Potential NPS Phosphorus Reductions in the Red Cedar River Basin

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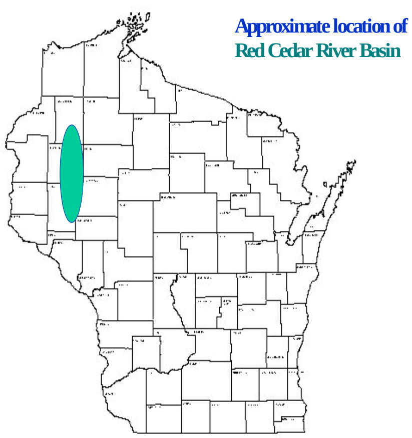
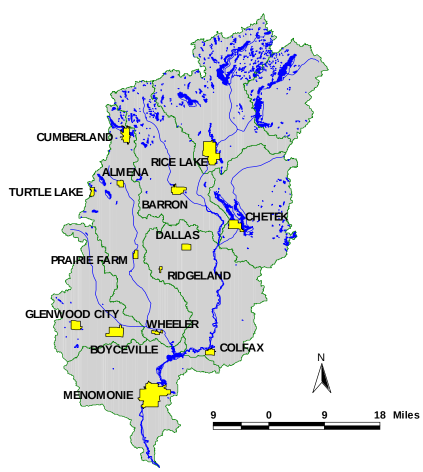
The Total Maximum Daily Load (TMDL) analysis for Tainter Lake identifies the need to reduce phosphorus loads from nonpoint sources. This document identifies the scope and relative importance of management practices needed to achieve nonpoint source phosphorus reduction.

Many stakeholder groups are needed to develop an implementation strategy for reducing phosphorus loads from nonpoint sources. They can assist in identifying a range of best practices to pursue, establishing implementation strategies and conducting evaluation activities.

The Red Cedar River Basin has been studied extensively in the past, and much is known about the nature and extent of its water quality problems. However, much less is known about how extensively best management practices proven to minimize pollutant losses are currently used. For example, we don't know the acreage of nutrient management for phosphorus control being practiced in the watershed. Nor do we know the acreage of land in reduced tillage practices. There are some indirect measures of practice trends over time, including county trends in average soil phosphorus level and number of agricultural soil samples collected. The lack of basic inventory information necessitates the use of more generic, literature-based approaches to estimating the potential benefits associated with various nonpoint-source best management practices.





This document combines BMP effectiveness information available in the literature with land use characteristics of the Red Cedar Basin compiled through the TMDL process. The resultant information illustrates the *relative* opportunities for control of phosphorus from nonpoint sources in the basin. This analysis is a starting point for developing a cost-effective strategy for phosphorus control and is intended to answer questions often encountered in public discussions about the relative benefits of various practices to control nonpoint sources of phosphorus.

In 1999, the Department completed a water quality model for the Red Cedar Basin that estimates sediment and nutrient (phosphorus) loading. Seven watersheds were analyzed in the basin with the Simulator for Water Resources in Rural Basins (SWRRB) model. The model identified and assigned unit area loading coefficients to a range of distinct land use categories, and predicted annual sediment and phosphorus loads delivered to Tainter Lake. Phosphorus loads from point sources (permitted dischargers) were calculated from measured P concentrations in effluent and flow volume. Calculations of phosphorus loads from barnyards complete the overall estimate of phosphorus loading.

