**Non-tidal Passaic River Basin Water Quality Trading Project**

*Review of Total Phosphorus Total Maximum Daily Loads*

*Implemented by Water Quality Trading Projects*

Seven Total Maximum Daily Loads (TMDL) reports that address total phosphorus are reviewed, all of which are being implemented through water quality trading and other measures. The seven TMDLs contain a wide range of approaches to problem definition, modeling, and implementation. The seven TMDLs are categorized as simple or complex based on their problem definition and modeling approach.

**Comparative analysis**

*Problem definition and modeling approach*

Four 'simple' TMDLs (Chatfield Reservoir, Cherry Creek Reservoir, Lake Dillon, and Lake Allegan) were designed to only address phosphorus and its impact to chlorophyll-a. These TMDLs were developed using simple mass balance models to protect reservoir endpoints.

Three 'complex' TMDLs (Lower Minnesota River, Snake River – Hells Canyon, and Stillwater River Basin) considered phosphorus in an integrated context of related water quality parameters such as sediment, dissolved oxygen, chlorophyll-a, and BOD. These TMDLS were developed using sophisticated water quality models such as HSPF, SWAT, and QUAL-W2. In contrast to the four 'simple' TMDLs which protect a single reservoir endpoint, the 'complex' TMDLs address large portions of their watersheds. For

example, the Lower Minnesota River TMDL addresses dissolved oxygen in the lower 22 miles of the Minnesota River.

*Establishing phosphorus water quality targets*

Chatfield Reservoir and Cherry Creek Reservoir TMDLs were based on achieving numerical phosphorus water quality standards. Lake Dillon, Lake Allegan, and Snake River – Hells Canyon TMDLs were based on seasonal site-specific chlorophyll-a targets which were then correlated to phosphorus water quality targets. The Lower Minnesota River TMDL correlated its seasonal phosphorus water quality target to a 40% BOD reduction target. Target values for total phosphorus in the Stillwater River Basin TMDL were based upon the drainage area, designated use of a given stream segment, and an appropriate reference stream concentration. Only the Stillwater River Basin TMDL considered biocriteria in setting a phosphorus water quality target. Both the Stillwater River Basin TMDL and Snake River – Hells Canyon TMDLs systematically considered designated uses in establishing phosphorus water quality targets. All the TMDLs considered seasonal effects (e.g. summer growing season for algae) in setting either the phosphorus target or load allocation.

*Margin of Safety*

The TMDL margins of safety were based on explicit and/or implicit factors. For example, the Snake River – Hells Canyon TMDL had a 13% explicit margin of safety incorporated into its total phosphorus water quality target. The Lower Minnesota River TMDL margin of safety was estimated at 10% based implicitly on model assumptions. The Lake Allegan TMDL had a small margin of safety (< 2%) because of the extensive data collected and low uncertainty in estimating point and nonpoint source loads.

*Implementation plan*

All the TMDL implementation plans contain a range of strategies for point and nonpoint sources to meet load allocations. Water quality trading is just one of many avenues to implement the TMDLs reviewed here. The Lake Allegan, Lower Minnesota River, Snake River – Hells Canyon, and Stillwater River Basin TMDLs offer specific timelines for TMDL implementation milestones.

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**Acronyms**

BOD – biochemical oxygen demand

DO – Dissolved oxygen

EPA – Environmental Protection Agency

LA – load allocation

MOS – margin of safety

TMAL – Total Maximum Annual Load

TMDL – Total Maximum Daily Load

TP – total phosphorus

USDA – U.S. Department of Agriculture

WLA – wasteload allocation

WWTP – wastewater treatment plant

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**TMDL title:** Chatfield Reservoir Total Maximum Daily Load

**Watershed / waterbody**: Chatfield Reservoir, Colorado.

**Watershed size**: Approximately 3000 square miles (Breetz *et al*., 2004)

**EPA approval date of TMDL**: 7/24/97 (USEPA)

**Summary of modeling approach**: A simple mass balance model was applied to predict total phosphorus loading to reservoir that can be assimilated without exceeding 0.027 mg/L water quality standard for total phosphorus. The TMDL was based on a conservative assumption of a one in ten year flow, or Q10. The target for chlorophyll-a in the growing season is 17 ug/L. The resultant TMDL varies with annual flow, so that higher annual loads are allowed at higher annual flows (Chatfield Watershed Authority, 2005).

