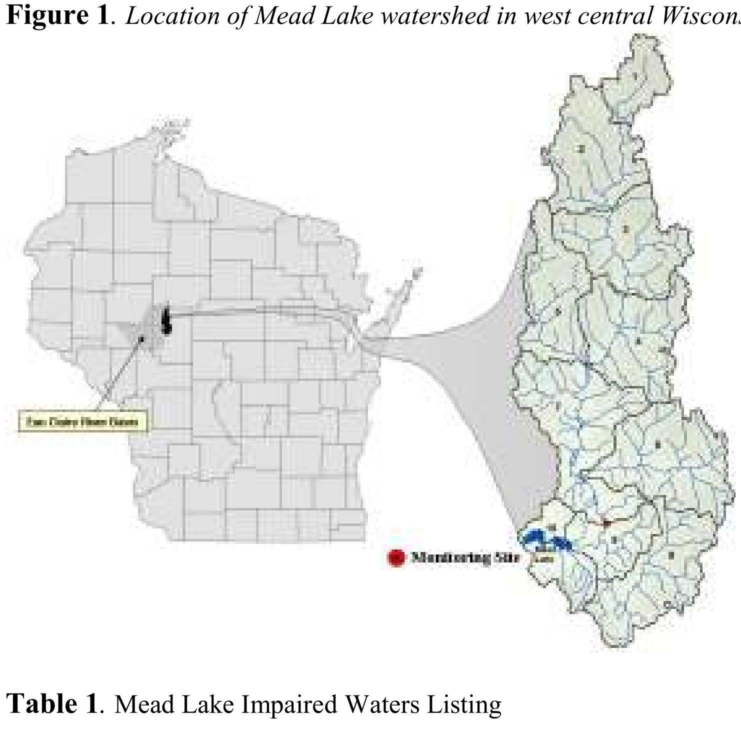


Table 1. Mead Lake Impaired Waters Listing

Waterbody Name	WBIC	TMDL ID	Pollutant	Impairment	Priority
Mead Lake	2143900	277	Total Phosphorus, Sediment	Degraded habitat, excess algal growth, pH	High

PROBLEM STATEMENT

Mead Lake is highly eutrophic and exhibits excessive concentrations of phosphorus and chlorophyll (a measure of algal densities) in its surface waters during the summer months (USACE 2005). Sediment and phosphorus enters the lake via the South Fork Eau Claire River, from nonpoint sources of pollution. Phosphorus is bound to the sediment particles, and once in the system, sediment has the capacity to transfer phosphorus to the lake bottom. The lake's shallow depth, phosphorus-laden sediments and excessive water column phosphorus levels, cause the lake to experience severe algal blooms during the "growing" season (May-October). These eutrophic conditions have significantly impaired body contact recreational activities. In addition, algal blooms in Mead Lake are often accompanied by exceedances of the Wisconsin water quality criterion for pH. The elevated lake pH levels are due to removal of carbon dioxide from water during photosynthesis (by algae). The reduction in carbon dioxide levels during daylight causes an increase in pH. A reduction in sediment loading would reduce phosphorus levels and the corresponding reduction in phosphorus levels would result in a decrease in chlorophyll levels (a measure of productivity) and a reduction in maximum pH levels.

WATER QUALITY STANDARDS

Currently, Wisconsin does not have numeric water quality criteria for phosphorus or sediment. Mead Lake is not currently meeting the applicable narrative *water quality criterion* as defined in NR 102.04 (1); Wis. Admin. Code:

"To preserve and enhance the quality of waters, standards are established to govern water management decisions. Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions: (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state, (b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in waters of the states, (c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the state."

This criterion describes acceptable water quality conditions and guides the WDNR in setting numeric target pollutant concentrations. The application of a narrative criterion for Mead Lake necessitates the development of a site-specific in-lake pollutant value for the purpose of this TMDL. For purposes of this TMDL, sediment is considered an objectionable deposit.

The designated use of Mead Lake is described in S. NR 102.04(3) intro., and (b), Wis. Adm. Code as:

"FISH AND OTHER AQUATIC LIFE USES. The department shall classify all surface waters into one of the fish and other aquatic life subcategories described in this subsection. Only those use subcategories identified in pars. (a) to (c) shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community as provided in federal water pollution control act amendments of 1972, PL 92-500; 33 USC 1251 et.seq.

"(b) Warm water sport fish communities. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish."

The applicable water quality standard for this TMDL is listed in S. NR 102.04(4) intro, and (c), Wis. Adm. Code as follows:

"Standards for Fish and Aquatic Life. Except for natural conditions, all waters, classified for fish and aquatic life shall meet the following criteria:

"(c) pH. The pH shall be within the range of 6.0 to 9.0, with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum."

Mead Lake has been listed as impaired due to documented water quality standard pH violations. The pH exceedances are most likely related to algal productivity, however, the relationship between pH and chlorophyll and/or phosphorus in Mead Lake is very complex. For this reason, goals established by this TMDL were not based on the pH criterion, but rather external phosphorus and sediment loads to the lake. Generally, reductions in phosphorus would lead to reductions in the frequency and extent of algal blooms, and decreased pH levels.

The water quality target for phosphorus for Mead Lake is based on a site-specific goal of 93 ppb P concentration. This target will reduce algal blooms, and reduce pH exceedances to meet TMDL goals. Since there are no numeric water quality standards for sediment in Wisconsin, the TMDL is derived from load reductions to meet in lake phosphorus and chlorophyll goals.

BACKGROUND

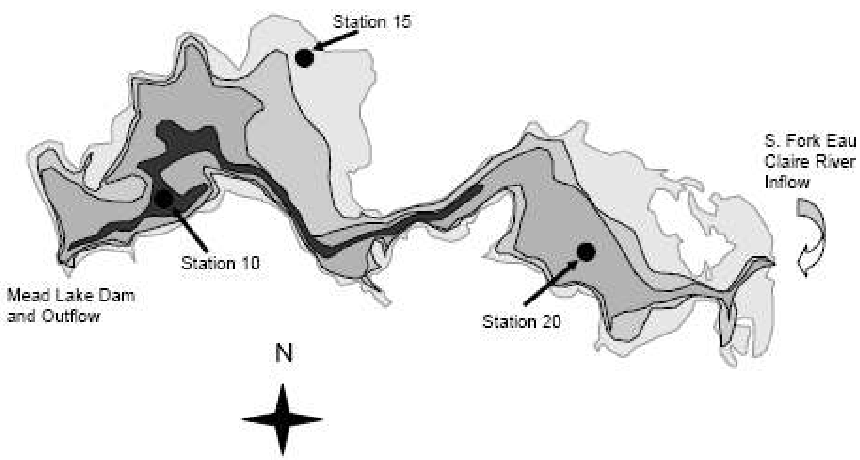
Mead Lake has a surface area of 1.3 km^2, a volume of 1.9 hm^3, and mean and maximum depths of 1.5 m and 5 m, respectively. The Mead Lake watershed is located in the Central Wisconsin Undulating Till Plain Ecoregion (Omernik and Gallant, 1988). This EPA ecoregion is characterized by nearly level to rolling glacial till plains. Lakes in the ecoregion have summer total phosphorus concentrations greater than 50 ppb; lakes over 20 ppb are indicative of eutrophic conditions. The most significant land use in this area is agriculture (Table 2).

A two year study (2002-2003) of water quality in Mead Lake and the South Fork Eau Claire River was conducted by the U.S. Army Corps of Engineers (USACE 2005). The study focused on external loading (suspended sediments and nutrients from the South Fork Eau Claire River), internal P fluxes from lake sediments and in-lake water quality. This study included continuous flow monitoring and bi-weekly and storm event water quality sampling of the South Fork Eau Claire River. Samples were analyzed for total suspended solids, total nitrogen, total phosphorus, and soluble reactive phosphorus. Sampling in Mead Lake was conducted bi-weekly at three locations from May through September of both years (Figure 2). *In situ* profiles of temperature, dissolved oxygen, pH, and conductivity were collected at 1-m intervals at each station. Water samples were collected at 1-m depth intervals for analysis of total nitrogen and phosphorus, soluble reactive phosphorus and chlorophyll. Water samples were collected and analyzed by USACE staff from the Eau Galle Aquatic Ecology Laboratory in Spring Valley, Wisconsin.

Table 2. Summary of land cover in the Mead Lake watershed in 2001(Freihoefer and McGinley 2007).