Background or uncontrollable phosphorus loads

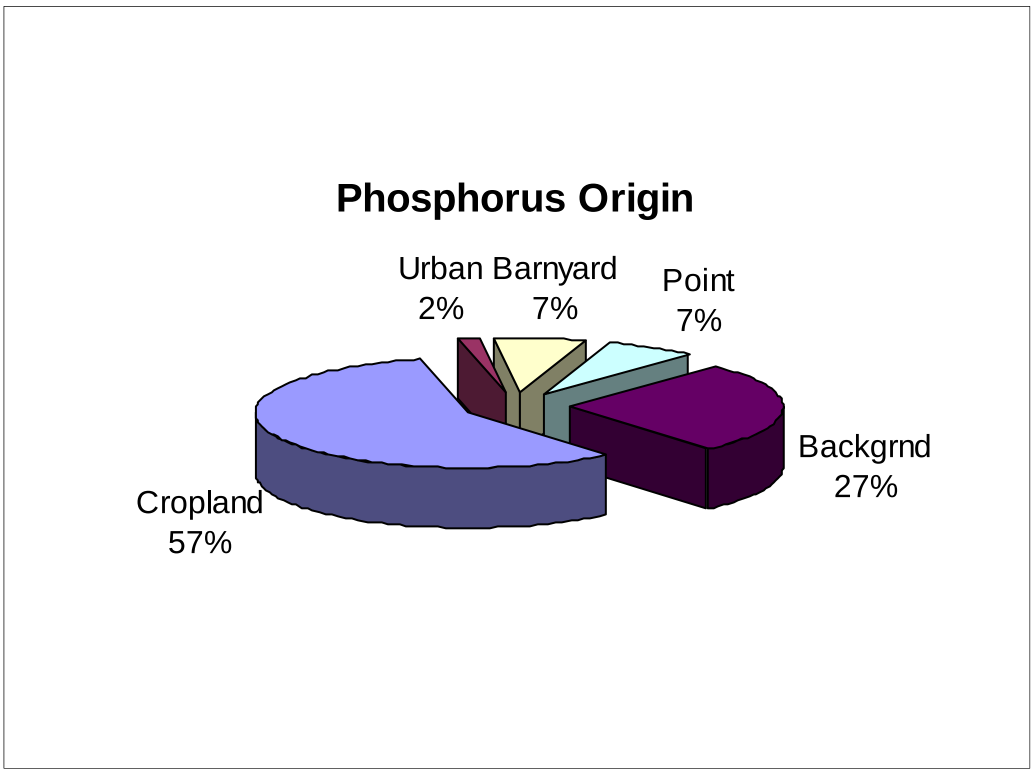
Phosphorus loads from forests, grassland and pasture were considered uncontrollable, or “background” loads. While some level of control on these land uses is possible, loads from these uses are small compared to other sources.

The SWRRB model was used to estimate the uncontrollable loads in the basin using the following process.

- Point source and barnyard loads were set to zero.
- Loads for cropland and urban areas were set to that of grassland/pasture for each contributing watershed.

This analysis treats all land uses in the basin as grassland/pasture, and simulates conditions that might be expected without human activity in the watershed. Figure 1 below illustrates the proportion of all loading to Tainter Lake, with the largely uncontrollable sources being aggregated under the designation of “background”. It is unrealistic to expect to ever reduce loads to background levels; however this exercise illustrates that a large proportion (over 70%) of the current load is being generated by human activity and is therefore to some extent controllable.

Figure 1. Percent of phosphorus delivery to Tainter Lake from controllable and aggregated, uncontrollable background sources



Controllable Phosphorus Loads

The following semi-quantitative analysis predicts phosphorus reductions from selected BMP applications on agricultural phosphorus sources. Most of the analysis is directed at answering the question, How much phosphorus can be controlled by implementing *X* amount of BMPs in the basin? This analysis has several fundamental conditions that are important to keep in mind.

1. The BMP applications are generally assumed to be over the entire basin area and are targeted only to a limited extent. Targeting the implementation of BMPs to those lands delivering the highest amounts of phosphorus will make all BMP investments more effective. The individual analyses indicate the extent to which targeting was assumed. Additional detailed planning could further target BMP applications to take full advantage of variable land use conditions in the individual drainage areas.
2. The estimations developed in this document are of the "back of the envelope" variety and are not as accurate as more rigorous mathematical analysis like the SWAT Model (Soil and Water Assessment Tool) or the Snap-Plus Model.
3. Credits or assignments of P reduction estimates by BMP do not take into consideration that some of these BMPs may overlap others. This analysis assumes that each BMP is independent of another.

Using methods explained in the following narratives, the practices summarized in this table are based on averages and were developed with very limited inventory information. Better inventory information could be used to adjust the figures. Examples of needed inventory information are cropland P Index values, numbers of barnyards in need of management, acres of cropland receiving winter manure applications and number of failing septic systems.

Best Management Practice	Lbs/yr P Reduced
Reduced tillage on 40,000 - 118,000 acres (depends upon level of targeting)	**81,000**
Eliminate winter manure spreading on 6,500 acres by adding 50 manure storage structures	**36,000**
Phosphorus based nutrient management on highest delivery 1/3 of cropland	**33,000**
Remove winter manure application from 1800 critical acres	**30,000**
Waste treatment for 30% of existing milk houses (13,200 cows)	**16,000**
Traditional conservation practices on 10% of cropland acres	**12,000**
Add runoff control to 1/3 of barnyards (270)	**8,200**
Install 113 miles of 50' wide stream buffer	**3,100**
Control of urban stormwater P delivery	**1500**
1000 acres of wetland restoration	**1,000**
Replace all failing, critically located septic systems (440)	**420**
Control stormwater on all rural, riparian, residential properties (2200 lots ¼ acre in size)	**220**
Total Reduction	**222,440**