**Margin of safety**: Three factors contribute to the MOS: a) conservative flow assumption (Q10 condition); b) Model overpredicts total loading to reservoir by 13% c) water quality standard for phosphorus (0.027 mg/L) yields chlorophyll-a levels below 0.017 mg/L growing season target (Chatfield Watershed Authority, 2005).

**TMAL allocations**: WLAs are constant across all flows, while LAs vary with flow (Chatfield Watershed Authority, 2005).

**Implementation plan**: The Chatfield Watershed Authority relies on a combination of programs related to stormwater management, nonpoint source pollution reduction, and water quality trading to implement the TMDL (Chatfield Watershed Authority, 2005; CDPHE, 1999).

**References**:

Breetz HL, Fisher-Vanden K, Garzon L, Jacobs, H, Kroetz K, Terry R; Dartmouth College (2004). 'Water Quality Trading and Offset Initiatives in the US: A

Comprehensive Survey'. Available at http://www.dartmouth.edu/%7Ekfv/waterqualitytradingdatabase.pdf. Accessed in March 2005.

Chatfield Watershed Authority (2005). Chatfield Watershed Report 2004: Annual Summary and Water Quality Fact Sheets.

Colorado Department of Public Health and Environment (CDPHE) (1999). Chatfield Reservoir Control Regulation, Regulation No. 73.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.

**TMAL title:** Cherry Creek TMAL

**Watershed / waterbody**: Cherry Creek watershed

**Watershed size:** Approximately 380 square miles (Breetz *et al*., 2004)

**EPA approval of TMAL:** 7/24/97 (USEPA)

**Modeling approach:** The TMAL was based on the endpoint of the Cherry Creek Reservoir. The Vollenweider phosphorus model relates in-lake phosphorus concentrations to total estimated annual loads. Application of this model established the maximum load of 14,270 pounds of phosphorus that could enter Cherry Creek Reservoir annually and maintain the in-lake water quality standard of 35 ug/L, which corresponds to an in-lake chlorophyll-a concentration of 15 ug/L. The Canfield-Bachmann model was calibrated to predict the sediment coefficient. Wastewater treatment facilities, nonpoint and regulated stormwater sources, septic, industrial, and background sources were used to define phosphorus inputs to the reservoir (WERF, 2000). Allocations for wastewater treatment facilities were based on 0.05 mg/L phosphorus effluent concentration (CCBWQA, 2003).

**Margin of safety:** 500 pounds were removed from the NPS load allocation, reducing the amount of potentially tradable pounds of phosphorus (CDPHE, 2001).

**TMAL allocations:** Allocations are divided proportionally among nonpoint and regulated stormwater sources, background sources, wastewater treatment facilities, industrial process wastewater sources, and individual sewage disposal system sources. (CCBWQA, 2003).

**Implementation plan:** The Cherry Creek Basin Water Quality Authority employs a phased approach to TMAL implementation. Studies to improve quantification of nonpoint source, stormwater, and background concentrations of phosphorus are implemented in parallel with NPS control projects, regulated decrease of WWTP effluent levels, stormwater control projects, and water quality trading. The TMAL itself is regularly evaluated to compare predicted impacts with actual reservoir water quality (CCBWQA, 2003).

**References:**

Breetz HL, Fisher-Vanden K, Garzon L, Jacobs, H, Kroetz K, Terry R; Dartmouth College (2004). 'Water Quality Trading and Offset Initiatives in the US: A Comprehensive Survey'. Available at http://www.dartmouth.edu/%7Ekfv/waterqualitytradingdatabase.pdf. Accessed in March 2005.

