

## II. INTRODUCTION

This section provides a brief history of the Rock River Watershed Partnership, its mission, and the basis for the studies reported herein.

### A. Brief History

The Rock River Basin includes about 3,750 square miles of area in south central Wisconsin. Figure 1 shows the boundaries of the Rock River Basin. As indicated in the figure, the basin includes significant portions of nine counties. For administrative purposes, the Wisconsin Department of Natural Resources (DNR) has divided the basin into two sections: the Upper Rock River Basin (eastern Columbia, Dodge, southwestern Fond du Lac, western Washington, northwestern Waukesha, northern Jefferson, and northeastern Dane counties), and the Lower Rock River Basin (remainder of basin).

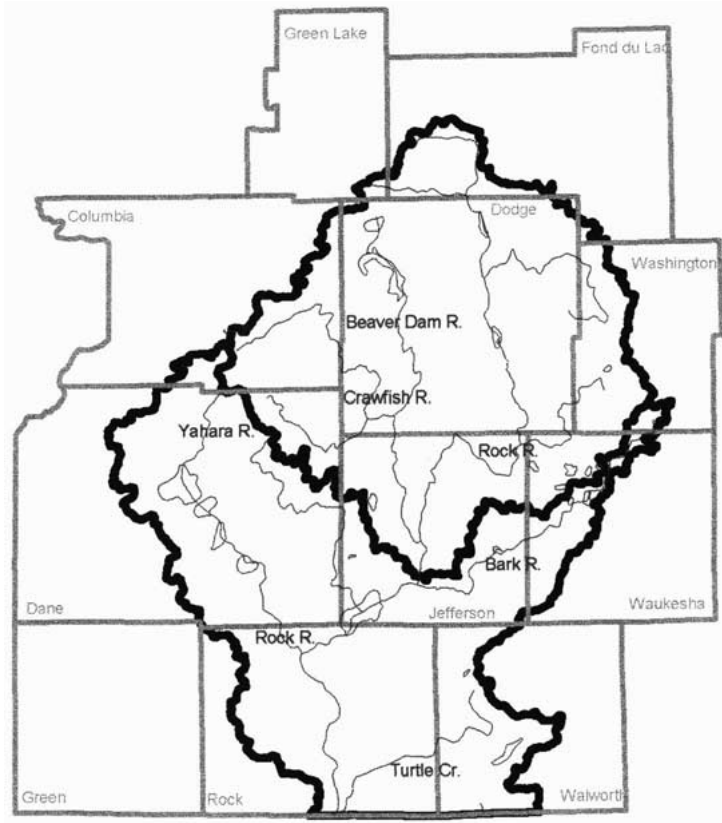


Figure 1 - The Rock River Basin

Water resources in the basin have been negatively impacted by nutrient enrichment. A number of water bodies in the basin are listed on the DNR's "303d List", which is an inventory of those water bodies in the state which do not meet water quality standards or support designated uses. Many water bodies are listed because of over-enrichment.

The Rock River Watershed Partnership is a stakeholder group, which was formed in 1996. The group is committed to addressing nutrient and other water quality management issues within the Rock River Watershed in an integrated, holistic manner using the tools of watershed-based planning/decision-making.

The Rock River Watershed Partnership encourages groups and individuals having an interest or 'stake' in nutrient and other water quality issues in the Rock River Basin to actively participate in the Partnership. The Partnership works to accomplish the following goals:

- Identify nutrient and other water quality concerns within the Basin and prioritize these concerns (e.g. phosphorus).
- Identify water quality objectives/desired conditions within the Basin for each parameter of concern.
- Inventory existing point and non-point sources for each parameter of concern.

- Identify strategies for achieving each water quality objective/desired resource condition. This may include developing site-specific water quality standards and/or total maximum daily loads (TMDLs).
- Establish unit costs for each controllable pollutant source (both point and non-point) and the least-cost-mix of alternatives that, if implemented, would achieve the water quality objective/desired resource condition.
- Implement actions based on priorities established by the stakeholders with implementation between point and non-point nutrient sources (e.g. phosphorus).
- Routinely monitor progress and make necessary adjustments

Division of the Basin into smaller units (watersheds or sub-watersheds) may be necessary to effectively accomplish water quality management issues. If division is necessary, the above approach may be independently applied to the resulting smaller units.

The Rock River Watershed Partnership is committed to find solutions to water quality problems based on a least-cost-mix approach, integrating point and non-point pollution reduction efforts.

On January 9, 1997, the Rock River Watershed Partnership entered into a “Memorandum of Understanding” with the DNR concerning water quality investigations in the Rock River Basin. Recognizing that the cause and effect relationships regarding water quality in the basin required study, the DNR agreed to delay implementation of the phosphorus control requirements of NR 217 of Wisconsin Administrative Rules, until the Rock River Watershed Partnership completed specific study tasks. The Wisconsin legislature also provided for a pilot program in the state budget, which would allow consideration of “effluent trading” for phosphorus control. A major goal of this pilot program was to better evaluate if “trading” between point sources or between point and non-point sources could offer monetary or other advantages to water quality protection. The Rock River Basin was selected as one of three basins for this pilot (others were Fox-Wolf Basin and Red Cedar River Basin). Investigation of the feasibility or “trading” was one of the major tasks of the Rock River Watershed Partnership in response to the Memorandum of Understanding with the DNR. The DNR’s agreement to delay NR 217 implementation has provided a window of time for Wisconsin Pollutant Discharge Elimination System (WPDES) Permittees to participate in the activities of the partnership, and to consider trading in lieu of construction of treatment facility improvements.

To help organize and fund essential activities of the Rock River Watershed Partnership, and to provide a means of focus for interests of municipalities involved in the partnership’s activities, an inter-municipal group was formed on April 28, 1998, under §66.30 of Wisconsin Statutes (the Rock River POTW Watershed Group). This group has served the Rock River Watershed Partnership well by raising funds from member contributions, receiving grant monies from DNR and the U.S. Environmental Protection Agency, formulating technical and legal tasks, and engaging engineering and legal consultants.

A portion of the grant support provided to the Rock River Watershed Partnership has been to fund a “Basin Educator” through the University of Wisconsin Extension (UWEX). The Basin Educator has been instrumental in helping to organize the activities of the partnership, plan and conduct meetings, assist with public outreach, and to provide a focus for communications.

More information concerning the Rock River Watershed Partnership and its activities may be found at the following World Wide Website:

<http://clean-water.uwex.edu/rrp/index.htm#Rock River>

## **B. Basis for Studies**

In July 1998, members of the Rock River Watershed Partnership Steering Committee met to discuss the technical needs of the partnership in meeting the goals of its mission and fulfilling its obligations under the Memorandum of Understanding with the DNR. Five tasks were identified by consensus. The basis and scope of each of the five tasks is described below.

### *1. Modeling*

Sediment and phosphorus loading to the watersheds in the Rock River Basin are viewed as major water quality problems. Sediments are not only a source of nutrient delivery (nutrients are associated with sediment solids), but sediment deposition causes significant degradation of aquatic habitat. Nutrient enrichment spurs excessive growth of aquatic weeds and algae, which choke waterways, cause aesthetic problems, and may result in dissolved oxygen depression during respiration or decay.

To better assess the sources of sediment and phosphorus loading to the Rock River Basin, it was determined that a computer-based water quality model should be developed. Model development would have the following major goals:

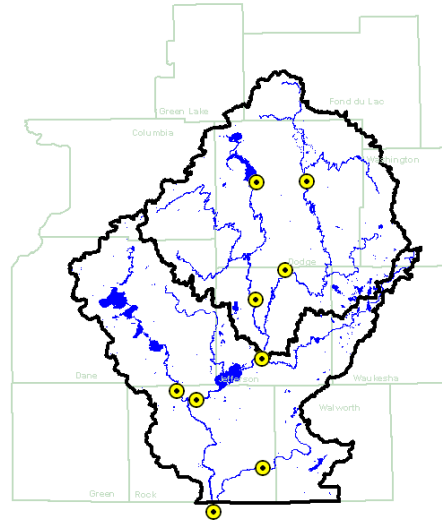
- Provide a predictive tool to project basin flows in relation to seasonal and climatic conditions.
- Provide a predictive tool to estimate sediment and nutrient transport from land areas within the basin to rivers and streams.
- Provide an estimate of what fraction of the phosphorus loading to the system results from non-point sources and what fraction results from point source loading.
- Provide a tool to allow an estimation of the reduction in phosphorus loading to rivers and streams in the basin by implementation of various point and non-point source practices.

The model selected was the “Soil and Water Assessment Tool” (SWAT) developed by the Agriculture Research Station at the Texas A&M University. This model utilizes geographic information system (GIS) information on soils, land use, slope, climatic data, agricultural practices, point source inputs, and other information to predict stream and river flows and sediment and nutrient loading on a non steady state basis. Although it was recognized that development of the model would require a major effort in data gathering, input, model construction, model calibration, and model verification, it was determined that the SWAT model best matched the level of detail required for the 3,750 square mile Rock River Basin so as to provide results that could be used with reasonable confidence for decisionmaking.

Please refer to Section III, Task 1 – Modeling, for further discussion of the scope and results of the modeling task

## 2. *Monitoring*

The need for the collection of comprehensive and contemporaneous hydrologic and water quality data was agreed. An approach was developed wherein nine sub-basins, representing the entire Rock River Basin in Wisconsin, would be monitored. The selected monitoring locations are shown in Figure 2. It was determined that a year of data would be collected. The specific monitoring stations were chosen because: (1) there was a U.S. Geological Survey (USGS) flow metering gage at the location; or (2) one could be readily installed (e.g., Rock River near Fort Atkinson). The goals of the monitoring effort were identified as:



**Figure 2 - Monitoring Sites**

- develop background information on water quality conditions on main water bodies in the Basin
- collect flow, sediment loading, and phosphorus loading data to assist in calibration and verification of a computer-based hydrologic and sediment/phosphorus transport model (Task 1 above)

Several of the participating municipalities (Beloit, Edgerton, Fort Atkinson, Lake Mills, Watertown, and Waupun) volunteered to provide staff resources for the sample collection program. Staff of the Publicly-Owned Treatment Works (POTWs) of these municipalities were trained in collecting the water samples in accordance with USGS and the DNR accepted procedures. USGS was contracted to design and manage the sampling effort which included routine sample collection over the one year period as well as sampling at selected times during wet weather to allow data collection during peak sediment/phosphorus loading periods so that the loadings could be better estimated. Approximately 27 samples were collected from each site during September 1998 through August 1999. The POTW staff collected and handled the samples in accordance with approved protocols and transported them to the Madison Metropolitan Sewerage District analysis lab by vehicle immediately following collection. Results of analyses were reported to USGS who compiled the data, together with flow monitoring results for each station, into a database (which was also published on the World Wide Web).

Please see Section III, Task 2 – Monitoring, for additional discussion of the scope and results for the monitoring task. This work has been deemed to be so beneficial that the POTWs have agreed to continue the monitoring program with the DNR and the Wisconsin State Laboratory of Hygiene.

## 3. *Trading Approach and Document Development*

As previously stated, a goal of the Rock River Watershed Partnership is to explore “effluent trading.” To implement “effluent trading” in a water quality protection context, a number of administrative details would require resolution, such as:

- How would “trading” be reflected in WPDES Permits?
- Who would be the parties to a “trade” and how would their contractual responsibilities under trading be spelled out?
- What would be the role of the DNR and local Land Conservation District (LCD) agents?
- How would “trade ratios” be established to, for example, determine how many pounds/year of phosphorus would need to be controlled by agricultural BMPs to “offset” the need for phosphorus control at a POTW?
- Where could trading occur, are there specific places that trading should not occur, and where should trading be encouraged?
- What would happen if installed BMPs were not properly maintained or if they did not perform as projected?
- Would monitoring of non-point source controls be required to prove performance?
- How long would “trades” last and could they be extended?
- What sort of agricultural BMPs would be eligible for “trades?”

Without “fleshing out” some of these issues and developing consensus “answers” among the involved parties, it was felt that “trading” could not effectively proceed.

To provide information on these and other issues of an administrative or implementation nature, it was determined that a subcommittee of the Rock River Watershed Partnership should be formed with the responsibility of reaching consensus on these complex and difficult questions. The subcommittee included active participation of legal staff of the Partnership and the DNR, LCDs, Rock River POTW Watershed Group members, and technical representatives of the DNR and the Partnership. A total of 47 implementation issues were identified. Of these, consensus was reached on 41 issues. Three of the remaining four items were addressed by a “Trade Ratio Workgroup” and only one issue was not totally resolved as it was determined that resolution would be unique for each “trade”.