Land Cover		Area (hectares)	Area (%)
Cropped Farmland		10,383	41.38
Forest		7,964	31.47
Grassland/Pasture		2,690	10.72
Wetland		2,423	9.66
Urban/ Impervious		1,214	4.84
Farmsteads		242	0.97
Water		172	0.69
	Totals:	25,088	99.73

Figure 2. Monitoring stations in Mead Lake, Clark County, Wisconsin (USACE 2005).



Mean total P concentrations of the South Fork Eau Claire River ranged between 0.115 and 0.123 mg/L and accounted for 54% of the total P load to Mead Lake. Laboratory-derived internal P loading rates from sediments were very high under anoxic conditions (range = 16 to 38 mg m^{-2} d^{-1}) suggesting the potential for substantial P flux from bottom sediments. Total P concentrations in the bottom waters increased markedly in 2003 in conjunction with a higher residence time, anoxia in the hypolimnion and reduced flushing rates, compared to 2002 which was a wetter year. Summer chlorophyll concentrations averaged 51 μg/L and 76 μg/L in 2002 and 2003, respectively (USACE 2005).

The USACE study found that on average 83% of the P load originated from direct drainage and tributaries to Mead Lake. Tributary P loading accounted for 87% and 78% of the measured P load in 2002 and 2003, respectively. In contrast, internal P loading from sediment accounted for about 12% and 21%, respectively, of the 2002 and 2003 measured P inputs.

The Wisconsin Trophic State Index (TSI) (Lillie et al. 1993) was estimated for the lake using the mean Secchi transparency values and surface concentrations of total P and chlorophyll estimated over the period May through September of both years. The boundary between mesotrophic and eutrophic lakes for TSI is 50; this study found the lake is highly eutrophic with mean summer TSI values greater than 60 during both years (Table 3).

Exceedances of the state water quality criteria for pH occurred on 16 of 39 (40%) of the sampling events considering all locations and sampling dates. These pH exceedances (>9) generally correspond to chlorophyll levels greater than 70 μg/L.

The seasonal (May – September) suspended sediment load to Mead Lake was estimated at 428 and 189 tons in 2002 and 2003, respectively. The annual sediment load was estimated at 774 and 609 tons in 2002 and 2003, respectively. Sediments deposited in Mead Lake contribute P to the water column via recycling under anoxia or high pH conditions (both which exist in Mead Lake during summer). Laboratory derived internal P loading rates were very high under anoxic conditions (16-38 mg m^{-2} d^{-1}) suggesting a high potential for P flux from bottom sediments (USACE 2005).

Table 3. Summer (May-Sept.) mean values for Secchi depth (SD), viable chlorophyll (CHLA) and total phosphorus (TP) and trophic state index (TSI) values for the surface waters of Mead Lake.

				Trophic State Index		
Year	**Secchi (m)**	**Chla (ug/l)**	**TP (mg/l)**	**TSI_{SD}**	**TSI_{CHLA}**	**TSI_{TP}**
2002	0.52	50.8	0.130	69.2	64.5	65.8
2003	0.70	76.2	0.125	65.0	67.6	65.5

Land Use Modeling

Modeling was conducted to a) determine current loading in the watershed through identification and quantification of current sources, and to b) assess the effectiveness of reducing phosphorus and sediment loads to Mead Lake. Modeling was completed using the Soil and Water Assessment Tool (SWAT version 4/18/2001). SWAT is a distributed parameter, daily time step model that was developed by the USDA-ARS to assess non-point source pollution from watersheds and subwatersheds. SWAT simulates hydrologic and related processes to predict the impact of land use management on water, sediment, nutrient and pesticide export. Crop and management components within the model permit reasonable representation of the actual cropping, tillage and nutrient management practices typically used in this area of the state. Major processes simulated within the SWAT model include: surface and groundwater hydrology, weather, soil water percolation, crop growth, evapotranspiration, agricultural management, urban and rural management, sedimentation, nutrient cycling and fate, pesticide fate, and water and constituent routing. The SWAT model was calibrated to simulate runoff, sediment and phosphorus loading in the Mead Lake watershed using detailed land management information developed from the Clark County Land Conservation Department (LCD), a 2002 farm survey and a 1999 land use transect survey. Seventy-four farms provided information on herd size, manure management, and crop rotations.

Appropriate crop rotations for the model were chosen with assistance from the Clark County LCD. The agricultural scenarios chosen for use in the SWAT model, are reasonable and feasible to implement in this region of the state. Three crop rotations were used to simulate farming practices in the watershed. A dairy rotation consisting of one year of corn grain, one year of corn silage, followed by three years of alfalfa. The first year of the alfalfa rotation was simulated with oats as a nurse crop and harvested as oat hay. Two cash crop rotations were simulated; a two year rotation consisting of corn grain and soybeans and a three year rotation consisting of corn grain, corn grain, and soybeans (Freihoefer and McGinley 2007).

The model was first calibrated for hydrology by balancing surface water, groundwater, and evapotranspiration for calendar year 2002. Once the simulated average annual water export was within ten percent of the monitored flows, simulations were run with daily output for comparison to monitored daily flows. Once surface runoff to base flow contributions were calibrated, sediment and phosphorus contributions from the sub basins were calibrated to 2002 monitored data on a monthly basis. Simulated results were then compared to values estimated based on monitored data. The long-term (25 year) average phosphorus export from the watershed to the lake during the May through September growing season is estimated at approximately 5,500 pounds per year (see Appendix 1).

The scenarios in Table 4 are modifications to the existing (baseline) model simulation to explore the impact of changes in phosphorus export due to different management and land use changes. The summary shows the simulated management scenarios and their impact on long term average growing season (May-September) phosphorus export from the watershed. The SWAT model was used to estimate suspended sediment export from the watershed on an annual and seasonal basis. The model was calibrated using sediment loads and flow from 2002 and 2003 (Appendix 2). Long-term sediment export modeling results are presented in Table 5.

Lake Modeling
The USACE BATHTUB lake model was used to predict changes in total P, chlorophyll, and Secchi transparency in Mead Lake under various P loading scenarios. Model coefficients were developed and calibrated using data collected during the summer of 2002 and used to predict lake responses to measured P loading and in-lake water quality in 2003 (Appendix 3). All model runs were based on a growing season (May – September) due to the relatively short hydraulic residence time of Mead Lake.

Simulated decreases in external P loading from the South Fork Eau Claire River resulted in predicted decreases in the average summer total P and chlorophyll concentration of lake surface waters and increases in Secchi transparency. For example, a 30% reduction in the modeled summer external P loading resulted in a predicted 24% decrease in total P and a 34% decrease in chlorophyll concentrations in the lake (Appendix 3).

Table 4. SWAT model simulated phosphorus export reflects % reduction from 5,500 lbs/yr annual load during May – September under different management scenarios in the Mead Lake watershed (Source: Freihoefer and McGinley 2007).

Scenario	Seasonal Total P Load (lbs.)	P Load Reduction (%)
Baseline	5,500	
Reducing soil P (25 ppm)	4,730	14%
Reducing Soil Erosion (50% reduction in USLE)	4,730	14%
Reduce manure P by 38% (animal dietary changes)	5,280	4%
Combination: reducing soil P, soil erosion control and manure management	4,015	27%
Winter Rye	Little change	5%
Continuous pasture (rotational grazing)	4,345	21%

Table 5. Model simulated long term suspended sediment export from the Mead Lake watershed (McGinley and Freihoefer, 2008).

SWAT simulated suspended sediment export from Mead Lake Watershed			
Growing Season (May - September)		Annual (January - December)	
Range (tons)	Average (tons)	Range (tons)	Average (tons)
236 - 431	151	427 - 1,416	535

BATHTUB modeling was also used to examine changes in the bloom frequency of algal densities in the lake under conditions of simulated reduction or increase in external P loading during both summers. The model results suggest that frequency of nuisance blooms with chlorophyll a concentrations of 30 mg/m^3 or greater (i.e., visible to the eye and considered an aesthetic problem) would be reduced by about 29% with a 30% reduction in the external P load.

LINKAGE ANALYSIS

Establishing a link between watershed characteristics and resulting water quality is a crucial step in TMDL development.