The above table is an example to illustrate how a combination of Best Management Practices can be applied to conditions thought to exist in Red Cedar Basin to obtain substantial watershed phosphorus reductions. The numbers in the table are expressed only to two significant figures in recognition that these are simple approximations without watershed inventory data. It is important to recognize the relative significance of each identified practice as well as the need to make progress in many areas to obtain the reductions identified in the TMDL. This list will need to be further developed over time, and perhaps other practices added, through an implementation process that will involve many watershed stakeholders. It is important to recognize that some of these identified improvements have already taken place since the modeling was done 15 years ago. It will also be important to incorporate economics into the decision process.

Conservation tillage

The term "conservation tillage" includes a number of different tillage systems currently used in Wisconsin and around the nation. To qualify for cost sharing in Wisconsin, guidelines require that the tillage practice maintain at least 30% crop residue cover. Studies show that residue below this level reduces conservation effectiveness,, while residue above this level optimizes soil erosion control and infiltration. Transect studies completed by both Barron and Dunn Counties reveal that residue levels vary widely over the basin and are dependent on variables including crop type, soil type, tillage implement, and operator style. While most of the cropland in this basin may appear to be under conservation tillage, in fact only a small percentage of cropland meets the 30% residue threshold (15% in Dunn County and 8% in Barron County). It is apparent that improvements in tillage practices that result in higher crop residue levels will result in phosphorus load reduction. Three different scenarios are presented below to demonstrate the potential for reduction.

Analysis:

There are 312,000 cropland acres in the Red Cedar Basin above Tainter Lake (DNR, 1999). Of this, 281,274 acres of cropland are below 30% residue (Barron and Dunn County Transect surveys, 1999).

- **Scenario 1 (Some Targeting)** - Tillage management at the 30% residue level is 64% effective (Cook, 1999) at reducing phosphorus. Modeled unit area loads of P are assumed at 1.26 lb/acre of cropland (Panuska and Lillie, 1999). The load reduction achieved by converting 100,000 acres of cropland at <30% residue cover to >30% residue cover would be:

  100,000 ac. x 1.26 lb P/ac x .64 = **80,640 lb P reduced**

- **Scenario 2 (No targeting) -** The weighted average cropland P loss for the Red Cedar Basin (DNR 1999) is 1.064 lb/acre, somewhat lower than the average loading of 1.26 lb/acre (Panuska and Lillie, 1999). Tillage management at the 30% residue level is 64% effective at reducing phosphorus (Cook, 1999). The cropland acreage needed to control 80,640 pounds of P given the average 1.064 lb/acre P loss in the Red Cedar Basin would be:

  80,640 lb / .64 / 1.064 lb/ac = **118,421 acres needed**

- **Scenario 3 (significant targeting) –** As part of a pollutant trading arrangement in the basin, the Barron County Land Conservation Department has been able to target implementation of no till planting to be able to achieve an average reduction of 2 lb/ac as estimated by Phosphorus Index (P Index) modeling (Ward Good and Panuska 2004). To achieve this level of P reduction, targeted cropland acres have a high P loading rate of over 3 lb/acre.

  2 lb/acre / .64 = **3.12 lb/acre**

  The acreage needed to achieve 80,640 pounds of P control with this level of targeting would be:

  80640 lb / 2 lb/acre = **40,320 acres**

  For all conservation tillage scenarios, **80,640 pounds of P are controlled**

Nutrient Management to Crop Phosphorus Need

Nutrient management practices have been promoted through a number of state programs that provide cost sharing and technical services to crop producers. Despite the emphasis placed on this practice in recent years, many acres of Wisconsin cropland are not currently under a nutrient management plan (NMP). Nutrient management will continue to be promoted and it is expected that significant gains in adoption and implementation of NMPs will occur over the next ten years. The use of nutrient management as a water quality tool is based on reducing nutrient inputs to levels required by crops. There is considerable evidence from the UW-Madison Plant and Soil Laboratory that phosphorus levels in cropland soils across Wisconsin are increasing over time (Combs and Peters, Wisconsin Soil Test Summary: 1974-1999, Department of Soil Science, UW-Madison).

Nutrient management can effectively balance inputs with crop uptake and through this method reduce the amount of excess nutrients vulnerable to runoff. The estimation of phosphorus reductions with this practice uses assumptions related to unit area load concentrations of phosphorus, cropland acreage, soluble versus particulate phosphorus, relationship of runoff P concentrations to soil test P concentrations, average soil test P levels and nutrient management practice adoption rates.