Please see Section III, Task 3 – Trading, for further discussion of results for this task.

#### 4. *BMP and Point Source Phosphorus Control Cost Summary*

It was recognized that those Partnership members interested in “trading” would benefit from information on the typical monetary cost and effectiveness of BMPs and “brick and mortar” point source control technologies. Having information on typical cost and performance would help these participants better gauge whether or not “trading” could provide a potentially viable approach. With this in mind, it was determined that information should be developed for the participants including:

- Technical information on the requirements for BMP installation (e.g., length of buffer strips, acreage of conservation tillage) to meet identified phosphorus removal goals and related costs.

- Information on typical capital and operating costs at Publicly-Owned Treatment Works (POTWs) for phosphorus control.

BMP-specific information was developed cooperatively by the DNR and LCD participants. Useful spreadsheets were developed for silt loam soils (typical of the basin) of various slopes to allow a projection of buffer strip length (for various buffer widths) and conservation tillage acreage (of various types including “no till”) to meet identified phosphorus control goals. Cost information was also presented to allow a dollar per pound phosphorus controlled estimate to be made for implementation of a BMP in a particular situation.

Typical POTW phosphorus removal costs were developed and supported by cost data for 20 POTWs where site-specific cost information was known.

Please see Section III, Task 4 - Treatment Cost Evaluation, for a further discussion of the scope and results for this task.

#### 5. *Biological Impact Assessment*

A number of the members of the Partnership questioned the current condition of the water quality in the Rock River Basin. Questions were raised, such as:

- What is the status of stream quality at representative sites throughout the Rock River Basin?
- How is water quality in the basin related to stream and watershed characteristics?
- Does stream quality change in response to increases or decreases in available phosphorus?

To answer these questions, it was determined necessary to complete an assessment of the physical and chemical conditions at a number of sites and to correlate these observations with biological indicators of stream health. Since Task 2 was focusing on the larger rivers and streams, it was decided that this task should focus on smaller watersheds and water bodies. These were selected to be representative of agricultural and natural land forms found in the Rock River Basin which do not include point or urban non-point discharges. A total of 14 streams were selected having watersheds generally in the 10 to 50 square mile range. Physical conditions were documented, water quality and biological community data were collected, and relationships between these observations and data were analyzed. Students and academic staff of the University of Wisconsin-Madison, College of Civil and Environmental Engineering, completed research for this task with laboratory support by the Wisconsin Laboratory of Hygiene.

Please see Section III, Task 5 - Biological Impact Assessment, for further discussion of the scope for this task and the results of the research conducted.

### **III. SUMMARY OF TASKS RESULTS**

#### **Task 1 – Modeling**

As a part of an overall phosphorus analysis and management program within the Rock River Basin, a comprehensive pollution source computer modeling effort was conducted. This section summarizes the background, goals, methodology, and results of that modeling task.

##### *Description*

The focus of the modeling was to construct an intermediate level, macro-scale model to better quantify phosphorus loading from point and non-point sources throughout the basin. The three major goals of the modeling effort are:

1. Estimate the average annual phosphorus load from external sources to the Rock River surface water system.
2. Estimate the relative contribution of phosphorus loadings from non-point and point sources.
3. Estimate the changes on annual phosphorus loadings from the application of global non-point best management practices and point source controls (based on NR 217 effluent levels).

Several models were evaluated based on the size of the Rock River Basin, data requirements, and project objectives. Models evaluated included SWAT, HSPF, WINHUSTLE, AgNPS, XP-SWMM, and unit area loadings. The selection of SWAT was a decision agreed upon by the Rock River work planning subgroup, which included members from the RRWP, DNR, Earth Tech, and Strand Associates.

##### General Description of the SWAT Modeling Effort

SWAT (Soil and Water Assessment Tool) is the continuation of a long-term effort of non-point source pollution modeling with the USDA-Agricultural Research Service (USDA-ARS). The purpose of the model is to predict the effect of different management techniques on hydrology, sediment, and agricultural chemical yields in large un-gaged watersheds. To satisfy these objectives, SWAT is a continuous time model (daily time step) which incorporates the effects of weather, surface runoff, evapotranspiration, crop growth, irrigation, groundwater flow, nutrient and pesticide loading, and water routing on the long-term impacts of varying management practices.

Even though the model was designed for use in un-gaged watersheds, it was agreed that the model would be calibrated to flow and phosphorous data (when available) from approximately 23 USGS gauging sites located throughout the basin. An average annual phosphorus load was then calculated for the basin using the calibrated model and compared (validated) to data collected in 1999 from the eight monitoring sites funded by the study and at other USGS stations with adequate records. Once validated, the model was used to evaluate the effects of various management techniques on phosphorus loading.

## *Approach and Methods*

### Analysis of Phosphorus Management Scenarios

The modeling task included the evaluation of six different scenarios to assess the effect of global best management practices and the implementation of NR 217. These scenarios are described below:

1. Current agricultural practices with current point source discharges. This includes relative comparison by watershed of point and non-point sources.
2. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till with current point source discharge levels.
3. Current tillage practices with nutrient management practices employed and current point source discharge levels.
4. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices with current point source discharge levels.
5. Current agricultural practices with point source discharge phosphorus concentrations reduced to 1mg/l (the level designated in NR217).
6. Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices employed with point source discharge levels at 1 mg/l.

Each of these scenarios was run for the period 1989-1996. This period provided a good evaluation because of the distribution of high flow, low flow, and normal flow years.

### Limitation of the SWAT Model

To minimize the potential for inappropriate use of output data from the model, it is important to keep in mind the limitations of the modeling effort. These limitations are identified below:

1. The model will not target specific sites for effluent trades.
2. The model will not “route” phosphorus beyond the sub-basin level and will not account for the effects of in stream phosphorus loads on overall water quality.
3. There is a significant degree of uncertainty associated with the output from non-point source models, however, this modeling effort will provide a general indication of the annual phosphorus load for a sub-basin for a given set of conditions.

### Procedure for Developing the Rock River SWAT Model

To ensure that modeling results would meet the needs of this study and to test specific routines in the SWAT model, two pilot subbasins were selected for testing the model and verifying its capability to accurately predict water flow, sediment and phosphorus loads. The criteria for selecting the sub-basins included size (less than 90 square miles), completeness and availability of USGS gauging and monitoring data, and minimal influences from dams, lakes, urban areas, and point sources on the hydrology and water quality within the sub-basin. The gauging stations that best met these criteria were the Yahara River at

Windsor and Jackson Creek at Petrie Rd. Once SWAT was successfully applied to these pilot areas, full-scale modeling commenced

The general categories of data necessary for modeling are summarized below:

Climate/Hydrologic Data	Land Data
stream gauging	land cover
hydrologic data	topography
precipitation	soils characteristics
temperature	cropland management practices
dams, lakes, & wetlands data	point source phosphorus and flow data

Information was obtained from public agencies including the U.S. Geologic Survey (USGS), Wisconsin Department of Natural Resources (DNR), U.S. Department of Agriculture, Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP), and County Land Conservation Offices. USGS historical streamflow records were obtained for twenty-three locations throughout the Rock River Basin. Land use information was determined from the WISCLAND coverage created through satellite imagery. Individual County Land Conservation Agents verified agricultural land use and general practices. Tillage practices were determined using a recently completed transect survey performed by the USDA. The STATSGO soil data coverage for the state of Wisconsin was used for soil inputs and the USGS 30-meter digital elevation model (DEM) was used to generate contours, derive average slopes, and delineate watershed boundaries. Climate data for 18 monitoring stations was obtained from the State Climatologist's Office. Point source data was collected from DNR permit records where available. Additional information was obtained from a survey sent to all municipal and industrial point sources within the Rock River watershed. A discharge rate of 4 mg/L was assumed for phosphorus if no response was received from the permitted source.

Internally Drained Areas: During delineation and calibration of the two pilot subbasins (Jackson Creek at Petrie Road and Yahara River at Windsor), Earth Tech noted discrepancies between the drainage area reported by the USGS and the actual contributing area (surface water flow). The total water yield reported by the USGS is based on the total drainage area, which often includes internally drained areas. In the model, failure to properly account for these internally drained areas produces excess runoff and reduces groundwater base flow. To identify internally drained areas, Earth Tech manually verified the subbasin delineation produced by SWAT's ARCVIEW interface against digital USGS quad maps and then modified the computer generated subbasin boundaries as needed.

Lakes, Impoundments and Wetlands: The Rock River basin includes many lakes, wetlands, and impoundment areas that affect the flow of water. Wetlands were modeled within SWAT based on the area of the wetlands, the volume of water necessary to fill the wetlands, contributing drainage area to the wetlands, and infiltration rate. The wetland's area was obtained from the WISCLAND coverage and infiltration rates were based on rates for hydric soils located throughout the basin. The pond subroutine was used to model small lakes and ponds. Input requirements are similar to those of the wetland routine, however, ponds were modeled using a lower infiltration rate than the wetlands. The reservoir routine was used to simulate large impoundments. Only reservoirs that significantly impact the flow of water through the watershed were included in the model. Significant reservoirs were selected based on reservoir storage, surface area, and the amount of contributing drainage area.

Point Source Phosphorus Loads: Monthly phosphorus loads from point source discharges were calculated several ways. Where less than one year of data was available, the average concentration was calculated from available data and loads were calculated using the average monthly flow. Where no phosphorus data was available, the monthly phosphorus loads were calculated based on an assumed average effluent

phosphorus concentration of 4.0 mg/L and the calculated average monthly flows. If a full year of phosphorus concentration data was available, those values were used with the average monthly flows to calculate an average monthly phosphorus load. If more than one year of data is available, average monthly phosphorus concentrations were calculated to determine the average monthly phosphorus loads.

Cropland Tillage Practices: A summary of tillage practices from a statewide transect survey by DATCP were used to help define agricultural management files. Percent and actual acreage of tillage practices was summarized by watershed. This data was used to generate and vary the tillage practices among watersheds. Interviews with county agents, UW-Extension, and examination of the WISCLAND coverage were used to determine and verify cropping practices.

Crop Yields: SWAT reports annual crop yields for the simulations. Variables used to adjust crop yields for corn, soybeans, and alfalfa were adjusted so crop growth would better reflect conditions in southern Wisconsin. Crop yields were used to verify that the crop is growing properly within the model. Crop yields affect model variables including soil moisture, evapotranspiration, and available bio-mass. Predicted crop yields were compared to actual measured yields published in USDA agricultural statistics. It should also be noted that SWAT does not have an input for percent residue, rather the tillage practice is modeled as percent incorporation. The actual percent residue varies over time, and SWAT models the breakdown of residue into organic matter or humus.

Urban Runoff: SWAT utilizes USGS regression equations to simulate the build-up and wash-off of pollutants from urban areas. Construction erosion has been identified as the largest source of sediment in urban areas. An attempt was made to estimate the amount of construction erosion occurring in each watershed however; insufficient information is readily available to generate such estimates. Because a relationship between population growth and acreage of construction could not be established, the sediment load due to construction sites was not broken out from the non-point load.

### Model Calibration

Calibration was performed in three sequential steps: (1) hydrology was calibrated, (2) in-stream sediment loads were calibrated, and (3) phosphorus loads were calibrated. Simulated results were compared to USGS gaging data. Hydrology was calibrated by comparing both total average annual water yields and daily flows. Once average annual water yields were within acceptable ranges, daily flows were adjusted to match monitored results during both high and low flow periods. In-stream sediment loads were calibrated by adjusting the peak or event load and the baseflow load. The baseflow concentration was estimated using values from “Measurement and Prediction of Sediment Yields in Wisconsin Streams” by the USGS. Phosphorus loads were broken down into soluble and sediment contributions. In general, the phosphorus loads predicted by SWAT were higher than those monitored at gaging stations. This can be attributed to fate and transport phenomena, which was not simulated in this modeling effort.

It is important to note that several observed discrepancies in data obtained from USGS gauging stations influenced calibration. Particular periods of concern are during the spring when ice jams may cause gauges to record artificially high flow measurements. The USGS generally “flags” data as being suspect, however there may be occurrences where these discrepancies were missed. Data where spring flows appear to be influenced by ice jams were not used for model calibration.

To compare the SWAT output values to measured data, the Nash-Sutcliffe coefficient of efficiency, and R-squared values were utilized. It was agreed to by the DNR, the RRWP and Earth Tech that, based on other modeling exercises, that values greater than 0.6 from either test applied to the annual flow values would be considered an acceptable fit. R-squared values tend to be higher than Nash-Sutcliffe values

because an outlying value on a single event will significantly lower the Nash-Sutcliffe coefficient while only slightly affecting the R-squared value. Calibration results are shown later in this chapter.