Cherry Creek Basin Water Quality Authority (CCBWQA) (2003). Cherry Creek Reservoir Watershed Plan 2003.

Colorado Department of Public Health and Environment (CDPHE) (2001). Cherry Creek Reservoir Control Regulation. Regulation No. 72. 5 CCR 1002-72.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.

Water Environment Research Foundation (WERF) (2000). Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach.

**TMDL title:** Dillon Reservoir TMDL

**Watershed / Waterbody**: Lake Dillon, Colorado

**Watershed size:** 325 square miles (Breetz *et al*., 2004)

**EPA approval of TMDL:** 7/24/97 (USEPA)

**Modeling approach:** The goal is to maintain the 1982 seasonal average chlorophyll levels of Lake Dillon. The loading necessary to yield a maximum in-lake total phosphorus concentration of 7.4 ug/L as a growing season average was calculated. Wasteload allocations for major dischargers were based on projected "build out" flows. (NWCCOG, 2002).

**Margin of safety:** Although the MOS is not discussed directly, the TMDL is subject to reevaluation to ensure its allocations are meeting water quality objectives (NWCCOG, 2002).

**TMDL allocations:** A wasteload allocation of 1634 lbs/year is divided proportionally among ten wastewater treatment plants (CDPHE, 2003).

**Implementation plan:** The management strategy includes local land use controls involving best management practices to address non-point source contributions, design criteria for on-site wastewater treatment systems, and water quality trading (NWCCOG, 2002).

**References:**

Breetz HL, Fisher-Vanden K, Garzon L, Jacobs, H, Kroetz K, Terry R; Dartmouth College (2004). 'Water Quality Trading and Offset Initiatives in the US: A Comprehensive Survey'. Available at http://www.dartmouth.edu/%7Ekfv/waterqualitytradingdatabase.pdf. Accessed in March 2005.

Colorado Department of Public Health and Environment (CDPHE) (2003). Regulation No. 71: Dillon Reservoir Control Regulation, 5 CCR 1002-71.

Northwest Colorado Council of Governments (NWCCOG) (2002). Blue River Water Quality Management Plan 2002.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.

**TMDL title:** Snake River – Hells Canyon Total Maximum Daily Load

**Watershed / waterbody name**: Snake River – Hells Canyon (SR-HC), Idaho

**Watershed size**: 221 miles of Snake River; total drainage area is 73,000 square miles (IDEQ and ODEQ, 2004).

**EPA approval of TMDL**: September 2004 (IDEQ)

**Modeling approach**: The TMDL is comprehensive in addressing multiple pollutants besides total phosphorus. The TMDL also addresses bacteria, pH, mercury, pesticides, dissolved oxygen, sediment and temperature. Although this leads to a larger and more complex TMDL, it allows for a more integrated and contextual assessment of phosphorus. For example, the TMDL discusses the impact of reduced phosphorus concentrations on algal growth and dissolved oxygen concentrations.

In order to establish a site-specific target for total phosphorus, the TMDL first established a site-specific target for chlorophyll-a. A 14 ug/L mean growing season chlorophyll *a* concentration and a nuisance threshold of 30 ug/L chlorophyll-a was projected to be protective of all designated beneficial uses. A total phosphorus concentration of 0.07 mg/L was correlated to the chlorophyll-a target based on water quality data. These targets are seasonal in nature and apply from May through September.

Water quality modeling was done using USACOE CE-QUAL-W2 model. The model predicted that attainment of 0.07 mg/L total phosphorus will result in a reduction

of roughly 50 percent in algal biomass (as measured by chlorophyll *a*) that in turn will result in improvement in dissolved oxygen concentrations in both the Upstream Snake River and Brownlee Reservoir segments. The reduction in organic matter will also decrease the potential for methylmercury production within the SR-HC TMDL reach (IDEQ and ODEQ, 2004).