The Phosphorus Index (P Index) has emerged at the preferred field scale model for cropland nutrient management in Wisconsin. Studies in a watershed in southern Wisconsin on the frequency distribution of cropland P Index values found that 11% of cropland delivered 20% of the cropland P load (Laura Ward Good unpublished data). These concepts were used to estimate the potential benefits of nutrient management in the Red Cedar Watershed. The frequency distribution of cropland P index values is not available for the Red Cedar Basin; therefore the distribution found in the southern Wisconsin study was used for the following calculations. . The reader is cautioned that this analysis is based on phosphorus **delivered to waterways** while P Index values are phosphorus **delivered to the field edge**. P Index investigators are suggesting that actual delivery to waterways may be only 10% of the edge of the field values however this relationship is highly site specific. Therefore this analysis did not attempt to project P Index values for the Red Cedar Basin.

Analysis:

The SWRRB model analysis indicates that the 312,000 cropland acres deliver an average of 1 lb/ac to waterways in the basin.

Estimating high phosphorus reductions from highest delivery fields:
As stated earlier, 11% of cropland is estimated to deliver 20% of the cropland P load.

11% of watershed cropland acres = 312,000 acres x .11 = **34,320 ac** of high delivery fields

20% of cropland load = 312,000 lb P x 0.2 = **62,400 lb P**

62,400lb / 34,320 ac = **1.8 lb/ac** average delivery to waterways from highest delivery fields.

Based on generic application of P Index concepts to Barron County soils it was estimated that that taking fields with a soil phosphorus (Bray) level of 100 PPM (high delivery fields) to crop need at 25 PPM, all else remaining the same, would reduce phosphorus delivery by 30%.

62,400 lb P X .3 = **18,720 lb P reduced** from highest delivery fields

Estimating moderate phosphorus reduction from moderate delivery fields:
From southern Wisconsin studies, 32% of cropland fields deliver 50% of the cropland P load. Moderate delivery fields are 32% of cropland acreage minus the highest delivery fields (11% of the acreage), or 21% of the 312,000 cropland acres in the basin.

312,000 ac X .21 = **65,500 ac** of moderate delivery fields

High and moderate delivery fields together deliver 50% of the P load. Phosphorus from moderate delivery fields is the total of the high and moderate field delivery minus the P from the high delivery fields.

312,000 lb X .5 – 62,400 lb (high delivery fields) = **93,600 lb P** from moderate delivery fields

93,600lb / 65,500 ac = **1.43 lb/ac** average delivery to waterways from moderate delivery fields

Based on generic application of P index concepts to Barron County soils it was estimated that that taking fields with a soil phosphorus (Bray) level of 50 PPM to crop need at 25 PPM, all else remaining the same, would reduce phosphorus delivery by 15%.

93,600 lb X .15 = **14,040 lb P reduced** from moderate delivery fields.

No additional nutrient management on remainder of watershed:
From southern Wisconsin studies, 68% of the (lower delivery) cropland fields deliver 50% of the cropland P load.

312,000 ac X .68 = **212,160 ac** of lower delivery cropland fields

312,000 lb X .5 = **156,000 lb** P from lower delivery cropland fields

156,000lb / 212,160 ac = **0.73 lb/ac** average delivery to waterways from lower delivery cropland fields

Combined effects of nutrient management on highest delivery fields (11% of watershed acreage) and moderate delivery fields (21% of watershed acreage)

18,720 lb + 14,040 lb = **32,760 lb P reduced** from highest and moderate delivery fields

Critical manure spreading areas

Inventories designed to document the extent of manure spreading on lands subject to runoff were conducted in a number of priority watershed projects. For example, the Yellow River Watershed project in Barron County estimated that 40 livestock operators each were spreading manure on more than 6 acres of critical lands, or lands subject to the highest risk of runoff. The best management practice would be the discontinuation of winter manure spreading at these high risk sites. This could mean that a manure spreading plan would be developed, or in some cases, manure storage might also be required. Phosphorus reductions from diverting manure application away from critical areas are best estimated by the P Index model on individual fields. However, this analysis uses more generic procedures to estimate phosphorus reductions from changes in manure spreading activities by accounting for reductions in P in runoff from high risk sites no longer receiving winter spread manure.

Analysis:

Assume 25 tons manure/acre/year was applied (UWEX Fast Facts).