Corrections and Modifications to the SWAT Model

During the modeling of the pilot areas, several errors were found in the SWAT code and user’s manual which required correction. In addition, several routines were modified to better reflect conditions in the Midwest. All modifications were reviewed and approved by the developers of the SWAT model.

During the modeling of BMP scenarios, a significant error in the in the phosphorus routine was found. It was discovered that SWAT did not report phosphorus attached to sediment particles and did not properly route soluble phosphorus. This is of significance because phosphorus transported by sediment typically makes up the greatest portion of non-point phosphorus loads. The developers of SWAT at Texas A&M and Paul Baumgart of Fox-Wolf 2000 corrected this error.

*Results*

Calibration

The modeling generated considerable data. The full report on the SWAT modeling project contains a more comprehensive reporting of results. Table 1.1 is a summary of the calibration results and results for the basin as a whole.

In general, the calibration procedure compared favorably to monitored data. Validation data supported that the model was accurately predicting flows, sediment, and phosphorus on an average annual basis.

<b>Table 1.1 - Summary of Average Annual Flow (Inches of Runoff) Calibration</b>							
	Station	Calibration Period	Avg. Annual Inches of Runoff			Efficiency	R <sup>2</sup>
			SWAT Model	Monitored	SWAT Model % of Monitored Value		
5423500	Upper Rock R.	1989 - 1996	4.66	9.30	50%	-0.316	0.696
5425500	Upper Rock R.	1989 - 1996	7.79	8.84	88%	0.425	0.775
5425912	Crawfish R. (Beaver Dam R.)	1989 - 1996	14.82	9.30	159%	0.443	0.726
5426000	Crawfish R.	1989 - 1996	9.12	9.24	99%	0.370	0.646
5426031	Middle Rock R.	1989 - 1996	9.33	8.53	109%	0.570	0.977
5426250	Bark River	1989 - 1996	9.34	9.26	101%	0.683	0.684
5427948	Yahara R. (at Pheasant Br. Cr.)	1989 - 1996	3.99	3.72	107%	0.671	0.686
5430500	Rock R. at Afton	1989 - 1996	8.86	8.83	100%	0.758	0.777
5431486	Turtle Creek	1989 - 1996	8.53	8.18	104%	0.549	0.720
5430150	Yahara R. (at Badfish Cr.)	1994 - 1998	14.83	18.61	80%	-0.080	0.026
5430175	Yahara R.	1994 - 1998	8.51	10.76	79%	0.049	0.064
5431022	Turtle Creek	1989 - 1996	7.51	6.29	119%	0.184	0.459

Basin-wide Phosphorus Loading

Under existing land use and management conditions, the model predicted a total average annual phosphorus load of approximately 1,680,000 pounds. Point sources accounted for 41% of this value, and 59% was from non-point sources. These numbers are reported as total phosphorus and do not distinguish between the different forms (ortho, soluble, particulate, etc.) of phosphorus.

Figure 1.1 is a bar chart depicting point and non-point loads for each of the six management scenarios modeled. The six scenarios are listed in Table 1.2. The data for Figure 1.1 is provided in Table 1.3.

<b>Table 1.2 Management Scenarios</b>	
<b>Number</b>	<b>Management Scenario</b>
1	Current agricultural practices with current point source discharges. This includes relative comparison by watershed of point and non-point sources.
2	Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till with current point source discharge levels.
3	Current tillage practices with nutrient management practices employed and current point source discharge levels.
4	Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices with current point source discharge levels.
5	Current agricultural practices with point source discharge phosphorus concentrations reduced to 1mg/l (the level designated in NR217).
6	Conventional tillage converted to conservation tillage and existing conservation tillage converted to no-till and nutrient management practices employed with point source discharge levels at 1 mg/l.

Evaluation of various BMP scenarios shows that with implementation of NR 217 (applicable point sources effluent at 1 mg/l of phosphorus) and changes in tillage practices and nutrient application practices, the total phosphorus can be reduced across the basin by approximately 40% (Scenario 1 to 6). This reduction is the representation a hypothetical “best case” condition. An estimated 25% reduction in phosphorus loads can be obtained by just implementing NR 217 (Scenario 1 to 5) and a 14% reduction can be obtained with implementing improved tillage and nutrient management practices (Scenario 1 to 4). Other BMPs could result in significant, additional phosphorus reductions. Please note:

- The study of agricultural source reductions was limited by the constraints of the SWAT model and not by what could actually be achieved in the field.
- The implementation of buffers and other BMPs could result in additional reductions in phosphorus, although study would be necessary to quantify the amount of those reductions.

These scenarios are not an exhaustive evaluation of potential BMPs. They do not include implementation of urban BMP practices, wetland restoration, or the construction of buffer strips. They do, however, provide a general indication of the level of control that can be achieved.

In addition to phosphorus loads, information was generated on sediment loads stemming from non-point sources. Modeling results indicate that under existing conditions, approximately 160,000 tons of sediment are delivered to the water bodies within the Rock River Basin on an average annual basis.

Discrepancies with monitored loads at in-stream gages can be accounted for by sedimentation, bed-load re-suspension, and scour. SWAT predicted that through the implementation of improved tillage practices (predominantly conservation tillage), sediment yields could be reduced by almost 20%.

### *Discussion and Conclusions*

Because of the diversity in the agricultural landscape, there is a wide range in the potential for losses of phosphorus from the land. Contributing to this diversity are: characteristics of the soils, topography, crop and plant vegetation, crop production cultural practices, phosphorus levels in the soil, and method of phosphorus application (from fertilizers). This modeling effort used average values and as such was not able to fully capture the diversity in each watershed. Most watersheds include sites that differ in one or more characteristics. If phosphorus loss from a watershed is a concern, it is beneficial to further identify the site(s) within that watershed that have the greatest potential for phosphorus loss. Current modeling results viewed by watershed and sub-watershed help target areas, however, identification of problem sources requires a more detailed screening. This conclusion is supported by several studies showing that up to 90 percent of annual phosphorous loss comes from less than 10 percent of the land in watersheds (Heathwaite et al., 1998). Knowing where these fields are located is an important part of implementing practical and effective BMP measures.

Evaluations into the impact of phosphorus on water bodies have been performed. Ongoing studies may impact future water quality goals. The U.S. Environmental Protection Agency (USEPA) is developing phosphorus water quality criteria for fresh water bodies as a guide for states through the TMDL program under the Clean Water Act. To control eutrophication, total phosphorus should not exceed 0.05 ppm in streams entering lakes/reservoirs and 0.025 ppm within lakes/reservoirs. For the prevention of plant nuisances in streams or other flowing waters not discharging to lakes/impoundments, the concentration of total phosphorus should not exceed 0.10 ppm (Daniel et al., 1998). A dissolved phosphorus concentration of 1 ppm is the limit required of most sewage treatment discharges and advocated by some as a critical flow-weighted-mean-annual concentration for agriculture runoff (Daniel et al., 1998). However, additional studies are needed to correctly define the numerical criteria for water quality. State and national efforts continue to better define appropriate water quality goals. Such criteria are likely not constant but depend on the characteristics of the specific water body as well as the intended use of the water.

For comparison purposes, the monitoring data collected in the Rock River indicates Total Phosphorus values ranging from 0.03 ppm to 0.89 ppm with an average for 343 data points of approximately 0.27 ppm. For Dissolved Phosphorus, the range is from 0.002 ppm to 0.644 ppm, with an average for 235 data points of approximately 0.0996 ppm.

Based on the results of the current modeling, it becomes clear that additional studies are needed. Past and current research shows that fields with excessively high soil phosphorous levels (levels well beyond the point where there are crop responses to additional phosphorous) can contribute significant phosphorus loads to surface waters through runoff and sediment loss. However, not all fields contribute to this potential problem. It is imperative that guidelines, BMPs, and restrictions on phosphorus usage have a scientific basis. Additional research needs to address these issues include additional modeling, continued monitoring, and research into effective BMPs.

Recommended additional modeling needs include:

- In-stream water quality modeling to relate the loads generated in this study by SWAT to in-stream conditions. The results of this effort could be used to help determine the numerical criteria for water quality as it relates to the type of water body and its use.
- The SWAT model should continue to be refined to better simulate transport phenomena. The nutrient routines should reflect the most current research and modifications should be made to allow more flexibility.
- Overall phosphorus loading levels should be identified which will not impair designated water uses or cause violations of water quality standards. The feasibility of achieving a reduction in phosphorus loading to this level, using feasible and implementable point and non-point controls, should be evaluated. Phosphorus loading reduction efforts must be practical and implementable, directed towards an achievable and tangible goal in terms of observable water quality improvement, with control efforts and costs equitably shared between the various point and non-point sources.
- Future monitoring work should be considered for further use for comparison and verification of the model.
- This study was performed at a macro scale, however, additional modeling at a finer resolution coupled with field reconnaissance will be needed to properly target non-point BMPs at specific sites or in specific areas.

Additional monitoring needs include:

- Continuation of sampling at key locations to provide additional data for model input and calibration. Long term monitoring records are also needed to generate trends and perform relevant statistical analysis.

Recommended further evaluation and study of BMPs includes:

- Further evaluate various designs of vegetative filter strips for efficacy in filtering phosphorus. If a heavy reliance is to be placed on filter strips as a control mechanism, studies should be conducted that reflect conditions in the Rock River Basin.
- Evaluate various designs of wetlands for efficiency in removing phosphorus.
- Evaluate composting processes to reduce volume of manure and produce a product that is easily transported and commercially acceptable and examine economic and social acceptability of manure cooperatives or banks that would help distribute manure to fields needing phosphorus. Current modeling results do not reduce phosphorus from manure applications because of the lack of such a framework. However, this type of strategy is key to creating a stable phosphorus balance. In addition, the use of animal feed that will lower phosphorus content of manure should be investigated.



<b>Table 2.1 Rock River Basin (WI) Monitoring Sites</b>		
<b>Location</b>	<b>Cooperating POTW</b>	<b>POTW Staff Liaison</b>
Beaver Dam R. at Beaver Dam	City of Beaver Dam	Don Quarford
Crawfish R. at Milford	City of Lake Mills	Bob Scherr
Rock R. at Horicon	City of Waupun	Glen McCarty
Rock R. at Fort Atkinson	City of Fort Atkinson	Paul Christensen
Rock R. at Watertown	City of Watertown	Paul Lange
Rock R. at Indianford	City of Edgerton	Randy Oren
Rock R. at Beloit	City of Beloit	Emil Benz/Ari Mathos
Turtle Cr. at Clinton	City of Beloit	Emil Benz/Ari Mathos
Yahara R. at Fulton	City of Edgerton	Randy Oren

There were approximately 27 sampling events at each site during the September 1, 1998 to August 31, 1999 period including both base flow samples as well as the 14 samples collected during precipitation-runoff periods at the request of USGS. Prior to the initiation of the sampling program, a training session was held with DNR and USGS personnel and representatives of the cooperating POTWs to ensure that appropriate and uniform sampling protocols were utilized for sampling. In general, samples were collected in the field as called for by the sampling schedule and protocols, and delivered by vehicle immediately following collection to the Madison Metropolitan Sewerage District laboratory in the dark and “on ice.” A “chain of custody” form was completed to document sample collection and delivery to the laboratory. Laboratory analyses were completed utilizing procedures consistent with “Standard Methods” and NR 219.

Laboratory data were provided by Madison MSD to Mr. Bill Krug of the USGS who set up and maintained a database for management of the program data. Mr. Krug was also responsible for evaluating the laboratory data, together with the continuous stream flow data collected at each site, and to determine annual sediment and phosphorus loadings at each location using standard procedures developed by the USGS.

*Results*

Analytical data have been posted on the following World Wide Web site:

<http://orcddwimdn.er.usgs.gov/public/plsql/rock.intro>

The data will also be published in USGS’s publication “Water Resources Data – Wisconsin, 1999” which should be available in May 2000.

Table 2.2 provides an overall summary of annual flow (expressed as runoff in inches) and loadings of dissolved phosphorus, total phosphorus and suspended solids (sediment) during the September 1998 through August 1999 period. Mr. Bill Krug of the USGS provided this data summary.