**Margin of safety**: A 13 percent margin of safety has been applied to total phosphorus load allocations and capacity for this TMDL as determined by the accuracy and representativeness of sampling techniques and analytical methods. This margin of safety has been incorporated into the identification of the 0.07 mg/L total phosphorus target for the SR-HC TMDL. Other areas of uncertainty such as system uptake, assimilative capacity, and relative impairment to different use categories were addressed to the extent possible through the use of conservative assumptions in the identification of the nutrient target, sensitive designated uses and critical period (IDEQ and ODEQ, 2004).

**TMDL allocations**: The TMDL assigns waste load allocations to direct point source dischargers to the Snake River operating mechanical treatment plants to reduce total phosphorus discharge concentrations by 80 percent. Nonpoint source discharges will be required to reduce to the 0.07 mg/L level. Inflowing tributaries have been assigned load allocations to meet the 0.07 mg/L total phosphorus target at their inflow to the Snake River. A load allocation for the addition of 1,125 tons of dissolved oxygen per season has been assigned to Idaho Power Company to offset reduction in assimilative capacity caused by the Hells Canyon Complex impoundments (IDEQ and ODEQ, 2004).

**Implementation plan**: This TMDL has adopted a phased approach to implementation that will identify interim, measurable milestones to determine the effectiveness of

management measures or other action controls being implemented, and a process for reviewing and revising management approaches to assure effective management measures are implemented. Agencies responsible for the preparation and approval of the SR-HC TMDL recognize that long time-frames (potentially 50 to 70 years) may be required for water all quality standards to be consistently met. Point sources are expected to implement biological nutrient removal or technologies that achieve equivalent reductions. Nonpoint sources are expected to implement BMPs. Pollutant trading, adapted from the Lower Boise River trading framework, is also encouraged (IDEQ and ODEQ, 2004).

**References:**

Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ) (2004). Snake River – Hells Canyon Total Maximum Daily Load (TMDL).

"Surface Water Quality: Subbasin Assessments, Total Maximum Daily Loads (TMDLs), and Implementation Plans," *Idaho Department of Environmental Quality*. Available at http://www.deq.state.id.us/water/data_reports/surface_water/tmdls/sba_tmdl_master_list.cfm. Accessed in March 2006.

**Additional comment:** This is a thorough and highly sophisticated TMDL. Selection of the TP in-stream target was site-specific, based on local data, and systematically considered all beneficial uses. The TMDL specifically projects benefits to DO and chlorophyll-a from reduced total phosphorus concentrations, and offers a detailed yet flexible implementation plan with many options. Remarkably, it is also an interstate effort between Idaho and Oregon.

**TMDL title:** TMDL for Total Phosphorus in Lake Allegan

**Watershed / waterbody name:** Lake Allegan (Kalamazoo River impoundment)

**Watershed size:** 2020 square miles (Kalamazoo River/Lake Allegan TMDL Implementation Committee, 2002)

**EPA approval of TMDL:** 4/24/01 (USEPA)

**Modeling approach:** Total phosphorus was shown to be the limiting nutrient in Lake Allegan, an impoundment on the Kalamazoo River. A site-specific total phosphorus goal of 60 ug/L was set for Lake Allegan. It was determined that the critical period for total phosphorus load to Lake Allegan is from April to September. Therefore, a seasonal approach was used in the development of the TMDL.

Measurement of April-September 1998 loads was used to determine the seasonal loading capacity necessary to achieve the total phosphorus goal of 60 ug/L.

Additionally, a preliminary non-point source (NPS) modeling effort of the Kalamazoo River watershed was conducted using data corresponding to a 1998-1999 river monitoring period to estimate NPS loads of phosphorus from recognized/delineated subwatersheds draining to Lake Allegan. Non-point source modeling in this application used a combination of empirical tools, remotely sensed data and a geographic information system database. Seasonal and annual phosphorus loads were calculated for each subwatershed using event-mean concentrations, land cover relationships and precipitation data. Tributary monitoring data collected in 1998-1999 for selected subwatersheds were used to adjust NPS loading model coefficients to match monitored load estimates to Lake Allegan. The distribution of land cover throughout the watershed, and the corresponding non-point source phosphorus loads derived from this effort, provided important insight into the most significant contributors of phosphorus to the river. Analyses indicated that nearly one-half of the non-point phosphorus load

appears attributable to urban related land covers that comprise only 8% of the total land use in the watershed above Lake Allegan. Although agriculture covers slightly less than half of the land surfaces in this same drainage, only about one-third of the non-point source phosphorus load may originate from agriculture (Kalamazoo River/Lake Allegan TMDL Implementation Committee, 2002).