There are 33 pounds of P in 25 tons of manure (UWEX Fast Facts).

Future phosphorus applications during nonfrozen periods would continue to supply some amount of P runoff 50% of the annual load (personal communication Barron County LCD). This rate is probably extreme, but these cropfields would constitute the highest risk of all cropfields.

It is assumed that all of the agricultural sub-watersheds in the Red Cedar Basin have the same density and distribution of critically spread acres. There are no field inventories of specific conditions outside of the two existing priority watershed projects. The estimate extrapolated from priority watershed data is of 1,800 acres of critical spreading in the Basin.

1,800 acres x 33 lb P x .5 = **29,700 lb P** controlled by eliminating critical winter spreading

Milk House Waste

Phosphorus reduction from milk houses can provide significant control opportunities, due to the relatively large amount of phosphorus contained in some of the acid washes in daily cleaning. Several hundred gallons per day of discharge can find its way to channelized flow areas and eventually into nearby surface waters. There are various different control technologies used to manage milkhouse waste discharge. Estimates of control are based on UWEX publication A3592.

Analysis:

Considering a variety of BMPs, average controls of P are 75% effective (effectiveness of control ranged from 30-89%). The average phosphorus load from milk house waste is 72 lbs/year for farms with 28 to 60 cows. Using 44 cows as an average herd size:

72 lb / 44 cows = **1.64 lb P/cow/year**

Agricultural statistics for Dunn and Barron counties, adjusted for the land area upstream from Tainter Lake, suggest a dairy cow population of about 44,000 (2002 Wisconsin Agricultural Statistics, Wisconsin Agricultural Statistics Service, Madison, Wisconsin). It was assumed that 30% of these cows are on farms that discharge to surface water.

44,000 cows X .3 = 13,200 cows on farms discharging to surface water.

13,200 cows X 1.64 lb P/year X .75 = **16,236 lb P** controlled with milk house waste BMPs

Barnyard Runoff Management (filter strips)

This BMP has a long history of implementation in Wisconsin. Inventory information from past priority watershed projects in the Red Cedar Basin was used to establish average phosphorus loads for barnyards in the Basin. A total of 194 barnyards with modeled phosphorus loads produced an average of 37 lb P/barnyard/year. Based on a report by Chad Cook, (A Review of Agricultural and Urban Best Management Practices for the Reduction of Phosphorus Pollution, Wisconsin DNR, undated) the application of filter strips to control barnyard runoff flows is 62% effective.

Analysis:

The SWRRB model (DNR 1999) estimated 1510 barnyards in the basin. Priority Watershed inventory data was adjusted to reflect conditions in the early 1990s based on observations of Dunn and Barron County Land Conservation Department staff. The number of dairy farms in WI has declined about 45% since the early 1990s (WI Milk Marketing Board). Adjusting for this reduces the estimated number to 830 barnyards. During this same time period the number of cattle and calves in Dunn and Barron Counties has declined about 27% (USDA-NASS). Putting 27% fewer cattle and calves on 45% fewer barnyards means the average size of the barnyards would increase about 30%.

It was assumed that one third of barnyards (277) would benefit from filter strips or similar management practices. The use of BMPs on all barnyards is unlikely and experience has shown that the highest loading yards are more often treated with a BMP. Priority watershed projects utilizing field inventories have reported numerous yards with zero discharge while others have been recorded with hundreds of pounds of P discharge.

The average of 37 lb P/barnyard derived from Priority Watershed inventory information was adjusted upwards by 30% (48 lb P/barnyard) to reflect the increase in barnyard size since the early 1990s.

277 barnyards x 48 lb P/barnyard x .62 = **8,243 lb P** controlled by barnyard runoff control practices

Manure storage

Phosphorus reductions associated with manure storage are derived from the absence of winter landspreading. Estimates of the amount of storage needed are based on an assumed number of storage units needed to prevent critical acre spreading and that these storage units would have 180 days of storage time. With winter storage, manure spreading can distributed over a much larger number of acres, and be confined to non-winter periods, thereby avoiding phosphorus loss due to frozen ground conditions.

Analysis:

As described above, there are an estimated 830 barnyards in the basin. Experience in the Wisconsin Priority Watershed program and statistics reported by the UW Program on Agricultural Technology Studies (Report Number 6, July 1997) concerning the rate of manure storage adoption by Wisconsin livestock operators suggest that about 50 of these might be spreading on critical acres and would need or qualify for and agree to storage.