<b>Table 2.2 Summary of 9/1/98 to 8/31/99 Monitoring Data at Rock River Basin Monitoring Stations</b>					
<b>Location</b>	<b>Drainage Area (sq. mi.)</b>	<b>Runoff (inches)</b>	<b>Dissolved P Loading (lb)</b>	<b>Total P Loading (lb)</b>	<b>Total Suspended Solids Loading (ton)</b>
Rock R. at Horicon	456	9.31	75,100	303,600	24,700
Rock R. at Watertown	969	9.54	88,200	417,900	36,300
Beaver Dam R. at Beaver Dam	157	9.94	25,700	58,600	2,810
Crawfish R. at Milford	762	9.54	102,000	325,000	32,900
Rock R. at Fort Atkinson	2,240	10.25	212,000	1,020,000	110,000
Rock R. at Indianford	2,630	10.01	106,000	948,000	99,000
Yahara R. at Fulton	518	11.66	27,700	174,000	21,600
Turtle Cr. at Clinton	199	11.73	24,700	69,300	7,600
Rock R. at Rockton (see note)	6,363	12.92	618,000	3,120,000	420,000

Note: Rock R. at Rockton station includes flows and loadings from the Sugar River basin.

Based on the data of Table 2.2, the following unit area loads as presented in Table 2.3 may be calculated.

<b>Table 2.3 Unit Area Phosphorus Loadings Summary 9/1/98 to 8/31/99 Monitoring Data at Rock River Basin Monitoring Stations</b>	
<b>Location</b>	<b>Pounds phosphorus/acre/year</b>
Rock R. at Horicon	1.04
Rock R. at Watertown	0.67
Beaver Dam R. at Beaver Dam	0.58
Crawfish R. at Milford	0.67
Rock R. at Fort Atkinson	0.71
Rock R. at Indianford	0.56
Yahara R. at Fulton	0.52
Turtle Cr. at Clinton	0.54
Rock R. at Rockton (see note)	0.77

Note: Rock R. at Rockton station includes flows and loadings from the Sugar River basin.

The computed total phosphorus yield figures of Table 2.3 compare well with values estimated by USGS as part of their national nutrient loading estimation (Sparrow) program:

Upper Rock R., IL and WI (Basin 7090001)	0.84 lb P/acre/year
Crawfish R. (Basin 7090002)	0.84 lb P/acre/year

According to USGS “SPARROW” (Spatially Referenced Regressions on Watershed Attributes) relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and stream transport. The model empirically

estimates the origin and fate of contaminants in streams, and quantifies uncertainties in these estimates based on model coefficient error and unexplained variability in the observed data.”

USGS Sparrow data can be found at the following World Wide Web site:

<http://water.usgs.gov/nawqa/sparrow/>

### *Conclusions*

Water quality data were collected at nine water quality monitoring stations in the Rock River Basin. Continuous flow data were also available from USGS flow gages at each site, which allowed the computation of mass pollutant loadings. Samples were collected by cooperative POTW staff, using procedures recommended by USGS and DNR. All water quality samples were analyzed by the Madison Metropolitan Sewerage District’s DNR-certified laboratory. Bill Krug of USGS developed a database system for logging and publishing (to the World Wide Web) collected flow and water quality information. Mr. Krug also estimated annual phosphorus and sediment loadings for the monitoring locations for the September 1998 through August 1999 period.

In general, the results compare closely with estimates made by USGS on the basis of hydrologic, soil, topographic, land use and other information as part of their nation-wide nutrient loading estimation project (Spatially Referenced Regressions On Watershed Attributes “SPARROW”). Event monitoring results indicated significantly higher phosphorus and suspended solids loadings versus average values.

### **Task 3 – Trading**

“Effluent Trading” is a concept that has been widely employed in the air quality control sector, but has not been extensively employed for water quality protection. An important focus of the Rock River Watershed Partnership’s activities has been evaluating whether or not “trading” for phosphorus credits in the Rock River Basin would make sense, where a particular phosphorus discharger would cooperate with a second discharger or group of dischargers in a “trading” approach. This would entail the second discharger or group removing enough phosphorus at their location to take care of the first discharger’s responsibility. Examples would include:

- A municipality helps fund non-point pollution control practices in their watershed, which will eliminate sufficient phosphorus in runoff that the municipality does not need to upgrade its Publicly Owned Treatment Works (POTW) for phosphorus control.
- A small municipality enters into an agreement with a large municipality for the large municipality to remove sufficient phosphorus at the large plant to take care of the phosphorus removal requirement for both municipalities.

Trading between a POTW and agricultural or urban non-point sources may offer economic advantage, if non-point controls can remove phosphorus at a lower unit cost than POTW controls, or if other environmental benefits (e.g., sediment control) result. Administrative issues, such as contractual relationships and regulatory requirements need to be clearly understood and evaluated.

One important administrative issue is the “trading ratio.” POTW controls are very reliable and consistent, with phosphorus control being effective under most plant flow and other anticipated conditions. Non-point control Best Management Practices (BMPs) may not be effective during severe storm events and non-point BMPs will not control daily phosphorus discharges during dry weather periods. Also, implementing BMPs some distance away from a POTW discharge location would likely not result in a

phosphorus concentration reduction near the POTW discharge equivalent to phosphorus removal at the POTW. For these and other reasons, the DNR and the USEPA have, as a policy matter, applied a “trade ratio” for a point to non-point “trade” which would require more phosphorus control by BMPs than required at the POTW for a trade to be approved. The Biological Impact Assessment report suggested that the need for trading ratios be re-evaluated.

Task 3 included an effort by the Rock River Watershed Partnership’s “Administration of Trading Committee” to provide information and make recommendations concerning administrative issues of importance to “trading” and to develop a basis, acceptable to DNR and USEPA, for establishing “trading ratios.” The results of this effort are summarized herein.

*Description*

The Administration of Trading Committee of the Rock River Watershed Partnership assigned the “Trading Structure Workgroup” the tasks of identifying issues of administrative concern and developing a consensus response to the issues of concern. The “Trade Ratio Workgroup” addressed the matter of the “trade ratio”. Both workgroups prepared written memoranda on their findings. Because it was desired to include a “targeting” incentive in the trade ratio calculation, where trading would be encouraged in selected areas in the Rock River Basin, the “Targeting Workgroup” evaluated geographic areas within the basin for targeting purposes, and recommended specific target areas. In practice, “targeting” would be encouraged by providing a modifier to the “trade ratio” in targeted areas to reduce the ratio. This would improve the economics for trading in targeted areas.

*Approach and Methods*

The “Trading Structure”, “Trade Ratio” and “Targeting” workgroups met formally to discuss ideas and concerns relative to their individual topics, and to develop final memoranda. Draft materials were presented to General Membership meetings of the Rock River Watershed Partnership to obtain input to the development of final draft information.

*Results*

The “Trading Structure” Workgroup ultimately identified forty-seven issues of administrative concern. The workgroup discussed the issues relative to each item of concern and attempted to reach a consensus on a response to resolve the concern, or at least to identify how the concern will be resolved. Table 3.1 provides a summary of items of concern and notes concerning resolution for each item. The full text of the trading issues list is contained on Appendix A.

<b>Table 3.1 – Administrative Items of Concern Regarding Trading</b>		
<b>Item</b>	<b>Concern</b>	<b>Discussion re. Resolution</b>
1	Will compliance with NR 217 meet statutory requirement for “water quality improvement?”	A trade must meet phosphorus reduction that would result from NR 217 implementation as well as the requirements of an appropriate “trade ratio.”
2	How will it be determined if a trade is successful?	If all requirements of a DNR-approved trade contract are met, and if all requirements of applicable WPDES permit(s) are met.

<b>Table 3.1 – Administrative Items of Concern Regarding Trading</b>		
<b>Item</b>	<b>Concern</b>	<b>Discussion re. Resolution</b>
3	Will the “water quality improvement” demonstration require actual water quality monitoring?	No, although DNR may choose to do some follow up monitoring in select areas.
4	What parameters may be “traded?”	Initial efforts will be to trade for phosphorus to meet NR 217 requirements. Ultimately any parameter for which a water quality standard exists or which has a direct impact on attaining a water quality standard could be the subject of a trade.
5	Can a single trade involve multiple water quality parameters? How will different forms of the same parameter be addressed?	Yes, a single trade could involve multiple parameters. DNR and the committee will work together to resolve issues relating to the relationship between contaminants.
6	Can trades be made for non-point practices that are either prohibited or the subject of performance standards?	Yes.
7	What Best Management Practices (BMPs) or other non-point source reduction projects will be allowed for trades?	Any BMP that is not considered a “minimal standard practice” in the county where the BMP is proposed would be eligible for trading.
8	Can economic incentives be offered to property owners to implement BMPs to encourage trading?	Yes.
9	What are the criteria for calculating trade ratios?	<i>Defer to recommendations of Trade Ratio Workgroup.</i>
10	Will trade ratios be site-specific or more general?	<i>Defer to recommendations of Trade Ratio Workgroup.</i>
11	Will trade ratios include a benefit “credit” for improvement of water quality for parameters other than the one being traded for?	<i>Defer to recommendations of Trade Ratio Workgroup.</i>
12	Can trades occur outside of targeted areas?	Yes.
13	How are targeted areas defined?	Targeted areas will be defined based upon monitoring and monitoring results (Tasks 1 and 2), results of Task 5, input from Land Conservation District representatives, and input from DNR fisheries managers/biologists.
14	What is the “unit” of a target area?	One or more of the eight sub-basins, with further delineation consistent with No. 13 (above).
15	Can trades cross sub-basin boundaries?	Yes.

<b>Table 3.1 – Administrative Items of Concern Regarding Trading</b>		
<b>Item</b>	<b>Concern</b>	<b>Discussion re. Resolution</b>
16	Can downstream trades occur?	<i>DNR representatives have indicated that a POTW must generally find “trades” upstream, although downstream trading may be allowed if certain criteria are satisfied.</i>
17	Same as item No. 12.	
18	What is the maximum length of a trade?	Trades are limited to five years by statute. DNR would seek to provide for extension of the trade time period so long as not barred by statute or regulation.
19	Can a trade be renewed?	Yes. See above response.
20	What criteria would be employed to see if a trade could be renewed?	DNR would allow renewal if renewal would be consistent with then-current statutes and regulations, and if the criteria for item No. 2 (above) were satisfied.
21	Can trade “credit” be given for an existing practice or for extending an existing practice?	An existing practice is not eligible. At some future time a “lapsed” existing practice may become eligible.
22	What happens if a TMDL or water quality standard is established, for parameters being traded for, after a trade has been approved or a WPDES Permit modified?	Existing contractual and permit obligations would need to be met by the parties. More or less phosphorus control could be required or allowed by a TMDL or water quality standards change. For a case where less control might be allowed, a permittee could petition DNR for a permit modification that may or may not be granted.
23	What are the major trading structures or formats?	Scenario 1 – Trade initiator deals directly with other party (ies) to trade contract(s). Scenario 2 – Trade initiator deals through third party (agent) that assists in completing trades.
24	For Scenario 2 (above) who would serve as third party broker?	State or local governments (e.g., LCD) may play the role of broker. Broker would be trade-specific.
25	Will DNR serve as a broker.	DNR is not expected to serve as a broker.
26	How will the broker recover its overhead costs?	The broker’s costs would be charged to the trading party. The costs must be agreed to prior to trade initiation.
27	What is the overall timing of trades (i.e., placement of money, permit modification, disbursement of funds, etc.)?	Timing would be trade-specific. WPDES Permit Compliance Schedules specify specific implementation dates.

<b>Table 3.1 – Administrative Items of Concern Regarding Trading</b>		
<b>Item</b>	<b>Concern</b>	<b>Discussion re. Resolution</b>
28	If money is going to be pooled (e.g., by several POTWs) and placed in an account, how would it be determined how much each party contributes?	In general, credit for pollutant removal would be contractually defined. Costs would be assigned in direct proportion to trade “credit” given to each party contributing to a pooled trade.
29	Is it necessary to have a specific non-point source project identified prior to pooling, in order to calculate the dollar amount owed by contributing parties?	Yes.
30	Who is responsible for monitoring and enforcing trade contracts?	The WPDES permittee(s) would ultimately be responsible. A third party “agent” could assume some contractual responsibility.
31	If a landowner goes bankrupt or out of business before the end of the term of a trade contract, what happens to the contract obligation?	Contractual requirements would be placed on properties as deed restrictions.
32	If a BMP needs repair to maintain effectiveness, who/how does the repair get paid for?	Ultimately the WPDES Permittee is responsible. Contractual responsibilities would be addressed by the trade contract(s).
33	If a BMP is found to be less effective than originally projected, who/how/or is the design to be improved?	At the end of the five year term of the trade, improvement would be required by the WPDES Permittee (or others by contract) if the trade were to be continued.
34	What are the future obligations of a WPDES Permittee if a non-point source does not install BMPs (USEPA’s “reasonable assurance” requirement)?	The money will not be transferred to the non-point source until the practice is installed. The permittee would work with the “agent” to get the practice installed or to find another project.
35	What are the future obligations of a WPDES Permittee in the event a non-point source does not maintain BMPs installed as part of a trade?	Ultimate responsibility is Permittee’s. Contractual responsibilities need to be clear in trade agreements.
36	In a “pooled” trade, how will legal responsibilities be shared if the pollutant load reduction is not maintained?	This issue would be dealt with (by agreement language) on a case by case basis.
37	Do antibacksliding/antidegradation provisions apply to permittees currently under a WPDES Permit compliance schedule for a parameter that is the subject of a trade?	These provisions do not apply so long as the date imposing a particular limit has not passed.