Sedimentation often acts as a transport mechanism for other pollutants, such as phosphorus, that will impact the water chemistry. The primary concern of sediment loading to Mead Lake is the capacity to transfer phosphorus from the watershed to the lake bottom. These phosphorus-laden sediments greatly contribute to summer algal blooms, especially under anoxic conditions. The sediment TMDL is derived from load reductions needed to meet in lake phosphorus and chlorophyll goals. As measures are taken to reduce sedimentation, phosphorus transport to the stream will decrease and phosphorus values in Mead Lake will decrease.

As stated above, phosphorus enters the waterbody bound to sediment particles typically during rainfall and runoff events. Phosphorus loading in water bodies can cause eutrophication of lakes, characterized by excessive plant (macrophyte) growth and dense algal growth. Algal blooms result in pH increases due to removal of carbon dioxide from water during photosynthesis (by macrophytes and algae). In lakes with minimal buffering capacity (like Mead Lake), this reduction in carbon dioxide levels during daylight causes a significant increase in pH. A reduction in phosphorus levels would result in a decrease in chlorophyll levels (a measure of productivity) and a reduction in maximum pH levels.

Mead Lake frequently exhibits pH values above the water quality criterion of 9.0 in its surface waters during summer Although the water quality criterion for pH in Mead Lake was not a primary water quality target for the TMDL, the loading reductions for phosphorus and sediment identified in this TMDL will reduce pH exceedances in Mead Lake.

WATER QUALITY GOALS

The goal of this TMDL is to reduce external loadings of phosphorus and sediment to Mead Lake. As mentioned earlier, since Wisconsin does not have numeric water quality standards for phosphorus and sediment, site specific targets were chosen based on existing data and modeling results. In order to achieve a measurable improvement in lake water quality, a summer epilimnetic mean phosphorus goal of 93 ppb has been established. The goal is based on achievable P load reductions in the watershed based on feasible restoration scenarios using the SWAT model, consensus of a local stakeholder group, and best professional judgment of WDNR staff. This site-specific target represents an approximate 24% decrease in mean growing season P and a 34% decrease in mean chlorophyll levels. The BATHTUB model simulations indicate that this phosphorus goal corresponds to a summer mean epilimnetic chlorophyll concentration of 39 μg/L and Secchi depth of 1.1 meters (Appendix 2). The phosphorus goal also corresponds to a 29 percent reduction in the amount of time the lake experiences summer algal bloom conditions in excess of 30 μg/L chlorophyll. By meeting the TMDL goal concentration of 93 ppb in Mead Lake, narrative water criteria stated in NR 102.04 (1); Wis. Admin. Code will be met. This in turn, will decrease algal blooms which impair recreational uses and decrease pH exceedances in Mead Lake.

After the phosphorus goal was identified for this TMDL, the SWAT model was used to determine the corresponding amount of sediment reduction needed to meet the phosphorus goal. A seasonal sediment reduction goal of 30% was set for the TMDL based on this method.

LOADING CAPACITY

The total loading capacity is the sum of the wasteload allocations for permitted point sources, the load allocations for non-point sources, and a margin of safety, as generally expressed in the following equation:

$$\text{TMDL Load Capacity} = \text{WLA} + \text{LA} + \text{MOS}$$

WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring a waterbody into compliance with water quality criteria or designated uses. The total phosphorus loading capacity of Mead Lake is a function of an identified mean summer epilimnetic in-lake phosphorus concentration goal of 93 ppb. Nutrient concentrations above this capacity cause designated use impairments and water quality criteria exceedances as discussed earlier in this report.

In order to achieve the identified phosphorus goal, the mean summer phosphorus load to Mead Lake needs to be reduced by 30% to 3,850 pounds and the annual P load needs to be reduced by 35% to 8,600 pounds. At this total phosphorus loading level, we expect that the occurrence of severe algae blooms and exceedances of the 9.0 pH criteria will be significantly reduced. This TMDL only addresses the external load to Mead Lake as a "first step" to meeting water quality goals. Once the external sources of phosphorus and sediment loads are controlled, the TMDL will be re-evaluated to see if decreasing the internal P load is needed.

The loading capacity for sediment is primarily based on the corresponding load reductions required for phosphorus. In order to achieve the summer in-lake phosphorus goal, SWAT modeling determined that the mean summer sediment load needs to be reduced by 30% to 233 tons and the annual sediment load needs to be reduced to 826 tons.

WASTELOAD ALLOCATION

Since there no point sources discharging in the Mead Lake watershed, the wasteload allocation is zero. If a point source discharge were proposed, one of the following would need to occur:

- A re-allocation of the phosphorus and sediment loads would need to be developed and approved by WDNR and EPA.
- Effluent limits of zero phosphorus and zero sediment would be included in the WPDES permit.
- An offset would need to be created through some means, such as pollutant trading.

LOAD ALLOCATION

A watershed calibrated SWAT model was used to develop load allocations for Mead Lake. The SWAT land use model was developed and calibrated using the 2002-2003 monitoring data. The baseline phosphorus and sediment loads to Mead Lake are based on estimated long long-term (25 year) SWAT simulations. The SWAT model loads developed by Freihoefer and McGinley (2007) were modified to more accurately account for long term flow conditions (Appendix 2). The load reduction and in-lake water quality goals for the Mead Lake TMDL are based on SWAT model simulations and input from local stakeholders.

Phosphorus
Tables 5 and 6 provide a summary of estimated mean long term May-September and annual phosphorus loads. The SWAT model predicts that implementation of BMPs in the watershed will achieve a higher percentage P load reduction on an annual basis than during May-September. Consequently, we established a 30% P load reduction goal for nonpoint sources during the May-September period and a 35% annual P load reduction goal for nonpoint sources. A basin-wide phosphorus reduction goal of 30% results in a seasonal (May – September) nonpoint source load allocation of 3,850 pounds and a daily load allocation of 25 pounds. Seasonal loads are important to determine for this TMDL since the “growing” season occurs May-September when algal blooms occur. A 35% reduction in the annual P load results in an annual P load allocation of 8,600 pounds and daily load allocation of 24 pounds.

Sediment
As previously mentioned, the sediment loading capacity is primarily based upon the amount of sediment reduction needed to achieve the phosphorus goal. A sediment loading reduction goal of 30% results in a seasonal load allocation of 233 tons and an annual load allocation of 826 tons (Tables 7 and 8).

MARGIN OF SAFETY

A margin of safety (MOS) is a required component of the TMDL to account for uncertainty in the relationship between pollutant loads and quality of the receiving waterbody. The MOS accounts for potential uncertainty in data and analysis, or in the actual effect management controls will have on loading reductions and receiving water quality.

The MOS may be either implicitly accounted for by choosing conservative assumptions about loading estimates or water quality response, or is explicitly accounted for during the allocation of loads. The Mead Lake TMDL incorporates an explicit MOS because the actual load reduction goals are more stringent than the loads needed to meet the in-lake water quality goal. Our modeling suggests that a 30% reduction in the P load will actually result in slightly better water quality than the in-lake goal of 93 ppb. The Bathtub model suggests that a seasonal P load allocation of 4,050 pounds would achieve the in-lake goal of 93 ppb, however, the TMDL allocation was set at 3,850 pounds, providing an MOS of 200 pounds P. The annual P load allocation of 8,600 pounds provides an MOS of 480 pounds. Because the sediment load reductions were determined based on load allocations needed for phosphorus reductions in Mead Lake (3,850 pounds P), the MOS for sediment is implicit. Consequently, if the proposed loading reductions are achieved, water quality in Mead Lake will exceed the in-lake target goal.

Another means of providing a margin of safety is through implementation of other ongoing nonpoint source control programs that were not incorporated into in the SWAT land use model simulations. An example is implementation of the Conservation Reserve Program (CRP) in the basin. Conservation gains through this federal program are not accounted for in estimating potential phosphorus loading reductions. In addition, direct barnyard runoff was not incorporated into the land use model, thus implementing barnyard BMPs would provide additional P load reductions.

SEASONAL VARIATION

As the term implies, TMDLs are often expressed as maximum daily loads. However, TMDLs may be expressed in other terms when appropriate. In this case, the TMDL is expressed in terms of allowable daily, seasonal, and annual phosphorus and sediment loads.

During spring, the combination of short residence times, cold temperatures and high runoff flows cause much of the P laden water to flush through the lake with minimal impact on algae blooms. However, runoff that occurs during October – April does contribute phosphorus laden sediments that release phosphorus to the water column during summer, especially under anoxic conditions. During summer, warm temperatures, increased residence time and anoxia in the hypolimnion increases internal recycling of phosphorus, contributing to blue green algae blooms.