It is assumed the 50 storage units serve an average of 130 acres of land each. The amount of land serviced by a single storage unit is based on estimated acres and the trend of larger operations utilizing manure storage reported by the UW Program on Agricultural Technology Studies (Report Number 6).

50 storage units x 130 acres cropland/unit = **6,500 acres served**

Future phosphorus applications would continue to supply some P to runoff at a rate significantly lower than the 50% of the annual manure P when winter spreading occurs on critical acres as reported by Barron County (personal communication).

A 20% P loss rate is used as a gross estimation of loss of land applied P on the 6,500 acres prior to being served by manure storage, and amounts to approximately 6.6 lb/acre annually. This number is supported by field investigation at the watershed level (Hazuga, 2009). This is a relatively high rate of P loss, but some acres would represent a high level of risk from P loss if winter spreading occurred on them.

The assumed application rate is 25 tons/acre/year of manure or 33 lb P/acre/year (UWEX Fast Facts). It is assumed that all nutrients applied are from manure.

33 lb P/acre/year x 6,500 acres x .2 = **42,900 lb P** lost prior to installation of manure storage

This is the rate of loss associated with winter spreading of manure. If manure is applied during spring or fall there will be some runoff associated with this activity at a reduced rate. Manure applied from spring or fall applications is estimated to lose 1 lb P/acre/year (the watershed average) as compared to the 6.6 lb P/acre/year from winter applications.

1 lb P/acre/year x 6,500 acres = **6,500 lb P** lost with winter storage in place

42,900 lb P – 6,500 lb = **36,400 lb P controlled** by use of winter storage

Traditional soil erosion control

For many years, the use of "traditional" practices like crop rotations, contour plowing, strips, grassed waterways and terraces have been promoted and implemented across the Red Cedar Basin. Reduction of cropland erosion through "traditional" practices and through conservation tillage has been estimated and reported in the Barron and Dunn County Land and Water Resource Management Plans. These plans estimate that about 50% of the cropland soil erosion control accomplished is due to "traditional" soil erosion control practices. Another 50% are due to tillage practices, independent of "traditional" BMPs.

Despite the acceptance of these practices over the years there remain a number of farming operations that have not implemented these practices. In addition, there is some evidence reported by the Barron County Land Conservation Department that some practices like grassed waterways are actually being removed as an outcome of the use of newer larger implements (personal communication, Barron County LCD).

The Land and Water Plans also estimate the number of acres that are below and above the "T" level of soil erosion (near 5 tons/acre). These estimates are derived from transect studies conducted in both counties, and are based on trained visual observations of croplands at assigned sample points.

Analysis:

Assume that 31,000 of the 312,000 cropland acres in the Red Cedar Basin (10%) could achieve better erosion control from traditional conservation practices. This work would need to be targeted to cropland above "T" with a goal to bring it below 5 tons/acre soil loss.

Assume that traditional conservation practices will reduce erosion from 5 tons/acre to 4 tons/acre at the field level. Further assume that cropland erosion contains 4 lb P/ton of soil (Panuska personal communication).Then 31,000 tons of soil loss prevented x 4 lb P/ton of sediment = 124,000 lb P controlled at the field level.

The WIN sediment delivery model developed by the DNR for use in the Priority Watershed Program indicated that only about 10% of this one ton/acre gross cropland soil erosion loss is actually delivered to a water body. Correcting for this:

124,000 lb P X .1 = **12,400 lb P** controlled by use of "traditional" conservation practices

Stream Buffers

This practice is very popular, especially with the development of the recent Conservation Reserve Enhancement Program (CREP) from USDA. Wisconsin allocates both state and federal funds for installation of riparian buffers and practices. Currently, Wisconsin ranks 6th in dollars committed among all states participating in the program. In 2008 DNR and NRCS funding was used to restore 19 miles of stream banks and shorelines and to enroll 28,600 acres of riparian buffers into the CREP in WI (WI DATCP 2009). The funding for this program is one of the largest ever targeted for conservation in Wisconsin. Buffers provide benefits associated with wildlife and fishery habitat and provide increased biological diversity along streams. These are benefits that do not directly affect water quality. Understanding the characteristics of buffers and how they work to improve water quality is important to evaluating how effective they will be in controlling phosphorus in the Red Cedar River Basin.