<b>Table 3.1 – Administrative Items of Concern Regarding Trading</b>		
<b>Item</b>	<b>Concern</b>	<b>Discussion re. Resolution</b>
38	If a WPDES Permittee enters into a trade contract, what will be the terms of the Permit and contract?	DNR and legal counsel for the Rock River Watershed Partnership have agreed to develop a draft outline to specify general terms and conditions.
39	Can a WPDES Permittee already removing phosphorus stop the phosphorus removal process if they implement a trade?	Yes, so long as the Permittee continues to operate the phosphorus removal process until the approved trade is in place and physically constructed/operating.
40	What are the local constraints to trading?	This is a site-specific issue.
41	Are Clean Water Funds available to WPDES Permittees for trading.	Possibly, although statutory changes may be required.
42	Can cost sharing funds (e.g., CREP, EQUIP) be used by a WPDES Permittee to help finance a trade?	Yes, if the funds could be obtained by the Permittee.
43	Will trading credit be given for all, part or none of state, local and federal cost sharing programs and how will a point source be allocated credits?	Full pollutant reduction credit will be given for projects that utilize federal cost share funds. <b><i>Agreement has not been reached on the issue of state and local funds.</i></b>
44	Would a trade limit a community's options for growth?	No.
45	What process will be used to administer the pilot?	The WPDES Permit process will be used to administer the pilot. It is anticipated that a modified WPDES Permit could cite or incorporate pertinent provisions of the "trade" and related agreements.
46	What process will be employed to address third party challenges?	The existing permit process contains opportunities for public comment and third party challenges.
47	What economics of agricultural and point sources must be factored into a trading structure?	This is an individual permit and trade issue and should be evaluated on a case by case basis.
48	Where limited trading partners exist, how is right to trade allocated? What is the decision point?	First come, first served.
<p>Note: If the "Discussion re. Resolution" (third column above) is bold and italic, this denotes that consensus was not reached by the "Trading Structure Workgroup."</p>		

The "Trade Ratio Workgroup" originally met in the spring and summer of 1999 to discuss potential approaches and develop a technical basis for computing trade ratios. It was determined by consensus that trading ratios must consider:

- factors of safety that would consider the reliability of non-point source Best Management Practice technology and O&M in relation to point source controls

- geographic, seasonal, and chemical (e.g., “bioavailability” of form of phosphorus) issues
- site-specific factors such as proximity of a non-point source to a waterway, relationships to critical water bodies, collateral water quality improvements (e.g., sediment control) of BMP implementation, etc.

The “Trade Ratio Workgroup” for computing trade ratios developed two spreadsheets: (1) point to non-point source trading; and (2) point to point source trading. The point to non-point source spreadsheet included four overall factors (factors of safety, nature of discharge, site-specific considerations and targeting) that would be cross multiplied to arrive at a trade ratio from about 1.4 to about 3.6 depending upon trade-specific factors. The point to point source spreadsheet included six factors that would be cross multiplied to arrive at a trade ratio between 1.0 and 2.5 (considering factors of distance between trades, watershed proximity, upstream/downstream, and impact on ambient concentrations, lake/impoundment impacts, and 303d segment impacts). A narrative guidance was also developed as an aid in using the trade ratio spreadsheets.

There are a number of factors that must be considered for a trade to occur. Some of these are:

- The Group, in its original charge, was to take into consideration the least cost mix approach when the trade ratio was finalized. The effectiveness of some of the pilot project may be in jeopardy because of the conservative approach with regard to the trade ratio.
- The limitation, due to permit constraints, of a maximum 5 year “guaranteed” trade period. Longer periods will make more trades cost-effective by spreading capital costs over a longer period.
- Political boundaries can impact trades. Many point dischargers are unwilling to spend funds for improvements outside of their jurisdictional boundaries.

In late 1999 and early 2000, a simplified numeric approach was proposed by the “Trade Ratio Workgroup” for establishing trading ratios. Table 3.2 describes the simplified approach.

<b>Table 3.2 Trade Ratio “Calculator”</b>	
<b>Component</b>	<b>Description</b>
A	Base Trade Ratio (A = 1.0 for point to point trading; A = 1.75 for point to non-point trading).
B	Add 0.125 if trade is not in target area.
C	Add 0.125 if trade is not in same DNR “Watershed.”
D	Add 0.125 if trade is not “nearby” (within 20 miles).
E	Add 0.125 if “credits” are obtained downstream of trader’s location.
<b>Trade Ratio = A + B + C + D +E</b>	

The simplified approach was adopted by the “Trade Ratio workgroup” by consensus.

The “Targeting Workgroup” was charged with identifying specific areas within the Rock River Basin where trading would be encouraged by a trade ratio incentive. After much discussion on approaches to establishing criteria for targeting areas within the Rock River Basin the following items were agreed upon by consensus:

1. The main purpose for targeting areas is to provide one of the criteria to be used for the calculation of the point – non-point pollution trading ratios. Other purposes (such as improving the chances of demonstrating measurable changes in water quality) may also result from the targeting process, but these other issues are secondary.
2. The targeted area(s) will use sub-basin units, as delineated for use by the SWAT (Task 1) model. There are approximately 105 SWAT sub-basins within the Rock River Basin.
3. Internally drained areas, as defined in the SWAT model, will be ineligible as pollutant trading sites. Field investigations may be conducted to verify the accuracy of the delineated internally drained areas, and this eligibility designation may be changed subject to more detailed information.
4. Each of the eight monitored drainage areas within the Rock River Basin will have one or more sub-basins identified as “targeted.” The targeting will be based upon:
  - a. the sub-basins with the highest phosphorus loading rates within each monitored drainage area (the definition of “highest” was not determined at this time)
  - b. those sub-basins contributing runoff to identified significant water resources

Table 3.3 lists the identified “Target Areas.”

<b>Table 3.3 Target Areas</b>		
<b>Monitored Area</b>	<b>DNR Watershed #</b>	<b>Description</b>
I. Horicon Unit	UR13: East Branch of Rock	Kohlsville R.; Allenton Cr.; Limestone Cr. Drainage areas
	UR12: Upper Rock	Gill and Irish Cr.; drainage areas
II. Watertown Unit	UR09: Oconomowoc R.	Oc. Lakes including Mason Cr., and Rosenow Cr. drainage areas
III. Crawfish R. Unit	UR02: Lower Crawfish R.	Rock Lake drainage area
	UR06: Upper Crawfish R.	Lazy Lake drainage area, and sub-basin below Lazy L. (north of Columbus)
IV. Ft. Atkinson Unit	UR01: Middle Rock R.	Deer Cr. Drainage area
V. Yahara R. Unit	LR09: Yahara R. & L. Mendota	Token Cr. drainage area; & Yahara R. north of gold course
	LR07: Badfish Cr.	Rutland Br. Drainage area
VI. Rockton Unit	LR11: Lower Koshkonong Cr.	Allen Cr. and drainage area above Cambridge
VII. Turtle Cr. Unit	LR01: Turtle Cr.	Unnamed tributary to Turtle Cr., north of creek, along Rock-Walworth Co. line.
VIII. Bark R. Unit	LR14: Whitewater Cr.	Whitewater Bluff Cr. drainage area
	LR15: Scuppernong Cr.	Drainage area upstream State Hwy 106.

Figures 3.1 through 3.12 show the boundaries of each of the “Target Areas.”

### *Conclusions*

The “Trading Structure Workgroup” developed a list of forty-seven items of concern regarding the implementation of trades. Consensus was reached on the workgroup concerning how forty-three of the

items would be specifically addressed in a trading scenario. Three items were forwarded to the “Trading Ratio Workgroup” for resolution. Consensus could not be reached on one item (please see Table 3.1).

The “Trade Ratio Workgroup” reached consensus on a simplified numeric basis for establishing trade ratios. In general the ratio would be developed based upon a base number (1.75 for point to non-point trades and 1.0 for point to point trades) with additive modifiers for site-specific conditions (please see Table 3.2). A number of factors must be considered for a trade to occur.

The “Trade Targeting Workgroup” identified eight specific areas of the Rock River Basin where incentives should be given to encourage trading (please see Table 3.3).

### *References*

Rock River Trading Structure Workgroup, “Issue List – Current as of 6/11/99.”

“Meeting Notes, Trade Ratio Workgroup”, March 10, 1999.

“Narrative on Phosphorus Trading Ratio Protocol”, with attached Trade Computation Spreadsheets and Slideshow Presentation, August 4, 1999.

“Slideshow Presentation – Simplified Trade Ratio Development”, January 27, 2000.

### **Task 4 – Treatment Cost Evaluation**

This task included: (1) an assessment of the likely range of costs for Publicly Owned Treatment Works (POTWs) to remove phosphorus by making plant additions; and, (2) an estimate of the cost per lb of phosphorus “removed” for installation of certain agricultural “Best Management Practices” (BMPs). The purpose for completing the POTW phosphorus removal cost assessment was to provide general cost guidance to municipalities for phosphorus removal at POTWs. The purpose of the second portion of this task was to provide guidance concerning BMP physical requirements (size and extent) and costs for two types of agricultural BMPs (buffer strips and conservation tillage). With comparative cost information, it was believed that municipalities would be in a better position to determine if funding agricultural BMPs rather than constructing POTW improvements (i.e., “trading”) might be attractive for their situation.

### *Description*

The Rock River Partnership entered into a Memorandum of Understanding (MOU) with the Wisconsin Department of Natural Resources (DNR) to investigate the potential for “trading” for phosphorus in the Rock River Basin. From the perspective of a POTW, “trading” could entail funding agricultural BMPs to meet all or a portion of the POTW’s requirements for phosphorus control. This would be a “point to non-point” trade. Such “trading” between the POTW and the agricultural sector may be attractive if cost savings or other advantages to the POTW would result from funding the BMPs rather than constructing and operating plant improvements.

As part of a “trade”, a municipality operating a POTW might also trade with another municipality (having a POTW) wherein the first municipality would compensate the second for removing enough phosphorus to satisfy the phosphorus mass removal requirements for both municipalities. This would be a “point to point” trade. A determination of whether or not this type of “trade” would be advantageous to the municipalities involved would depend upon monetary and other factors.

To assist municipalities in evaluating the feasibility of “trading”, the Rock River Partnership directed its consultants to prepare some general information concerning the ranges of capital and operation, maintenance and replacement (O, M&R) costs for phosphorus control at POTWs. Two memoranda were prepared by the consultants, dated April 28, 1997, and January 12, 2000 which provide information on costs for phosphorus control at POTWs. This information is summarized herein.

DNR staff worked closely with Dane County Land Conservation District staff to provide a spreadsheet system to estimate costs for buffer strips and conservation tillage agricultural BMPs. A summary of the agricultural BMP cost information is provided herein.

The reader is directed to the source documents for more detailed and complete information. It is stressed that although the developed information on POTW and agricultural BMP costs is believed to be representative, it is “generic” in nature and relies on numerous important assumptions. Site specific cost information should be developed as necessary to support a local trading economic analysis.

### *Approach and Methods*

For the April 28, 1997, cost memorandum, costs for phosphorus control at POTWs were developed on a “generalized” basis for POTWs for various sized facilities, for two levels of phosphorus control (i.e., NR 217 limits and <0.5 mg/L effluent P). Both chemical phosphorus control and biological phosphorus control technologies were considered. In developing the cost information, capital and O,M&R costs were projected for the facilities directly associated with phosphorus control. In addition, capital and O,M&R costs were projected for ancillary facilities that would be impacted by phosphorus removal and projected costs were included to for expanded facilities to replace “lost” capacity for sludge handling and storage, and for recycle loadings. Thus, an effort was made to capture “total costs” resulting from the regulatory requirement for phosphorus control. For this memorandum, a conservative approach was also taken in that it was assumed that new structures and buildings would be required and that existing building space was unavailable, for example, to house chemical feed equipment. It was also assumed that backup chemical feed systems would be required in cases where biological phosphorus control technologies were implemented. With these assumptions, and others as outlined in the memorandum, “generic” cost information was assembled in the form of graphs and formulae. The April 28, 1997, memorandum is included as Appendix B.