Increased TP loading is dependant on flow conditions rather than seasonality. The spectrum of flow conditions that would be expected during the entire year are used in the SWAT modeling for this TMDL. Growing season (May –September) loading as predicted by the SWAT modeling scenarios were used in conjunction with the BATHTUB model to predict the impact of management practices on growing season in-lake water quality. It is important to note, that the summer seasonal P load has a more direct impact on algal growth than that which occurs during other time periods, but by implementing BMPs to control runoff of phosphorus and sediment in the watershed all time periods will be addressed.

REASONABLE ASSURANCE

The Clean Water Act requires that states provide a “reasonable assurance” that the TMDL will be implemented. Reasonable assurance will be provided through a variety of voluntary and/or regulatory means in the Mead Lake watershed. The TMDL will be implemented through enforcement of existing regulations, financial incentives and various local, state and federal water pollution control programs. Following are some activities, programs, requirements and institutional arrangements that will provide a reasonable assurance that the Mead Lake TMDL is implemented and the water quality goal will be achieved.

In general, Wisconsin’s Section 319 Management Plan (approved by EPA) describes a variety of financial, technical and educational programs in the state. The primary state program described in the 319 Management Plan is the Wisconsin Nonpoint Source Water Pollution Abatement

Program (s. 281.65 Wis. Stats. and ch. NR 120 Wis. Admin. Code). This TMDL and the implementation plan (when completed) will be incorporated as an amendment to the area wide water quality management plan under ch. NR 121(Wis. Admin. Code).

Wisconsin Administrative Code NR151 identifies performance standards and prohibitions to control polluted nonpoint source runoff. The rule also sets urban performance standards to control construction site erosion and manage runoff from urban development.

The WDNR and Clark County Land Conservation Department (LCD) will implement agricultural and non-agricultural performance standards and manure management prohibitions (Wis. Admin. Code NR 153) to address sediment and nutrient loadings in the Mead Lake watershed. Many landowners voluntarily install Best Management Practices (BMPs) to help improve water quality and comply with the performance standards. Cost sharing may be available for many of these BMPs. In most cases, farmers will not be required to comply with the agricultural performance standards and prohibitions unless they are offered at least 70% cost sharing funds. If cost-share money is offered, those in violation of the standards are obligated to comply with the rule.

The Clark County LCD may apply for Targeted Runoff Management (TRM) grants through WDNR. TRM grants are competitive financial awards to support small-scale, short term projects (24 months) completed locally to reduce runoff pollution. Both urban and agricultural projects can be funded through TRM grants which require a local contribution to the project. The state cost share is capped at $150,000 per grant. Projects that correct violations of the performance standards and prohibitions and reduce runoff pollution to impaired waters are a high priority for this grant program.

Lake Protection grants are available to assist lake users, lake communities and local governments to undertake projects that protect and restore lakes and their ecosystems. This program is administered under Wisconsin Administrative Code NR 191, and typically provides up to 75% state cost sharing assistance up to $200,000 per project. These projects may include watershed management projects, lake restoration, shoreland and wetland restoration, or any other projects that will protect or improve lakes.

The Environmental Quality Incentive Program (EQIP) is another option available to farmers. EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.

USDA Farm Service Agency's (FSA) Conservation Reserve Program (CRP) is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, FSA provides participants with rental payments and cost share assistance.

Table 5. Seasonal (May – September) P load allocations for the Mead Lake watershed

Category	Baseline Phosphorus Load (pounds)	Percent Reduction	Reduction in Phosphorus Load (pounds)	Phosphorus Load Allocation (pounds)	Daily Phosphorus Load Allocation (pounds/day)
Nonpoint Sources	5,500	30	1,650	3,850	25
Point Sources	0	0	0	0	0
Margin of Safety				200	1.5
Totals:	5,500	30	1,650	4,050	26.5

Table 6. Annual P load allocations for the Mead Lake watershed

Category	Baseline Phosphorus Load (pounds/yr)	Percent Reduction	Reduction in Phosphorus Load (pounds/yr)	Phosphorus Load Allocation (pounds/yr)	Daily Phosphorus Load Allocation (pounds/day)
Nonpoint Sources	13,230	35	4,630	8,120	22
Point Sources	0	0	0	0	0
Margin of Safety				480	2
Totals:	13,230	35	4,630	8,600	24

Table 7. Seasonal (May – September) sediment load allocations for the Mead Lake watershed

Category	Baseline Seasonal Sediment Load (tons)	Percent Reduction	Reduction in Sediment Load (tons)	Sediment Load Allocation (tons)	Daily Sediment Load Allocation (tons/day)
Nonpoint Sources	333	30	100	233	1.5
Point Sources	0	0	0	0	0
Totals:	333	30	100	233	1.5

Table 8. Annual sediment load allocations for the Mead Lake watershed

Category	Baseline Annual Sediment Load (tons/yr)	Percent Reduction	Reduction in Sediment Load (tons/yr)	Sediment Load Allocation (tons/yr)	Daily Sediment Load Allocation (tons/day)
Nonpoint Sources	1,180	30	354	826	2.3
Point Sources	0	0	0	0	0
Totals:	1,180	30	354	826	2.3

PUBLIC PARTICIPATION

A local advisory group was formed in September 2007 to provide input in developing the Mead Lake TMDL. The advisory group consisted of WDNR staff, Clark County Land Conservation Department staff, town officials, farmers, lake district members and other private individuals. Public informational meetings on the draft TMDL were held on May 24, 2008 and June 14, 2008.

The Mead Lake TMDL was subject to public review from May 22, 2008 to June 30, 2008. On May 15th, 2008, a news release was sent to local newspapers, television stations, radio stations, interest groups, and interested individuals in the west central region portion of the state. The news release indicated the public comment period and how to obtain copies of the public notice and draft TMDL. The news release, public notice, and draft TMDL were also placed on the DNR's website: http://dnr.wi.gov/org/water/wm/wqs/303d/Draft_TMDLs.html

WDNR received three letters of support regarding the Mead Lake TMDL with no specific technical comments. In addition, EPA Region 5 submitted comments during the public comment period. All comments were documented, considered, and addressed, with many incorporated into the final report. Comments and responses can be found in Appendix 4 of this report.

IMPLEMENTATION

The Mead Lake TMDL identifies water quality goals and wasteload allocations. The next step following approval of the TMDL is to develop an implementation plan that specifically describes how the goals will be achieved. The implementation planning process is expected to be completed following approval of the TMDL.

The implementation planning process will develop strategies to most effectively utilize existing federal, state, and county based programs to achieve nonpoint source load allocations outlined in the TMDL. Generally, funding sources are available to install BMPs, but most of these sources do not include funds to hire local staff.

The implementation plan will address various management issues including:

- Funding priorities for implementing BMPs based on cost effectiveness
- Funding for local land conservation staff to implement the project
- Develop or identify an existing organizations or agencies to implement the project
- Develop targeted performance standards (if needed)
- Determine how to implement agricultural performance standards

Developing an implementation plan will require a collaborative effort that utilizes the funding and expertise of various agencies and private organizations. Participating partners will likely include the Clark County Land Conservation Department, WDNR, Mead Lake District, TMDL Advisory Group and possibly other interested parties. An inter-agency cooperative agreement can be used to define contributing roles and responsibilities of each respective partner. Details of the implementation plan will include project goals, actions, costs, timelines, reporting requirements, and evaluation criteria.

Internal P Load Control

While a 30% reduction in the external P load to Mead Lake will result in a noticeable improvement in water quality, further improvement would occur from measures to reduce the internal P load during summer. Several possible methods that could be employed to reduce the internal P load include;

- Alum treatment: This requires treatment of areas of the lake bottom that typically go anoxic and therefore release P. This could not be done cost effectively until external sediment and P loading is controlled, because new P-laden sediment will cover the alum layer and render it ineffective.
- Aeration: Air bubble lines could be placed in the deep holes, and be used to prevent stratification and anoxic release of bottom sediment P. The costs of operation and maintenance may be prohibitive, as electricity is needed to run the pumps.
- Siphoning: This involves siphoning off water continuously from the bottom of the lake, before it can become anoxic. This would prevent the bottom water from becoming anoxic. However, in dry years, there may not be enough flow through the lake to allow this approach.