Buffers improve water quality when they receive overland sheet flow from upslope drainage areas. Through processes of infiltration, filtration and sedimentation, buffers improve the quality of runoff water. Slope, drainage area, land use, and upland management practices are a few of the important variables affecting buffer performance. Buffers cannot treat the entire landscape. NRCS technical guides for riparian buffers do not credit buffer control of runoff water more than 300 feet upslope of the buffer. Beyond 300 feet, runoff water is most likely to travel in a concentrated channelized flow, and not be subject to the beneficial effects of a buffer (NRCS Technical Guide 393). Additionally, at distances beyond 300 feet, runoff will often be drained to an adjacent drainage area that flows to a nearby swale or similar drainage feature, rather than directly to the stream (Randy Gilbertson, NRCS, personal communication, 2001).

Analysis:

The average phosphorus control achieved by 50-foot buffers is estimated to be 60% (Cook DNR, 1999). A Barron County field survey reported in the Barron County Land and Water Plan identified 485 potential buffer sites. Extrapolated to Dunn County, the total number of buffer sites in the basin is estimated at 685.

One buffer is assumed to be 50 feet wide by 871 feet long, or 1acre in size. The up-gradient treatment area associated with this buffer is 300 feet wide.

300 feet x 871 feet/43,559 sq. feet/acre = 6 acres treatment area draining to buffer

All the treated drainage area is assumed to be cropland because the survey conducted by Barron County specifically identified riparian sites that had cropland close to streams.

685 buffers x 6 acres treated cropland/buffer = **4,110 acres** of cropland receiving treatment

4,110 acres cropland x 1.26 lb P/acre x .6 = **3,107 lb P** controlled by buffers

871 feet per site X 685 sites / 5280 ft/mi = 113 stream miles of 50-foot buffer on one side of the stream. (This mileage would be decreased if buffers were put on both sides).

Runoff control in incorporated areas

Because of the rural nature of the Red Cedar River Basin, urban runoff contributions are estimated to be a small contributor of phosphorus. The SWRRB model estimated an urban stormwater phosphorus load of 12,500 lb P/yr which is 2.5% of the total load coming from above Tainter Lake. While construction sites of one acre or more and industrial sites are regulated by DNR permit (and included in the point source wasteload allocation of the TMDL), no incorporated areas upstream from Tainter Lake are currently designated as a Municipal Separate Storm Sewer System (MS4), which would require WPDES stormwater permit coverage. However, Rice Lake is in the process of MS4 designation.

Communities regulated by stormwater permits are expected to implement BMPs to reduce suspended solids delivery from existing development by 40% as compared to loads that would be delivered without BMPs. This is demonstrated through local modeling studies. It is likely that Rice Lake will need to eventually comply with this regulatory requirement for MS4 communities while the other incorporated areas within the basin would fall into the category of voluntary compliance. Urban BMPs include a wide variety of practices including temporary detention basins, infiltrations practices, public education, etc. It has been estimated that a 40% suspended solids reduction in an urban area using a variety practices will also reduce phosphorus delivery by about 24% (Rortvedt & Kirsch 2010). Because temporary detention basins trap mostly sand, they are less effective at reducing phosphorus which is largely attached to silt and clay and not effectively trapped. Urban BMPs that infiltrate stormwater water rather than routing it to surface water are much better at eliminating phosphorus delivery. When selecting urban stormwater BMPs in the basin it will be important to give consideration to their ability to reduce phosphorus.

Analysis:

Estimate the combined effect of future regulation of urban stormwater in Rice Lake and partial, voluntary control by other communities. Partial, voluntary control would likely take place in conjunction with future development or rehabilitation projects where incorporation of stormwater BMPs could be economically added.

The US Census Bureau 2008 estimates the Rice Lake population at 8,257, and all other incorporated areas at 16,782. Based on this, it was estimated that 1/3 of urban stormwater generated in the watershed upstream from Tainter Lake originates in Rice Lake. Similarly, 1/3 of the urban P load (Rice Lake) will be 24% controlled by achieving the 40% suspended solids control requirement. It is assumed that for 2/3 of the urban P load, 25% of the urban source area will voluntarily install BMPs to achieve 24% control of the P from the source area.