For the January 12, 2000, memorandum, the cost of phosphorus control at POTWs was revisited on the basis of actual reported costs at twenty facilities (11 employing chemical P-control and 9 employing biological P-control). All twenty facilities were planned, designed and/or constructed to comply with NR 217 requirements (i.e., < 1.0 mg/L or an alternative limit in the case of biological systems). Costs for phosphorus removal-related improvements to the facilities were obtained from facilities planning documents, opinions of probable cost, or actual project capital costs. The January 12, 2000, memorandum was developed to provide POTW cost data more representative of actual projects implemented at POTWs for phosphorus control. The January 12, 2000 memorandum is included as Appendix C.

Ken Johnson of DNR and Aicardo Roa of the Dane County Land Conservation District developed the agricultural BMP information. This effort was completed during 1999. The spreadsheet-based information was developed by using the Universal Soil Loss Equation to estimate the reduction in soil loss from implementing the BMPs, the phosphorus associated with the soil, typical costs to the agricultural community to implement the BMPs, and effectiveness of the BMPs on different slopes and different soil types. Analyses are presented for 25 ft wide, 50 ft wide and 75 ft wide buffer strips. Analyses are presented for the conversion of moldboard plowing to: (1) conservation till – low residue,

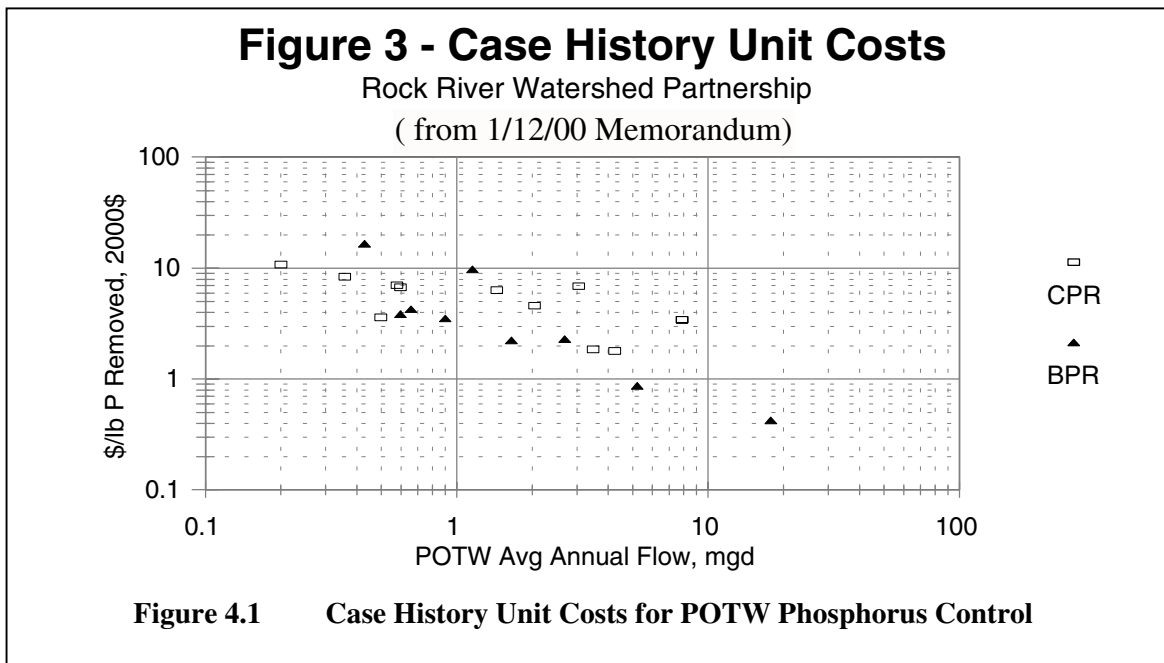
(2) conservation till – high residue, and (3) no till practices. The spreadsheet information for agricultural BMPs may currently be found on the World Wide Web at the following address:

<http://clean-water.uwex.edu/rrp/buffer1.htm#Economics of Trading> –

A portion of the spreadsheet information is provided in Appendix D.

### Results

Figure 4.1, (Fig. 3 from the January 12, 2000 memorandum) shows calculated unit costs of POTW phosphorus removal based on the twenty case histories for facilities planned/constructed to meet NR 217 requirements.



A significant economy of scale is evident from this information, with costs from POTWs greater than 10 mgd in capacity having costs about an order of magnitude lower (per lb of P removed) than POTWs of 1 mgd capacity or smaller. For facilities of less than 1 mgd capacity, chemical and biological approaches appear to involve similar monetary cost. For larger facilities in the case history analysis, however, biological phosphorus control generally provided a significant cost advantage. These relationships seem reasonable in that biological phosphorus removal generally involves higher capital cost, but lower O, M&R cost. For larger facilities, the advantages of less sludge generation and reduced or eliminated chemical requirements with biological systems result in an overall advantage compared with chemical treatment technology.

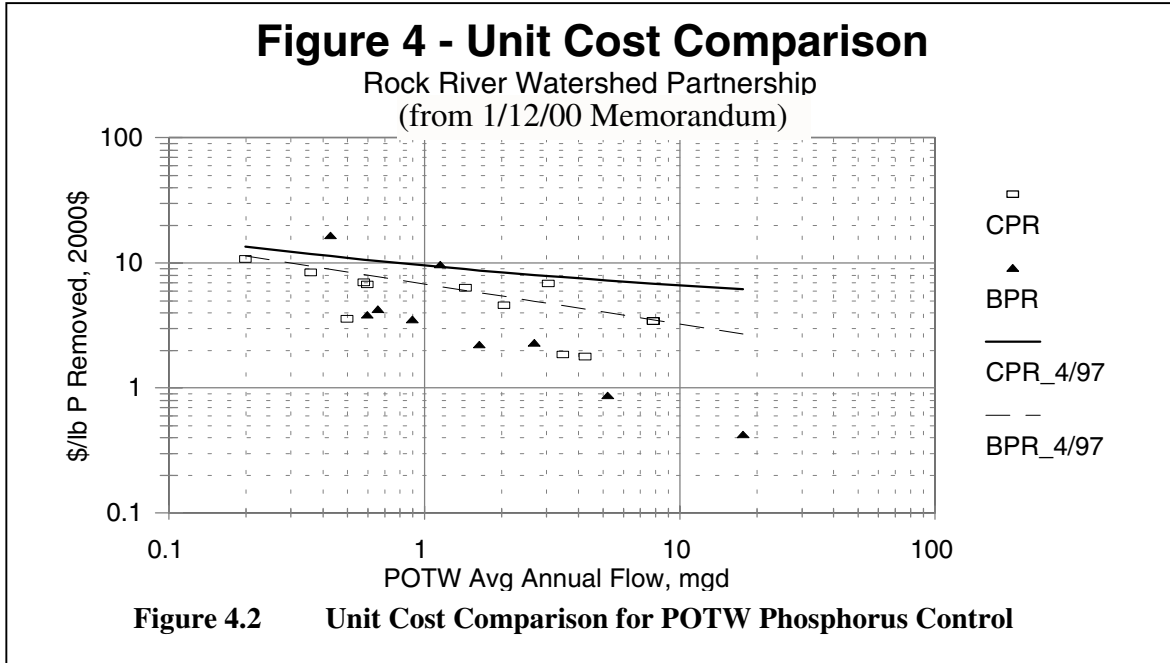


Figure 4.2 (Fig. 4 from the January 12, 2000 memorandum) compares the case history unit costs (total costs/lb P removed) with projections from the April 28, 1997 memorandum.

As indicated, the case history unit costs are generally lower than projected in the 1997 memorandum. This is likely due primarily to the ability on the case history projects to use existing building space and tankage, as well as the case history projects not actually experiencing some of the cost factors (e.g., need for added sludge handling/storage facilities or wastewater unit expansion) that were included in the 1997 information. The 1997 information may be more representative of costs when all factors must be addressed.

Figure 4.3 shows typical results from the agricultural BMP spreadsheet for the length of buffer strip required. The information in the figure is for silt loam soil and 50 ft wide buffer strips. The length represents that buffer strip length required to obtain POTW phosphorus credit of 1,000 lb/year at a trade ratio of 2:1. The “Cons Till” information is for tillage with a primary chisel plow having a three inch twisted shovel point, and secondary tillage using a narrow ripple coultter planter and a V blade cultivator.

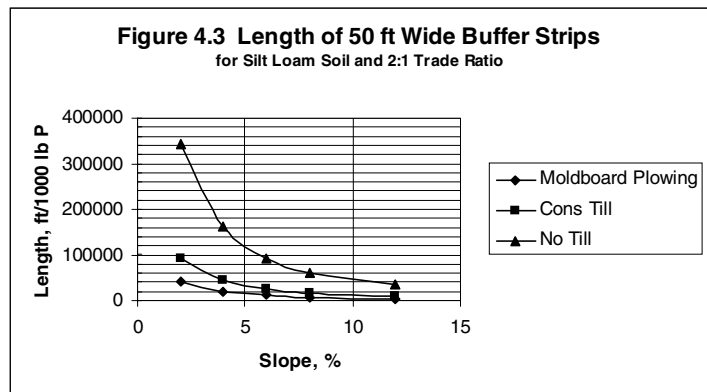


Figure 4.3 shows the projected buffer strip length required per 1,000 lb per year of POTW phosphorus “credit.” 1,000 lb/year is approximately the quantity of phosphorus that would be required to be removed for each 0.1 million gallons per day (mgd) of wastewater flow at a POTW. For each 1,000 lb of phosphorus “credit” the total length of required buffer strip would be high, as indicated in Figure 4.3, particularly for lower slopes and for sites where conservation tillage or no till practices are employed.

Figure 4.4 shows unit cost information from the spreadsheet for buffer strips. The information in the figure is for silt loam and incorporates a 2:1 trade ratio. As for the previous figure, the “Cons Till” information is for tillage with a primary chisel plow having a three inch twisted shovel point, and secondary tillage using a narrow ripple coultter planter and a V blade cultivator. As shown, the unit costs are substantially higher for lower slopes and for sites where conservation tillage or no till practices are utilized.

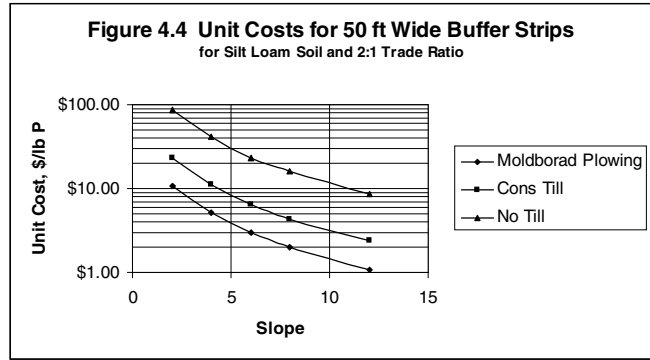


Figure 4.5 shows the results of the BMP spreadsheet for the required acres converted from conventional moldboard plowing to conservation tillage practices. The figure shows the amount of acreage required to be converted to conservation tillage for each 1,000 lb of phosphorus POTW trade “credit” based on a trading ratio of 2:1. The “Cons Till” information is for tillage with a primary chisel plow having a three inch twisted shovel point, and secondary tillage using a narrow ripple coultter planter and a V blade cultivator. According to Aicardo Roa of the Dane County Land Conservation District, the BMP spreadsheet figures are based on detailed sampling and analysis of BMP practices for an agricultural watershed in Dane County.

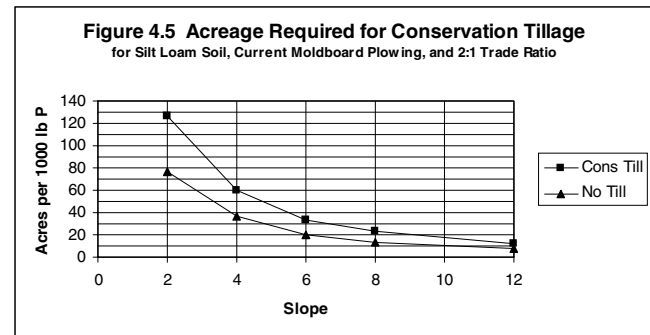
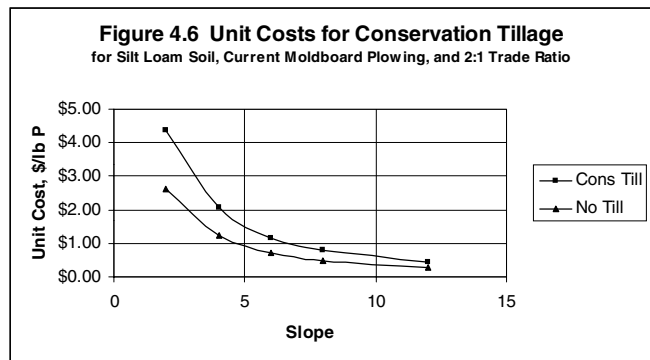


Figure 4.6 shows the unit costs derived from the BMP spreadsheet for conservation tillage practices at a trading ratio of 2:1. As with the previous figure, the “Cons Till” information is for tillage with a primary chisel plow having a three inch twisted shovel point, and secondary tillage using a narrow ripple coultter planter and a V blade cultivator.