After considerable control of external P sources has been achieved and financing to reduce internal loading become available, internal loading control efforts will be pursued if feasible.

MONITORING

Water quality monitoring will be conducted by the WDNR on Mead Lake and in its watershed beginning 5 years after initiation of the TMDL implementation plan. This monitoring will provide an interim evaluation of project effectiveness and goals. The monitoring approach will generally replicate monitoring conducted in 2002-2003 as outlined in USACE (2005).

Pollutant loads will be measured for two years at a station located on the South Fork Eau Claire River where it enters Mead Lake. Streamflow will be measured continuously and water chemistry samples will be collected bi-weekly for two years. Lake water quality will be monitored at three sites in Mead Lake, following the protocol outlined in USACE (2005). Land use data will be updated, which in conjunction with the monitoring data, will be used to develop an updated watershed SWAT loading model for Mead Lake. The watershed model and an updated lake response model will be used to re-evaluate project goals for Mead Lake.

Volunteer monitoring

An ongoing monitoring effort sponsored by the Wisconsin Self-Help Citizen Lake Monitoring program provides basic water quality data that is collected by local volunteers. Self-help volunteers have been collecting Secchi depth data five times per summer in Mead Lake since 1996. In order to more effectively measure implementation effectiveness, this effort will be increased to capture summer monthly Secchi depth, total P and chlorophyll data at two sites in Mead Lake on an annual basis.

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Appendix 1. Simulating Mead Lake water quality from land management changes (McGinley, P. and A Freihoefer, 2008).

MEMORANDUM

To: Ken Schreiber and Pat Oldenburg
From: Paul McGinley and Adam Freihoefer

Simulating Mead Lake Water Quality
from Land Management Changes
Revised January 15, 2008

The impact of land management changes on Mead Lake water quality was projected using SWAT simulations linked with BATHTUB simulations. The SWAT model was used to generate monthly flow and phosphorus export to the lake. This was converted to a growing season total flow and flow-weighted concentration for input to BATHTUB. The BATHTUB model was used to estimate growing season water quality. The BATHTUB modeling used an average of the calibration coefficients from the James et al. (2005) study.

Comparison to 2002/2003 Conditions

The SWAT/BATHTUB simulations were first used to demonstrate how the results of the combined models match the measurements from 2002-2003. Table 1 compares the SWAT/BATHTUB simulation results with the measured range and average for 2002 and 2003. The SWAT/BATHTUB results are shown both as "average" and "maximum" from simulations based on six different simulation starting dates. This starting date affect is largely due to year-to-year variations in cropping assignments. The SWAT modeling used a staggered assignment of crop rotation starting points to approximate a uniform distribution of crops on different soils, but because the distribution is not exact, it leads to variations for a specific year depending on the starting point in the simulation. The model was calibrated using a single starting year, but the staggered starting dates might provide some measure of how variations in land management influence the variation in lake response. In the discussion that follows, the SWAT/BATHTUB simulation results were evaluated as both annual averages of the multiple year simulations or as the average of annual maximums from the multiple year simulations. Table 1 summarizes the averages of the different starting dates for those two analysis methods for the two monitored years.

The results in Table 1 show general agreement between the measured and simulated lake response. The measured average results fall between the SWAT/BATHTUB modeling for 2002 and exceed the simulated maximum for 2003. In all cases, the range in measured lake concentration is much larger than the simulated averages and maximums. It appears reasonable to use the average and maximum rotation averages to bracket the likely lake response to management changes.

Influence of Land Management Changes on Mead Lake

Combined SWAT/BATHTUB modeling was also used to examine the impact of management changes on Mead Lake water quality. To provide year-to-year comparisons, the modeling was similar to that described above, where results from staggered starting dates were modeled using SWAT/BATHTUB and then the results shown as averages or maximums for each year.

Table 1. Comparison Between Measured and SWAT/BATHTUB Simulated using 88-93 Start Dates and Averaged BATHTUB Model

	2002			2003		
	TP (ug/l)	**Chlorophyll a (ug/l)**	**Secchi (m)**	**TP (ug/l)**	**Chlorophyll a (ug/l)**	**Secchi (m)**
Measured Average (Range)	112 (44-237)	51	0.5	125 (62-189)	76	0.7
Simulated Average	101	46	0.7	99	44	0.7
Simulated Maximum (Max P/Chla & Min Secchi)	123	61	0.6	112	53	0.6

Notes: Simulation staring dates from 1988-1993 to provide six to eleven year warm-up periods prior to evaluation period from 1999 to 2004.

Figures 1 and 2 show the baseline and phosphorus reduction scenarios. The phosphorus concentrations in the lake are lower under the different management scenarios. As would be expected, the concentration in the lake is a little different from year-to-year, primarily reflecting the variations in rainfall timing and quantities.

Table 2 summarizes the average of the different staggered-start-date simulations for both the baseline and phosphorus management conditions. Similar to results that were shown in previous project memoranda, they lead to phosphorus reduction scenarios with changes of approximately 15% for the soil P and soil erosion scenarios, and almost 30% for the combination scenario (soil P, erosion, and dietary P). The total phosphorus export is shown for both annual and the May through September growing season. The annual export is much greater than the growing season and reflects the very high export simulated for February, March and April. In general, those months were simulated without the benefit of field data for calibration, so the annual export totals are more uncertain than those for the growing season. The phosphorus export for the baseline and reduction scenarios is larger than that reported in the November 27, 2007 project memorandum. The simulations presented here are shorter term simulations to reduce the impact of changes in watershed phosphorus storage, and they combine the results of multiple starting years, both of which lead to a larger overall phosphorus export. Comparison of these results with those shown previously demonstrates that the percentage reductions are relatively robust regardless of simulation approach (long-term average with a single starting date or shorter-term average with multiple starting dates).

Table 3 summarizes the results from averaging the maximum for each year in the staggered-start-date simulations. This leads to a higher phosphorus export and lake phosphorus concentration, and a larger percentage reduction in phosphorus in the management scenarios. These values represent a more extreme combination of management practices that would result in higher phosphorus export for all years in the rotation. The increased phosphorus reduction percentage for the different management scenarios than those in Table 2 is consistent with a greater percentage of the phosphorus coming from agricultural land management that is impacted by the land management change simulated.

Consistent with the modeling shown in James et al. (2005), the percentage reduction in the lake total phosphorus response is relatively similar to (as a percentage), although slightly lower than

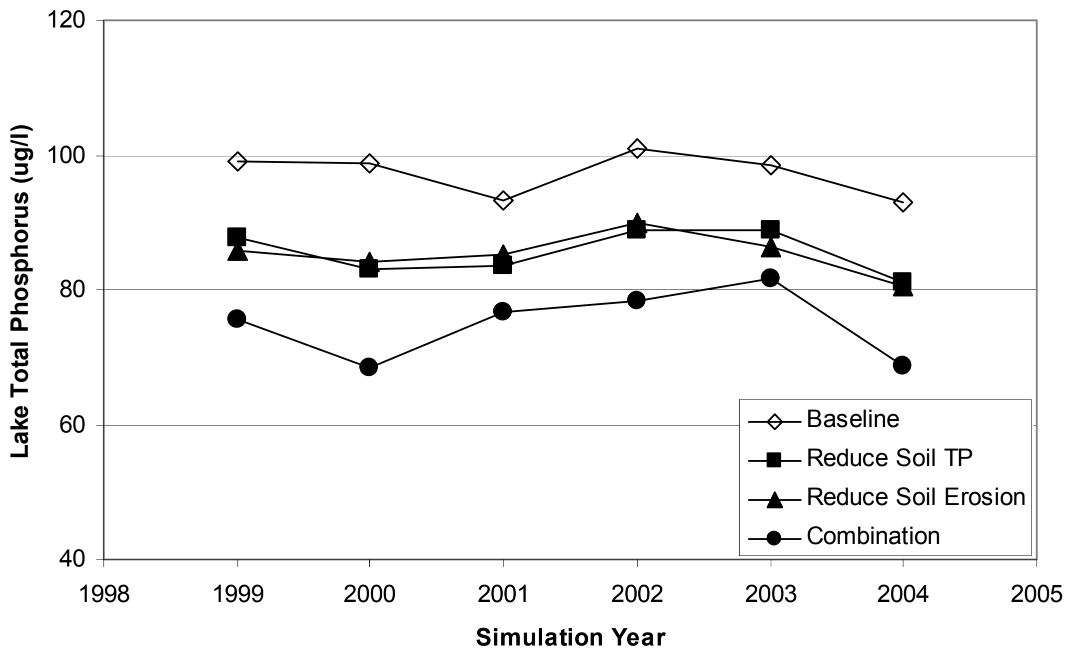

Figure 1. Predicted lake phosphorus concentration for the baseline and reduction scenarios 1, 2 and 8. Phosphorus concentrations are the mean of the six BATHTUB simulations for each year using the different SWAT starting dates.