> 12,500 lb P/yr (from all urban areas) X .33 = **4,125 lb P/yr currently from Rice Lake and anticipated to be subject to regulatory control**
>
> 12,500 lb P/yr X .67 = 8,375 lb P/yr currently from other urban areas
>
> 8,375 lb P/year other urban areas X .25 = **2,094 lb P/yr anticipated to receive voluntary control**

(4,125 lbsP/yr from Rice Lake + 2,094 lbsP/yr from other areas) X .24 = **1,492 lbs P controlled from urban sources**

Restore Wetlands

Restored wetlands have some water quality benefits in addition to the obvious improvements of biological diversity and wildlife and fisheries habitat. This practice can be considered for use in the Red Cedar River Basin and is currently being implemented through a variety of cost share and financial incentive programs. Phosphorus uptake by wetland plants in the spring and summer can effectively diminish the amount of phosphorus from incoming runoff water. However, studies indicate that during plant decay in the fall of the year some of this phosphorus is released and is subject to movement downstream. One way to estimate the ability of wetlands to control phosphorus is by predicting accumulation rates of P per unit area of wetland. As with many of the BMPs there are wide ranges of controllability depending on the specific variables of the practice. Wetland phosphorus accumulation rates have been reported at .05 to .22g/m^2/year (Cook, DNR, 1999). These rates can be used to estimate the P controllability associated with restored/created wetlands.

Analysis:

The average accumulation rate is 0.14g/m^2/year.

> 0.14g/m^2/year x .03527 ounces/g x 1 lb/16 oz. = 0.0003086 lb/m^2/year

After conversion of m^2 to acres, the phosphorus accumulation rate is 1.055 lb P/acre/year, similar to the unit area loading rate for croplands in the basin (DNR 1999). Note that some restoration of wetlands would retire croplands, and reduce P loading by a small amount.

Assume 1000 acres of restored or re-created wetlands.

> 1000 acres x 1.055 lb P/acre/year = **1,055 lb P accumulated/retained** from 1,000 acres of wetland restoration

Replace Failing Septic Systems

Phosphorus tends to bind to soil particles and does not easily move through the soil column to reach groundwater, unlike nitrogen which readily passes through soil. Human sewage entering septic systems contains phosphorus. In properly operating systems in good soils, phosphorus tends to remain in the soil adjacent to the septic system. However, as septic systems age the binding capacity of the soil can be saturated, particularly in sandy soils. Under these conditions, phosphorus can begin to move off the site in groundwater. In addition, failing septic systems often discharge wastewater to the surface and create an additional opportunity for phosphorus to leave the site. A study in Minnesota has estimated the phosphorus delivery from riparian septic systems at 0.32 kg/capita/yr for failing (surfacing) systems and 0.16 kg/capita/yr for other systems (Barr Engineering 2004). A study by WI DATCP estimates the percentage of failing septic systems in WI at 20% (Wisconsin Department of Commerce, 1998).

An investigation in a nearby watershed that applied the above figures estimated a phosphorus delivery of 1 lb/mi^2 of watershed from rural, riparian septic systems (Trombly, Dec. 2009). This study also indicted a density of 0.84 rural, riparian residences per mi^2 of watershed area. This number was used to estimate the phosphorus from rural residential properties near waterways in the watershed upstream from Tainter Lake. To account for the high density of residential properties around Tainter and Menomin Lakes, the Lake Improvement Association reported membership of 836 households was added the above total. Not all of these have lakefront property but for the purposes of this estimate all were treated as riparian property.

Analysis:

1660 mi^2 watershed above Tainter Lake X 1lb/mi^2 = **1660 lb P** from septic systems near waterways in the watershed.

836 X 0.2 households X 2.5 residences per household X 0.32 kg/cap/yr = 133.7 kg/yr or **294 lb P/yr** from the estimated 20% of failing riparian septic systems.

836 X 0.8 households X 2.5 residences per household X 0.16 kg/cap/yr = 267.5 kg/yr or **589 lb P/yr** from the estimated 80% of functioning riparian septic systems.

Total estimated septic load = 1660 + 294 + 589 = **2543 lb P/yr** from riparian household septic systems

Replacing the 20% of the failing septic systems reduces their loads by 50%, which results in a 17% reduction overall in riparian septic load.

> 2543 lb/yr X .17 = **423 lb P reduced** watershed septic load achieved by replacing failing riparian septic systems

The total number of rural riparian septic systems is 1660 mi^2 X .84 riparian residences per mi^2 (1394 residences) plus 836 Lake Tainter riparian residences, for a total of 2230 riparian residences.

Stormwater Control on Rural, Riparian, Residential Properties

From the septic analysis it was estimated that 2,230 rural residences are close to waterways in the Tainter-Menomin watershed. Installation of practices to infiltrate stormwater on residential riparian property can be estimated to reduce the phosphorus delivery about 0.4 lb/ac/yr (Panuska 2004). If the average size of rural residential properties in the riparian zone is ¼ acre then the estimated benefit from controlling rural residential stormwater phosphorus is:

> 2230 residences X .25 acres/residence X 0.4 lb P saved = **223 lb P controlled**

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