*Conclusions*

Representatives of POTWs considering a “trade” require information concerning the comparative economic cost of phosphorus control at POTWs and by implementing agricultural best management practices. General information on POTW costs for phosphorus control has been provided in memoranda dated April 28, 1997 and January 12, 2000. The January 2000 information includes actual costs from twenty “case studies.” The “case study” costs generally show that biological phosphorus control, where implementable, has been more economical for larger POTWs. The “case study” results also show that actual costs have been lower than projected in April 1997, apparently because it has been possible at a number of facilities to adapt existing structures and tankage, and because replacement of “lost capacity” (e.g., because of lower volatility in the activated sludge process with chemical phosphorus removal systems) has not generally been replaced as part of the projects in the “case studies.”

A useful spreadsheet has been developed to allow estimation of the physical requirements and unit costs for implementing agricultural best management practices (BMPs) to reduce phosphorus loadings from agricultural lands. Two BMPs are addressed in the spreadsheet: (1) buffer strips and (2) conservation tillage practices. For buffer strips, the length of buffer strip and the unit cost (\$/lb P controlled) is provided for silt loam soils, different buffer strip widths, different slopes, and different type of tillage practices. For conversion from moldboard plowing to conservation tillage practice, the required acreage and unit costs (\$/lb P controlled) are provided for silt loam soils, different slopes, and different conservation tillage practices.

The information developed as part of this task provides useful information to help POTWs evaluate the economics of phosphorus “trading.” Some adaptation and refinement of the information to local conditions will be necessary for its use in a detailed analysis.

As future efforts are made to control phosphorus at POTWs and to implement agricultural BMPs there will be more “case study” information developed regarding costs and control effectiveness. Additional research and data gathering should be conducted in compiling information of this type to provide a more extensive database for projecting costs for POTW and BMP approaches to phosphorus control.

### *References*

*POTW Phosphorus Control Costs*, Michael D. Doran, P.E. DEE, Strand Associates, Inc., Madison WI, April 28, 1997.

*POTW Phosphorus Removal Costs*, Michael D. Doran, P.E. DEE, Strand Associates, Inc., Madison WI, January 12, 2000.

*Riparian Buffer and Tillage Spreadsheets*, Ken Johnson (Wisconsin Department of Natural Resources) and Aicardo Roa (Dane County Land Conservation District), Madison WI, 1999 (includes descriptive memorandum and Microsoft Excel® spreadsheet).

### **Task 5 – Biological Impact Assessment**

The response of lakes and impoundments to nutrient loadings has been intensely studied. The response of rivers and streams to nutrient loadings is historically less well studied and therefore the principal cause-effect relationships between environmental stimuli and river and stream response are not well understood. Task 5 was undertaken to help evaluate this. Furthermore, although the Rock River Partnership was proceeding to collect water quality data for larger rivers and streams in the Rock River Basin as part of the overall effort (please see the summary for Task 2), it was recognized that phosphorus impacts might be more directly observed in smaller stream segments.

To provide additional knowledge concerning water quality issues and relationships for smaller streams in the Rock River Basin, the Rock River Watershed POTW Group commissioned a research effort led by Professor Kenneth W. Potter of the Department of Civil & Environmental Engineering at the University of Wisconsin-Madison. The results of this research are summarized herein.

*Description*

As part of this research, field studies were conducted to address the following questions:

1. What is the status of stream quality at representative sites throughout the Rock River Basin, where stream quality is defined with respect to the ability of a stream to support a desirable fishery?
2. How is stream quality at the sampling sites related to river and watershed characteristics?
3. Does stream water quality change in response to increases or decreases in available phosphorus?

*Approach and Methods*

To address these questions, the investigation focused on 14 subwatersheds within the Rock River Basin, which were selected in accordance with several criteria:

- representative of agricultural and natural landforms found in the Rock River Basin which do not include point or urban non-point discharges
- geographically dispersed throughout the Rock River Basin
- generally in the 10 to 50 sq. mi. watershed area range, a size small enough for detailed research yet large enough to support a substantial fishery
- wadable streams to facilitate data collection
- ready access to the streams at sampling sites

Table 5.1 lists the sites investigated. Figure 5.1 shows the site locations.

<b>Table 5.1 Study Sites</b>		
<b>Stream Name</b>	<b>Downstream Sampling Site</b>	<b>Watershed Size (sq. mi.)</b>
Allen Cr.	Peoppel Rd. near Fort Atkinson	8.7
Bass Cr.	Kessler Rd. near Afton	57.5
Calamus Cr.	County Hwy S near Lowell	16.5
Crawfish R.	Johnson Rd. near Columbus	55.2
Deer Cr.	County Hwy N near Fort Atkinson	23.9
Duck Cr.	Betschler Rd. in Jefferson Co.	27.2
Johnson Cr.	County Hwy Y near Johnson Creek	40.0
Little Oconomowoc R.	Kilbourne Rd. near North Lake	12.6
Little Turtle Cr.	North Rd. near Allen Grove	43.7
Maunsha R.	County TT downstream of Deansville State Wildlife Area	36.2
Marsh Cr.	Burdick Rd. near Janesville	27.5
Oconomowoc R.	Funk Rd. near North Lake	37.0
Saunders Cr.	Central Park in downtown Edgerton	40.9
Scuppernong R.	County Hwy N near Eagle	13.5

Collected data included water chemistry, stream biota, and the physical characteristics of the streams and their watersheds. Field investigations began in June 1998 with the goal of assessing existing conditions. Access points were located at road crossings and in public recreation areas. All accessible stream reaches

upstream of selected sampling sites were reportedly explored, and stream reaches 100 yards upstream and downstream of each sampling site were waded. At this time, stream physical characteristics of clarity, temperature, flow rate, streambed material, riparian conditions, channel morphology, and aquatic vegetation were observed and recorded.

Following the field investigations, the streams were subjectively ranked from best (#1) to worst (#14). The ranking was made with consideration to water clarity, streambed condition and channel morphology. Clear streams with natural streambed and morphology were ranked highest and turbid streams with sediment deposits and altered morphology were ranked lowest.

Monthly grab samples were collected at each sampling site for: total phosphorus, dissolved reactive phosphorus, ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, turbidity, trichromatic chlorophyll, monochromatic chlorophyll, and suspended solids. Samples were collected from May through November of 1998. Lab analyses were performed by the Wisconsin State Lab of Hygiene.

Base flow rates at the sampling sites were measured using the “midsection method”, and numerous velocity and depth measurements across the channel width, in the fall of 1998 and the fall of 1999. Measured base flows were related to watershed area (cfs/sq. mi.) and were also “indexed” to data collected at the nearest U.S. Geological Survey (USGS) flow gaging station.

Based on biological samples collected, biotic indices were calculated including the Hilsenhoff Biotic Index (HBI) for macroinvertebrates and the Index of Biotic Integrity (IBI) based on fish community attributes.

Diurnal dissolved oxygen (DO) measurements were made in the summer and fall of 1999 at each of the monitoring sites. Diurnal DO data were collected at 15 minute intervals for a period of one week at each location, and were normalized to percent of saturation to account for varying temperature conditions from site to site.

The degree of sediment present at each sampling site was evaluated, and a “sediment rating” given based on percent of streambed covered and thickness of sediment.

Each watershed was delineated on the basis of topography, with the topographic boundaries converted to geographic information system (GIS) computer files for area determination and for identification of watershed land use composition utilizing existing “WISCLAND” database information.

### *Results*

Table 5.2 presents the subjective stream ranking from the initial physical surveys.

<b>Table 5.2 Stream Rank</b>	
<b>Stream Name</b>	<b>Subjective Rank</b>
Scuppernong River	(Best) 1
Little Oconomowoc River	2
Oconomowoc River	3
Marsh Creek	4
Allen Creek	5
Deer Creek	6

<b>Stream Name</b>	<b>Subjective Rank</b>
Crawfish River	7
Bass Creek	8
Saunders Creek	9
Little Turtle Creek	10
Calamus Creek	11
Duck Creek	12
Maunsha River	13
Johnson Creek	(Worst) 14

The subjective stream rank was used as a basis of comparing trends in the quantitative data collected as discussed below.

The following data interpretation were made:

1. Sediment score was positively correlated with stream rank (Table 5.2) with the “worst” streams having the highest sediment impacts and the “best” streams the lowest. Turbidity also was positively correlated with stream rank, although turbidity was generally low except for the Maunsha River and Johnson Creek.
2. Total phosphorus concentration was positively correlated with stream rank. The two streams with the highest total phosphorus concentrations were determined to be primarily agricultural with no significant point sources of phosphorus, such that the high total phosphorus concentrations appeared due to agricultural runoff. Ammonia and Total Kjeldahl Nitrogen also correlate positively with stream rank. Nitrate nitrogen concentrations do not correlate well. It was postulated that agricultural groundwater drainage practices at some sites caused an increase in measured nitrate values.
3. Minimum diurnal DO levels correlated well with the subjective ranking, with the lowest values (normalized to percent saturation) observed at the “worst” sites.
4. Algae concentrations as measured by *Chlorophyll a* correlated positively with the subjective ranking, except for the Oconomowoc River site, which was an outlier, and apparently has high *Chlorophyll a* due to upstream lakes and impoundments.
5. The Hilsenhoff Biotic Index (HBI) correlated well with the subjective stream rank except for the Scuppernong River where the sampling location (wetland muck bottom) did not provide good conditions for HBI determination. The HBI was also found to correlate very well with minimum DO observations at the sampling sites.
6. The IBI indicator did not correlate well with stream rank with some high ranked streams providing low IBIs and some low ranked streams providing high IBIs.
7. Base flow did not correlate well with the subjective ranking, possibly due to the result of drain tile systems at some sites.
8. The subjective ranking was correlated with the fraction of watershed area in agricultural use. There is little correlation when only the watersheds with 50 percent or more of their area in agriculture are considered.
9. Higher nitrate and base stream flow levels were observed in watersheds with extensive drain tiling.
10. Channelization appears to have reduced the beneficial aspects of wetlands in the areas studied.

- Streams with higher slopes generally had the highest subjective rank. Higher slopes increase reaeration rates (increase DO replenishment) and reduce sedimentation. High relief basins also have less agriculture.

Figure 5.2 (Fig. 19 from Potter, et al, 2000) shows the relationship reported between total phosphorus and *Chlorophyll a* at the sample sites.

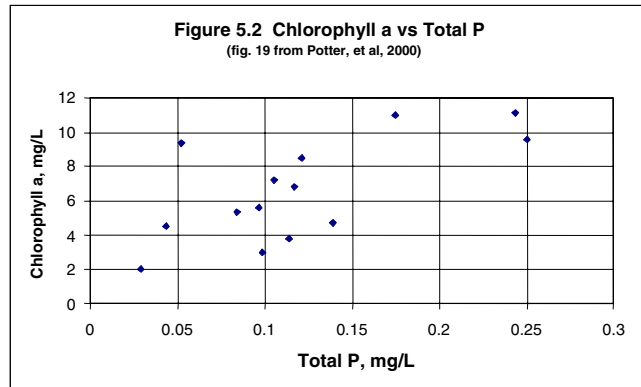
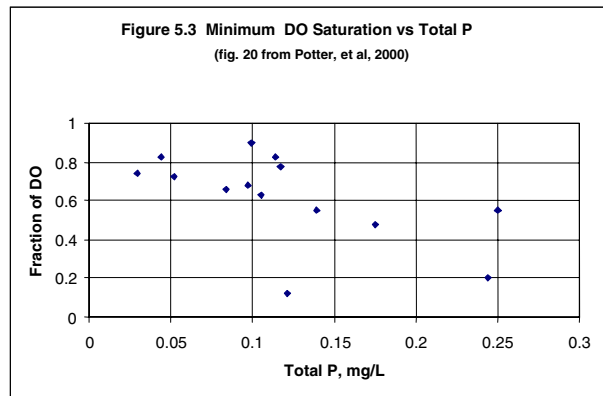


Figure 5.3 (Fig. 20 from Potter, et al, 2000) shows the relationship reported between total phosphorus and minimum daily diurnal dissolved oxygen levels (as percent of saturation).