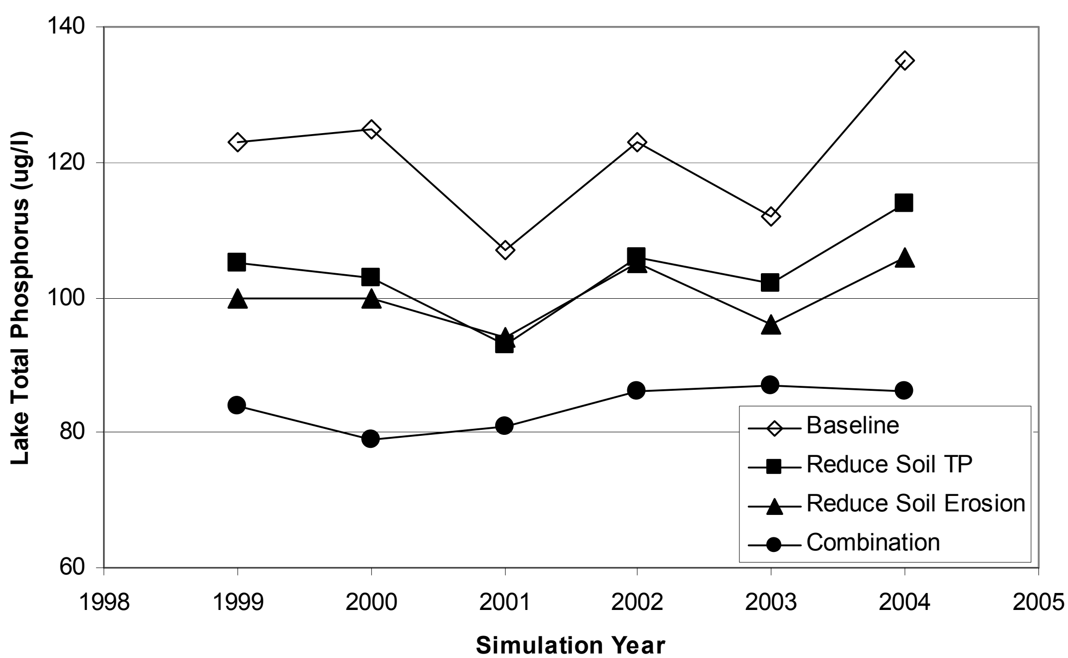

Figure 2. Predicted lake phosphorus concentrations for the baseline and reduction scenarios 1, 2 and 8. Concentrations are the maximum for each year based on six BATHTUB simulations using different starting dates in the SWAT simulations.

Table 3. Simulated Phosphorus Export, Stream Concentration and Lake Concentration Using Rotation Annual Average SWAT / BATHTUB Simulation Results

	Annual Phosphorus Export (Pounds)	Growing Season Phosphorus Export Pounds (% Reduction)	Mead Lake Growing Season TP ug/l (% Reduction)	Growing Season Chlorophyll a ug/l (% Reduction)	Growing Season Secchi Depth (ft) (% Increase)
Baseline	15,873	4,896	97	43.1	2.4
Reduce Soil P (Scenario 1)	13,386	4,173 (15%)	86 (11%)	35.9 (17%)	2.6 (9%)
Reduce Soil Erosion (Scenario 2)	12,831	4,156 (15%)	85 (12%)	35.8 (17%)	2.6 (8%)
Combination (Scenario 8)	10,871	3,518 (28%)	75 (22%)	29.4 (32%)	2.9 (21%)

Notes: Values calculated from annual and growing season (May-Sept) monthly export using 1999-2004 results with six different simulations with starting dates 1988-1993. These represent the average values from thirty six different year-simulations (six different years in the six simulations).

Table 4. Simulated Phosphorus Export, Stream Concentration and Lake Concentration Using Rotation Average of Annual Maximum SWAT / BATHTUB Simulation Results

	Annual Phosphorus Export (Pounds)	Phosphorus Export Pounds (% Reduction)	Mead Lake Growing Season TP ug/l (% Reduction)	Growing Season Chlorophyll a ug/l (% Reduction)	Growing Season Secchi Depth (ft) (% Increase)
Baseline	20,536	6,717	121	59.3	2.0
Reduce Soil P (Scenario 1)	16,808	5,509 (18%)	104 (14%)	47.5 (20%)	2.2 (9%)
Reduce Soil Erosion (Scenario 2)	15,622	5,265 (22%)	100 (17%)	45.0 (24%)	2.3 (17%)
Combination (Scenario 8)	12,639	4,235 (37%)	84 (31%)	34.8 (41%)	2.6 (33%)

Notes: Values calculated from growing season (May-Sept) using 1999-2004 results with six different simulations with starting dates 1988-1993. These represent the average of the annual maximum values for each year (average of the six annual maximums).

the watershed phosphorus reduction. For example, a fifteen percent reduction in growing season watershed export in Table 2 leads to an eleven to twelve percent reduction in growing season lake phosphorus concentration.

The relationship between reductions in phosphorous export from the watershed and improvement in water quality in Mead Lake was also examined for the different SWAT/BATHTUB simulations. While the lake response to loading reductions will be influenced by the flow and concentration that year, the results of different annual SWAT/BATHTUB simulations in Figures 3 and 4 show that for the Mead Lake watershed, they generally adhere to a similar relationship. This relatively linear response simplifies evaluating other reduction scenarios or permits an evaluation using a baseline lake concentration that differs from those used in Tables 2 and 3 above.

Summary and Recommendations

1. Results from the linked SWAT/BATHTUB simulations were similar to the measured Mead Lake water quality. To minimize the influence of staggered agricultural management in rotations, results are shown as both average and maximum for each year in the simulation using multiple starting years. The average measured values appear to generally fall between these values.

2. Expressing the impact of management changes on phosphorus reduction as a percentage reduction from the average baseline is relatively robust regardless of simulation approach (long-term, short-term, multiple start dates). Therefore, when possible, express the phosphorus reductions as a percentage from the baseline. The percentage reductions are greater when examining the maximum years in a combination of different starting years, reflecting the higher percentage of phosphorus export attributable to agricultural activities in those simulations.

3. The range of phosphorus export that is simulated in the model for rotation average and rotation maximum suggests a growing season phosphorus export of 4,896 to 6,717 pounds for the Mead Lake watershed. This range accommodates uncertainty in the different cropping practices from year to year in the watershed. The anticipated reduction in phosphorus export from year-to-year will also vary depending on the combination of management practices, but the average scenario condition estimates in Table 3 would be the recommended percentage growing season reductions associated with the implementation of the management strategies to reduce phosphorus export.

4. The impact of phosphorus reductions on lake response using SWAT/BATHTUB can be done as either a percentage or as a projected value (eg., TP concentration). Projected values for the lake total phosphorus concentration in the baseline simulation range from ~100 to 120 ug/l depending whether it is based on the rotation average or maximum, respectively. The response of the lake phosphorus or chlorophyll a is relatively linear with respect to changes in watershed phosphorus export over the likely reduction range and it may be useful to use a graphical approach (Figures 3 and 4) based on any baseline assumptions to show the impact of percentage reductions on water quality.