**Margin of safety:** The MOS developed for this TMDL is lower than typically derived because of the low uncertainty involved in estimating the point source and nonpoint source loads to the lake. An extensive amount of information was collected on ambient loadings of total phosphorus entering the lake from the watershed. In addition, point source loadings were intensely investigated so that accurate point source loadings and allocations could be developed. Therefore, an explicit MOS of 100 pounds per month is allocated for the early season from April through June, since loads are greater in the spring season to account for the higher peak flow periods. An explicit MOS of 50 pounds per month is allocated for the summer season, since loads are lower in July to September (MEDQ, 2001).

**TMDL allocations:** The WLA set for the April to June season maintains current conditions. The WLA for the July to September period represents a 23% reduction in total phosphorus discharge. It is during this season that point source load reductions are most important, since during this time, point source loading dominated the total load going to Lake Allegan. The LA for nonpoint sources results in a 43% reduction from current during the April to June period, and a 50% reduction for the July through September season. (MEDQ, 2001)

**Implementation plan**: The implementation plan outlines clear milestones. Point sources are expected to achieve WLAs by 2006, and NPS discharge is expected to achieve 50% reduction by 2012. Water quality standards are to be attained by 2015. Strategies for reducing NPS discharge are outlined for each NPS category. Point sources agree to assist in preparation and implementation of NPS reduction plans. An excellent watershed-based approach with strong public participation underscores the implementation plan (Kalamazoo River/Lake Allegan TMDL Implementation Committee, 2002).

Water quality trading in compliance with Michigan state rules on trading is featured, and specific trading ratios are detailed. A web-based registry, trading board, and credit estimating tools are designed to make trading more practical and reduce transaction costs (Kieser and Fang, 2005).

**References:**

Kalamazoo River/Lake Allegan TMDL Implementation Committee (2002). Water Quality Improvement (Implementation) Plan for the Kalamazoo River Watershed and Lake Allegan through a Phosphorus Total Maximum Daily Load (TMDL) Process.

Kieser, M.S. and A.F. Fang (2005). Water Quality Trading in the United States: An Overview. Available at http://ecosystemmarketplace.com/pages/article.news.php?component_id=3954&component_version_id=5593&language_id=12. Accessed in March 2006.

Michigan Department of Environmental Quality (MEDQ) (2001). Total Maximum Daily Load for Total Phosphorus in Lake Allegan.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.

**TMDL title:** Lower Minnesota River Dissolved Oxygen Total Maximum Daily Load Report

**Watershed / Waterbody name:** Minnesota River Basin

**Watershed size:** 17,000 square miles (MPCA, 2004)

**EPA approval of TMDL:** 9/28/04 (USEPA)

**Modeling approach:** This Phase II TMDL identifies the allowable levels of phosphorus that will result in the attainment of the dissolved oxygen standard in the lower 22 miles of the Minnesota River during low flow conditions. The low dissolved oxygen problem occurs during low flow conditions in this stretch of the Minnesota River (MPCA, 2004). Phosphorus is targeted because the nutrient causes excessive algal growth, which in turn produces BOD as a result of algal decomposition. High BOD leads to the low dissolved oxygen. Phase II focuses on achieving the 40 percent BOD reduction goal by reducing the high phosphorus loading upstream (Fact sheet).