“Background” nutrient levels identified by USGS, for natural streams with minimal anthropologic impact, are cited as 0.1 mg/L phosphorus, 0.1 mg/L ammonia nitrogen and 0.6 mg/L nitrate nitrogen. Eight of the fourteen studied streams exceeded “background” for phosphorus, one of the fourteen exceeded “background” for ammonia nitrogen and nine exceeded “background” for nitrate nitrogen.



Three of the streams studied had minimum diurnal dissolved oxygen levels below 5 mg/L (warm water fish and aquatic life standard), with Duck and Calamus Creeks having minimum diurnal DO < 2 mg/L and Johnson and Maunsha Creeks having minimum diurnal DO < 5 mg/L. Data analysis indicated that increasing stream phosphorus concentration explained only about 30% of the variance in minimum diurnal DO. Turbidity of some streams may mitigate high phosphorus levels, with respect to low DO concentrations caused by eutrophication.

In conjunction with the work that Dr. Potter conducted, Dr. Paul Garrison of the Department of Natural Resources conducted studies at 27 different sites within the Rock, Red Cedar, and Fox River Basins. Much of Dr. Potter’s work was based on biological indicators collected by Dr. Garrison. Garrison’s work concentrated primarily on flora and fauna parameters and is in the process of being written. For a copy, contact the DNR’s Bureau of Integrated Science Services.

### Conclusions

Principal findings were reported as:

- All water quality indicators except nitrate nitrogen, total Kjeldahl nitrogen and unit-area base flow were found to be correlated with a subjective ranking of water quality.
- Fine grained sediment deposits, derived primarily from agricultural activity, were judged to be the most serious problem in the streams studied.
- Cultural eutrophication (nutrient enrichment) was evident in the streams studied, with eight of the fourteen streams studied exceeding “background” phosphorus levels of 0.1 mg/L as reported by the USGS for natural streams with minimal impacts. *Chlorophyll a* concentrations were found to correlate with phosphorus levels. Minimum diurnal DO levels were also found to correlate with

phosphorus levels, and two of the studied streams had minimum diurnal DO levels <2 mg/L with two other streams having minimum diurnal DO levels <5 mg/L (stream standard).

- Most of the sediment and phosphorus in the streams studied is ultimately derived from runoff from agricultural lands.
- The presence of extensive drain tiling systems in four watersheds complicates the relationships observed between water quality indicators and the extent of agricultural activity. Drain tiling decreases soil moisture, increases infiltration rates, and decreases surface runoff and runoff-transport of sediment and phosphorus.
- There is little evidence that wetlands in the watersheds study are providing a beneficial effect, likely because the wetlands have been degraded by agricultural activities such as channelization.

It is stated that fine-grained sediment is “clearly the most serious problem in our study streams.” It is recommended that efforts to improve rural streams in the Rock River Basin focus on control of sediment. A caution is given that improved water clarity could worsen problems with low minimum diurnal DO and that phosphorus loading reduction may be required in such streams. It is also stated that restoration of degraded wetlands may be an effective strategy for improving stream quality. Lastly, it is stated that “serious efforts to improve stream quality in the Rock River Basin should target degraded streams with high potential for significant improvement. This would include streams that have high-gradient reaches, flow into larger streams with good fish populations, and have opportunities for wetland restoration.”

The following recommendations for future research were made:

- The basis for phosphorus “trading ratios” should be evaluated. Recognizing the importance of sediment loading to stream impairment in the watersheds studied, it is stated that “a strong argument can be made for a trading ratio of one or even less than one.”
- The need to develop more effective and expedient means of estimating sediment loadings and assessing the impacts of sediment load on stream quality is stated.
- Additional data should be collected relating the Hilsenhoff Biotic Index with minimum daily diurnal dissolved oxygen levels.
- The potential benefits of tile draining, in conjunction with constructed wetlands, should be considered as a potential means of improving water quality in some streams.

### *Reference*

“Stream Quality in the Rock River Basin of Wisconsin”, Kenneth W. Potter, David E. Armstrong, and Christopher J. Bonick, Department of Civil & Environmental Engineering, University of Wisconsin-Madison, 2000.

#### **IV. ANALYSIS AND CONCLUSIONS**

The Rock River Watershed Partnership was formed in 1996 to address nutrient and other water quality management issues within the Rock River watershed. Through the last three years, six major tasks were undertaken. These tasks were completed under the guidance and funding of the Rock River POTW Watershed Group, a collaboration of municipal POTWs and industrial dischargers formed under Wisconsin State Statute §66.30, Intermunicipal Agreements. Significant funding was also provided by the State of Wisconsin, Department of Natural Resources, and the USEPA through the University of Wisconsin-Extension.

Each of the tasks had separate goals, objectives, approaches, and outcomes. It is difficult, therefore, to draw definitive conclusions from the overall effort, as opposed to the results of the individual tasks. However, some common threads, as well as some contrasting conclusions, can be drawn. To best organize these comparisons, this report will use the goals of the Partnership as the outline under which the comparisons will be made. Each of the goals will serve as a subheading in this section of the report.

##### **Identify Nutrient Concerns and Prioritize**

The Modeling Report indicates significant contributions of phosphorus from both point (POTW) and non-point sources. As indicated by the monitoring work, both Total Phosphorus and Dissolved Phosphorus concentrations in the Rock River and some of its tributaries exceed desirable levels as per a variety of sources. Therefore, phosphorus is a concern. This is also stated in the Stream Quality in the Rock River Basin of Wisconsin report. It is reasonable to conclude that both non-point and point sources need to be addressed to achieve lower levels of phosphorus in the Rock River.

Nitrogen was not evaluated in detail. Ammonia, Nitrate Nitrogen, and Total Kjeldahl Nitrogen were tested as part of the monitoring work. The Stream Quality report indicated a "...less clear relationship" between nitrate nitrogen concentrations and the subjective stream quality ranking. No analysis of the nitrogen data from the monitoring effort has been performed. No conclusions have been drawn.

##### **Identify Water Quality Objectives/Desires**

The tasks completed did not address the issue of water quality objectives and desires. It is interesting to note that the USEPA has just recently issued a draft document regarding nutrient controls and guidance. Obviously, the overall goal of any pollution controls is an improvement in water quality. The relationship between water quality and phosphorus concentration is not linear or simple. The DNR's Phosphorus Workgroup identified this difficulty and suggested target phosphorus concentrations based on a variety of stream characteristics and uses. Since the Stream Quality report by the University of Wisconsin indicates a greater concern with sediment, it is unclear whether or not the potential reductions in phosphorus loads identified in the Modeling Report will result in water quality improvements or where those improvements will be most beneficial. The highest areas of potential phosphorus impact are in lakes, impoundments, and slow moving portions of the river.

##### **Inventory Existing Pollutant Sources**

The modeling has resulted in a macro-scale identification of the sources of phosphorus and sediment in the Rock River Basin. The Modeling Report further indicates a split of approximately 59% of the phosphorus entering the entire Rock River watershed comes from non-point sources and approximately 41% from point sources. While the relative contribution of phosphorus from point sources was higher than expected, nearly 60% of the phosphorus loading was non-point sources. Significant reductions in

phosphorus loading cannot be achieved by focusing on point sources alone and must consider a mix of point and non-point source controls. The Stream Quality report indicates that non-point source sediment is a major contributor to poor stream quality. It appears that both phosphorus and sediment are significant pollutant sources in the Rock River Basin.

### **Identify Strategies for Achieving Objectives**

Since objectives were not yet clearly defined, strategies cannot be identified. However, the Modeling Report shows significant reductions in phosphorus loadings can be achieved through currently available technologies. It is not clear if these reductions would result in significant, if any, measurable water quality improvements. Both the Modeling Report and the Stream Quality report indicate a need for significant additional study to determine the impact of these pollutants on stream quality. The Stream Quality report suggests that more improvement can be achieved by addressing sediment.

Effluent or watershed based trading of phosphorus “credits” was evaluated by a separate workgroup organized under the Partnership. Trading has been considered for some time as a potentially viable strategy for achieving pollutant reductions, and hopefully water quality improvements, in a cost-effective manner. Although the USEPA has published the “Draft Framework for Watershed-Based Trading” (USEPA 800-R-96-001, May 1996), specific issues were identified that required resolution for any trades within the Rock River Basin. The workgroup identified 47 issues of administrative concern. The resulting list with resolutions is an excellent source of information on the detailed issues that must be addressed for effluent trading to occur. The number of issues to be addressed may be an impediment to trading.

Also discussed was the critical issue of trading ratios, the ratio of non-point pollutant removal required to offset a required point discharge pollutant removal. The intent of the ratio is to compensate for the lack of certainty and variability of success of non-point pollutant removal projects compared to the measurable and much more certain point discharge controls. Initially, a subjective spreadsheet was developed to attempt to quantify the levels of uncertainty and benefit of a potential point to non-point trade. Later, the DNR determined that it would require trade ratios in the range of 2:1. This may be an impediment to trades depending upon the economic analyses.

### **Establish Least Cost Mix of Alternatives**

Task 4 evaluated the economics of phosphorus removal. The evaluation included calculated and actual plant information on point source phosphorus removal. A spreadsheet prepared under the guidance of the DNR was used to estimate non-point phosphorus removal costs. Because of the variety of inputs of this analysis, a range of values was developed. The identified values indicate it is likely to be slightly less expensive to implement non-point controls versus point controls for phosphorus, except for very large treatment plants where economies of scale may reduce the per pound phosphorus removal costs.

Because the costs were fairly close, administrative costs and trade ratios may significantly impact the ability to achieve cost-effective trades. This is already been seen with a more detailed evaluation prepared by one of the Partnership POTWs. Site specific analyses are required to determine the cost-effective approach to the reduction of phosphorus loadings.

### **Implement Least Cost Alternatives**

The Partnership does not have the funds or authority to implement pollutant reduction alternatives. To date, the POTW Group, which has the authority with member concurrence, has not yet identified any projects to implement nor has expressed a desire to serve as an agency for implementation. Monitoring of the actions of the individual members will be required to assess the implementation of any alternatives

and to determine their cost-effectiveness. A number of communities have indicated a desire to consider trades. At the time of this writing, it was not clear if any trades would be implemented or if any other steps to identify and implement least cost alternatives would be undertaken. It appears that many communities have decided, based upon the cost information and trading requirements available, to simply implement phosphorus removal at their POTWs to the NR 217 limits.

## V. BIBLIOGRAPHY

“Agricultural Phosphorus and Eutrophication: A Symposium Overview”, by Daniel, T. C., A. N. Sharpley, and J. L. Lemunyon, 1998. *J. Environ. Qual.* 27:251-257.

“Draft Framework for Watershed-Based Trading”, USEPA (EPA 800-R-96-001), May 1996.

“Integrating Phosphorous and Nitrogen Management at the Catchment Scale”, by Heathwaite, A. L., A. N. Sharpley, and W. Gburek. Abstracts of OECD Workshop. Practical and innovative measure for the control of agricultural phosphorus losses to water. Greenmount College of Agriculture and Horticulture, N. Ireland, June 16-19, 1998.

“Meeting Notes, Trade Ratio Workgroup”, March 10, 1999.

“Narrative on Phosphorus Trading Ratio Protocol”, with attached Trade Computation Spreadsheets and Slideshow Presentation, August 4, 1999.

“The Potential for Nutrient Trading in Wisconsin: The Case of the Rock River Valley”, by Paul Faeth, World Resources Institute, Washington, D.C., 1998.

POTW Phosphorus Control Costs, Michael D. Doran, P.E. DEE, Strand Associates, Inc., Madison WI, April 28, 1997.

POTW Phosphorus Removal Costs, Michael D. Doran, P.E. DEE, Strand Associates, Inc., Madison WI, January 12, 2000.

“Prediction of Phosphorus Loads in the Rock River Basin, Wisconsin, Using SWAT (Soil & Water Assessment Tool)”, by Earth Tech and Strand Associates, Inc., August 2000.

Riparian Buffer and Tillage Spreadsheets, Ken Johnson (Wisconsin Department of Natural Resources) and Aicardo Roa (Dane County Land Conservation District), Madison WI, 1999 (includes descriptive memorandum and Microsoft Excel® spreadsheet).

Rock River Trading Structure Workgroup, “Issue List – Current as of 6/11/99.”

“Slideshow Presentation – Simplified Trade Ratio Development”, January 27, 2000.

“Stream Quality in the Rock River Basin of Wisconsin”, Kenneth W. Potter, David E. Armstrong, and Christopher J. Bonick, Department of Civil & Environmental Engineering, University of Wisconsin-Madison, 2000.