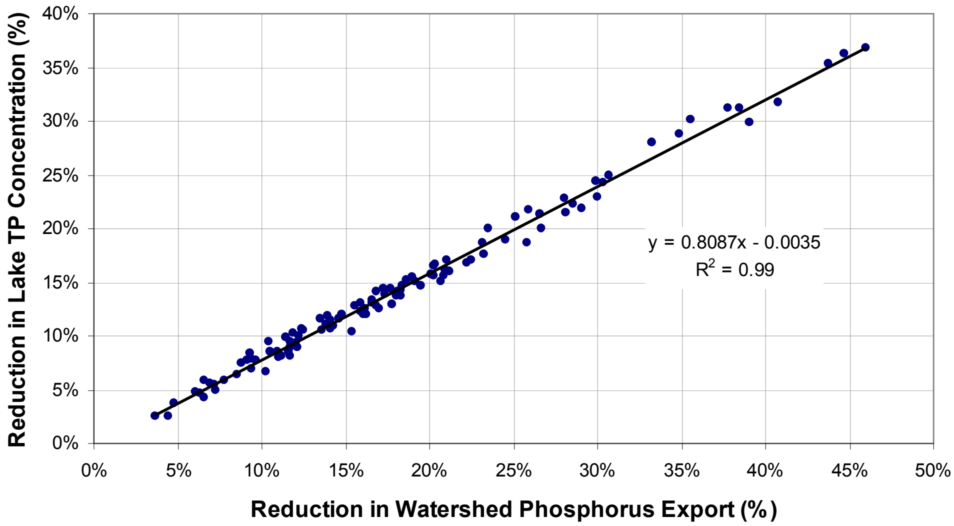

Figure 3. Relationship between reductions in watershed phosphorus export and predicted lake total phosphorus concentration using the results from the six years of the six different starting date SWAT/BATHTUB simulations and three reduction scenarios.

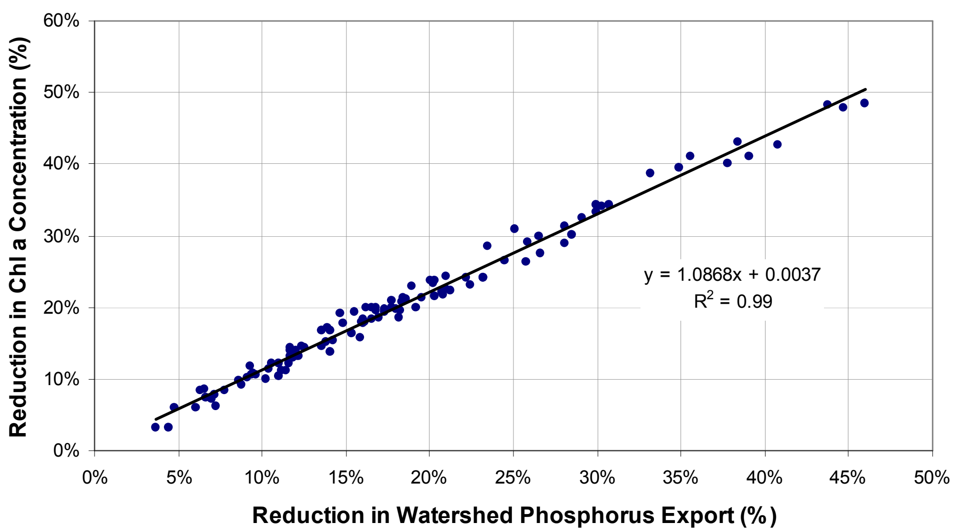

Figure 4. Relationship between reductions in watershed phosphorus export and predicted lake chlorophyll a concentration using the results from the six years of the six different starting date SWAT/BATHTUB simulations and three reduction scenarios.

Appendix 2. BATHTUB Modeling of Mead Lake, Clark County, Wisconsin

The following analysis was developed by P. Oldenburg (WDNR) and drawn from two main sources, SWAT modeling work done by Paul McGinley and Adam Freihoefer (2007) and the monitoring work of Bill James (USACE 2005).

The UWSP modeling results presented a range of possible loading rates as the "baseline scenario". This approach was the result of the impact of starting dates on model output results. This starting date affect was largely due to year-to-year variations in cropping assignments. The SWAT modeling used a staggered assignment of crop rotation starting points to approximate a uniform distribution of crops on different soils, but because the distribution was not exact, it lead to variations for a specific year depending on the starting point in the simulation. The results of this exercise predicted mean summer (May – September) external phosphorus loading to Mead Lake of 4,896 lbs. and an annual load of 15,873 lbs. However, by using the same calibrated model and different start date, the model predicted average external summer phosphorus loading to Mead Lake of as high as 6,717 lbs. and an annual load of 20,536 lbs. (See January 15, 2008 memo from Paul McGinley and Adam Freihoefer).

The USACE monitoring results were from 2002 and 2003. The seasonal phosphorus loading estimates were 3,704 kg (8,165 lbs.) for summer 2002 and 2,062 kg (4,546 lbs.) for summer 2003. Since the tributary loading was only monitored for two years, data from a nearby gage was used to estimate longer term loading. The Neillsville gage on the Black River (USGS #05381000) has been operated from 1905-09, 1913-2000 and 2001 to present. Using 1974 to 2005 as a long term estimate of flow, 2002 was in the 90th percentile of annual flow and 93rd percentile for the summer flow. By contrast 2003 was in the 31st percentile of annual flow and 40th percentile for summer flow. The long term loading to Mead Lake can be estimated by using the ratio of 1974 to 2005 median to the 2002 and 2003 flows flow at the Black River gage. This results in a long term estimate of loading to Mead Lake of 2,625 kg/summer (5,787 lbs.) and 6,021 kg/yr (13,274 lbs.).

Based on these two approaches, 2,500 kg/summer (5,510 lbs) and 6,000 kg/yr (13,230 lbs) should be used as baseline P loads for the TMDL. The 2,500 kg/summer load was used because it matched up well with a long term estimate arrived at by using the loading data and subsequent discussions with Paul McGinley about the SWAT model results in which he was concerned that the 2,221 kg figure may be an underestimate of loading. The annual load of 6,000 kg/yr was based on the loading data and review of SWAT modeling data which show a tendency to over-predict winter base flows and runoff.

Since a percentage reduction goal has already been identified by the stakeholder group at 30% for the growing season, a May – September load goal of 1,750 kg/yr (3,860 lbs/yr.) is recommended. Since SWAT modeling predicts that use of many agricultural best management practices will achieve a higher percentage reduction in annual loading than the May - September load, I recommend that the annual load goal be set at 35% of 6,000 kg/yr (13,227 lbs/yr), or 3,900 kg/yr (8,600 lbs/yr).

In order to estimate the effect of this load reduction on Mead Lake water quality, I ran a BATHTUB May – September baseline scenario with a external load of 2,625 kg (5,790 lbs), a 30% external load reduction (i.e. external load = 1,837 kg) and a 30% external load reduction with a 70% internal load control. The results are shown in Table 1.

Table 1. Mead Lake BATHTUB model loading reduction scenarios.

Parameter	Baseline (5,790 lbs/summer)	30% Reduction (4,050 lbs /summer)	30% Reduction w/internal load control
Total Phosphorus (μg/L)	122	93	76
Chlorophyll-a (μg/L)	59	39	30
30 μg/L Chlorophyll-a bloom frequency (%)	78	55	37
Secchi Depth (m)	0.7	1.1	1.4

An in-lake goal of 93 μg/L growing season mean total phosphorus is recommended for the TMDL. The BATHUB model indicates that this goal could be met with an external loading rate higher than the recommended TMDL goal, therefore choosing this in-lake goal in conjunction with the TMDL load goal will provide a margin of safety in the TMDL.

Note that this BATHTUB model is different that that used in the James study, but analysis of the response curves show that the models behave nearly identically over the range of expected reductions for the TMDL, indicating a fair amount of model robustness. The modeling conditions for both model calibration based on the 2002 and 2003 monitoring data and modeling for the long term analysis are listed in Table 2.

Table 2. Estimation of Long Term P Loading to Mead Lake.

Long term annual and season loadings were developed for the South Fork Eau Claire River at CTH MM using a ratio method based on flow data from the from Black River at Neillsville. First the long term average of the annual and seasonal flows was determined at the Black River site:

Summary of Data from Black River at Neillsville:
POR: 1974-1998, 2001-2005. n=30
30 yr annual mean = 648.4 cfs
2002 mean annual flow = 990.6 cfs
2003 mean annual flow = 483.7 cfs

30 yr May – Sept mean flow = 554.0 cfs
2002 mean May – Sept flow = 1162.5 cfs
2003 mean May – Sept flow = 394.9 cfs

Then the ratio between the Black River flows of an individual year vs. the long term average was determined as:

$$\text{Ratio} = \frac{\text{30 Year Mean}}{\text{Individual Year Mean}}$$

2002 Annual Ratio = 0.655
2003 Annual Ratio = 1.341
2002 May-Sept Ratio = 0.477
2003 May-Sept Ratio = 1.403

Summary of Data from South Fork Eau Claire River at CTH MM:

2002 mean annual flow = 62.2 cfs
2003 mean annual flow = 45.9 cfs
2002 mean May – Sept flow = 73.8 cfs
2003 mean May – Sept flow = 43.8 cfs
2002 estimated annual TP Load = 6682 kg (14,731 lbs)
2003 estimated annual TP Load = 4931 kg (10,871 lbs)
2002 estimated May – Sept TP Load = 3397 kg (7,489 lbs)
2003 estimated May – Sept TP Load = 1872 kg (4,127 lbs)

To estimate the long term flow/load the ratio developed from the Black River data was applied to the South Fork Eau Claire River to estimate the long term flow and load.

Appendix 3. SWAT model simulations of suspended sediment loading to Mead Lake (McGinley and Freihoefer, 2008).

MEMORANDUM
To: Ken Schreiber and Pat Oldenburg
From: Paul McGinley and Adam Freihoefer

The results of the SWAT modeling were used to estimate the suspended sediment export from the watershed on both an annual (Jan-Dec) and growing season (May-Sept) basis. The SWAT model was calibrated using growing season loads and flows from 2002 and 2003. The longer-term SWAT simulation results are presented in Figure 1 as the average and range in sediment load for each year based on simulations with six different simulation starting dates. Similar to the phosphorus results, the starting date affect is largely due to year-to-year variations in cropping assignments. The SWAT results are presented in Table 1 as the average of the different starting-year simulations or as the average of annual maximums from the different starting-year simulations. Similar averages are obtained for the annual sediment load when looking at a twelve year time period that starts with 1993. Therefore, an average annual sediment load of approximately one million kilograms is estimated for the watershed and the unit area suspended sediment export for the entire watershed is approximately 43 kg/ha or 4300 kg/km^2.

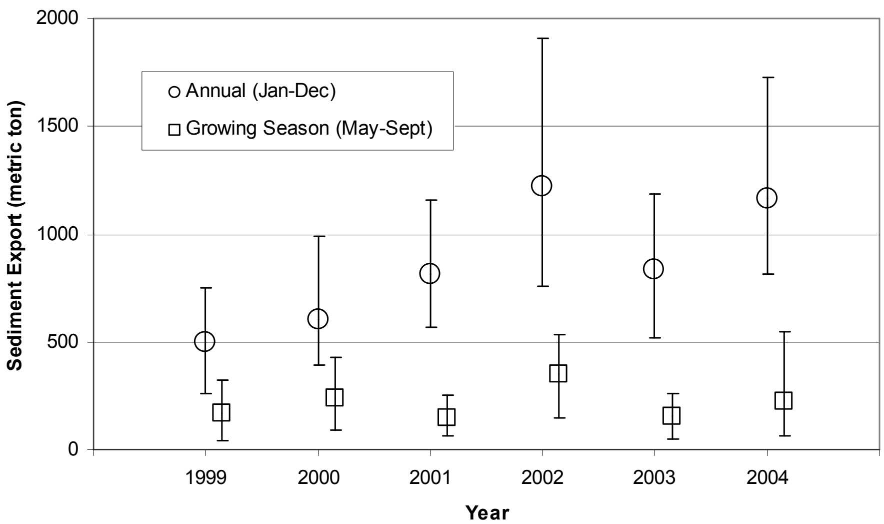

Figure 3. Simulated suspended sediment export across evaluation period shown as average and range for the different simulation starting dates.

Table 1. SWAT Simulated Suspended Sediment Export for Mead Lake Watershed

Growing Season (May-September)		Annual (January-December)	
Range (kg/year)	**Average (kg/year)**	**Range (kg/year)**	**Average (kg/year)**
214,000-391,000	302,000	854,000-1,285,000	1,070,000

Notes: The range is from the mean of the averages to the mean of the maximums for each year using the different starting point simulations across the evaluation period. The average is the mean of average annual and average maximum. Simulation staring dates from 1988-1993 to provide six to eleven year warm-up periods prior to evaluation period from 1999 to 2004.

Appendix 4. Comment and Response Log

Comments received from US EPA on 08/02/2008
Addressed by Ken Schreiber and Nicole Richmond

NOTE: Comments were summarized and this TMDL report was re-formatted to be more readable and answer many of the comments and questions below. Page numbers have changed due to formatting.

1. The USACE 2005 report provides support for eutrophication impairment, correct?
   WDNR: Yes, the USACE report provides supports that the lake is highly eutrophic.

2. The primary goal of the TMDL is to address the eutrophication impairment by reducing levels of P in the Lake. What about the other impairments?
   WDNR: The text has been changed in the document to emphasize that this TMDL is addressing both phosphorus and sediment and their corresponding impairments.

3. Is this table consistent with the 2006 list? The 2008 list?
   WDNR: This table has been updated to reflect changes to the 2008 303(d) list (pending US EPA approval as of 08/01/08). Total phosphorus is incorrectly listed as an impairment on the 2008 list (this is only a pollutant for this impaired water body and is being corrected).

4. What is the significance of having P levels greater than 50ppb?
   WDNR: Lakes are generally considered eutrophic when P concentrations are measured at over 20 ppb. This was addressed in the text.

5. This section includes very good information about previous studies and their conclusions, however, a clear linkage is needed to the impairments and pollutants for which loads are being established.
   WDNR: This was addressed by adding a "Problem Statement" section in the TMDL report and also additional text in the "Water Quality Standards section."

6. What are acceptable TSI values?
   WDNR: 50 is the boundary between eutrophic and mesotrophic conditions in the lake. Any TSI over 50 is considered eutrophic. This was addressed in the text as well.

7. Include a statement why SWAT is a reasonable model to use for this TMDL.
   WDNR: Text was added to explain why SWAT was used for this TMDL.

8. Include a statement explaining why these were simulated and why these are reasonable scenarios for this TMDL.
   WDNR: The scenarios for this TMDL were chosen with assistance from the Clark County Land Conservation Department. These are reasonable and feasible scenarios that are linked to agriculture and may be implemented in this region of the state. This was addressed in the text.

9. What is the basis of the estimated values?
   WDNR: The term estimated values has been changed with "monitored loads" since the model was developed based on what was actually measured in the watershed.

10. What is the basis for saying they were simulated correctly?
    WDNR: This was addressed in the text. After the model was calibrated with 2002 monitored loads, the model was verified by predicting the 2003 measured load. Good agreement between the calibrated and verified loads is an indication the model was predicting accurately.

11. (Multiple comments) Please address the impairments, pollutants and the linkage of how they were selected to meet water quality standards in the report.
    WDNR: This was addressed by adding a "Problem Statement" section in the TMDL report and also additional text in the "Water Quality Standards section."

12. The TMDL is only addressing external loadings of P to Mead Lake, correct? Will these external load reductions, without any internal load reductions, achieve the applicable water quality standards?
    WDNR: The goals set for phosphorus and sediment for this TMDL will meet the identified water quality standards. Further improvements could be made to the lake in the future if more water quality improvements, including internal load reductions,, are pursued. This was addressed in the text.

13. Explain how you determined that the mean summer sediment load needs to be reduced by 30% to 233 tons and the annual load needs to be reduced to 826 tons.
    WDNR: Text was added to explain that the SWAT model used P as a surrogate to reach a sediment reduction target for Mead Lake.

14. In the WLA sections, something should be said about the other two impairments, i.e. sedimentation and pH and how the WLA addresses these.
    WDNR: Comment addressed in the text.

15. Explain why seasonal and annual daily load allocations are necessary to achieve water quality standards.
    WDNR: This was addressed in the text.

16. If you want to use the 30% as a MOS, what is the reduction needed to achieve the 93 ppb so it is obvious that the TMDL and associated load allocations are indeed more conservative than needed.
    WDNR: This was addressed in text – p. 11

17. The seasonal variation section explains the impact of seasonality on phosphorus but how was seasonal variation taken into account specifically in the model runs that led to the % reductions used to calculate the allocations and how was seasonal variation taken into account in calculating the loading capacity?
    WDNR: This was addressed in text – p.7 and 11

18. Please indicate in Tables 5-8 that you are assigning the load allocation to nonpoint sources.
    WDNR: In tables 5-8 the load allocation is assigned to nonpoint sources only since the Mead Lake Watershed contains no point sources.