Phase II provides: 1) an understanding of how the nutrient phosphorus creates BOD in this large river system; 2) a more comprehensive understanding of the loading contributions from upstream dischargers and area-wide nonpoint pollution sources; and 3) an understanding of how the loading and eutrophication cycles travel downstream to Shakopee (MPCA, 2004).

To meet dissolved oxygen standards, the WLA Study established a 40 percent BOD reduction target for the Minnesota River upstream of Shakopee. Therefore, BOD target for this TMDL is 3.7 mg/l. The model projected a 0.131 mg/l phosphorus concentration would be needed to reach the 3.7 mg/l BOD target. A previous study

indicated that an inflow goal for Lake Pepin of 0.130 mg/l of total phosphorus would be necessary in order to achieve an in-lake concentration of 0.070 under 1988 flow conditions (MPCA, 2004).

Building on the algae-phosphorus relationship, a basin scale computer modeling project using the Hydrologic Simulation Program - FORTRAN (HSPF) model was started. The HSPF model was calibrated with data from 1986-1992. This timeframe included the last low flow period of 1988 as well as average and high flow years (MPCA, 2004).

The HSPF model, like any other, more accurately estimates longer term (week or month) water quality rather than daily concentrations. Therefore, **a two-month critical low flow period of August and September 1988** was selected to represent the meteorological conditions and hydrologic response for this TMDL (MPCA, 2004).

Once the phosphorus load during a future low flow period was estimated, additional scenarios were intended to determine how sensitive the river was to changes in various source categories (e.g. wastewater treatment facilities and agriculture) or geographic locations. The impact of each scenario on chl-a concentration was simulated. A variety of management practices were modeled (MPCA, 2004).

**Margin of safety:** The margin of safety was provided implicitly in the model assumptions. It is estimated to be at least 10 percent of the allocation (MPCA, 2004).

**TMDL allocations:** The allocations are set for the August – September period when critical low flow conditions occur. Under current practices, approximately 1,240 pounds per day of phosphorus is projected to be generated in the Basin during critical low flow conditions. The TMDL reduces the amount to 752 pounds per day during low flow

conditions. Strategies to solve the problem involve decreasing the amount of phosphorus that reaches the river and increasing the amount of flow so low flow periods occur less frequently for shorter periods of time (MPCA, 2004).

**Implementation plan:**

The implementation plan outlines strategies for each source category (MPCA, 2006).

*Wastewater Treatment Facilities*

WWTFs are the major source of total phosphorus in the watershed. For the larger WWTFs, the goal is to reduce total phosphorus discharged by 35 percent by the year 2010. To reduce the total amount of phosphorus, the MPCA is implementing a new basin-wide phosphorus permit which allows for water quality trading.

*Stormwater from urban areas*

Communities, industries, construction sites and others needing a stormwater permit already will submit Stormwater Pollution Prevention Plans as part of permit requirements. Those located in the Minnesota River Basin will be required to address phosphorus reduction in their plans. Non-permitted communities will rely on education and voluntary measures to reduce phosphorus.

*Sewage from failing septic systems and unsewered communities*

Failing systems must be located and fixed. Financial assistance and loans will be used to encourage and enable homeowners and small communities to do this.

*Runoff from agricultural cropland*

Utilizing crop residue and protecting open tile intakes – or equivalent practices – will be encouraged.

Timelines

Most activities will be implemented by 2015 except for urban stormwater retrofits (construction activities such as replacing pipes or adding ponds) which will be allowed 20 years to implement because of the complexity and cost to make these changes in areas that have already been developed (MPCA, 2006).

**References:**

"Fact Sheet – Lower Minnesota River TMDL: Low Dissolved Oxygen," *Minnesota Pollution Control Agency*. Available at http://www.pca.state.mn.us/publications/wq-b3-07.pdf. Accessed in March 2006.

Minnesota Pollution Control Agency (MPCA) (2004). Lower Minnesota River Dissolved Oxygen Total Maximum Daily Load Report.

MPCA (2006). Lower Minnesota River Dissolved Oxygen Total Maximum Daily Load Implementation Plan.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.

**TMDL title:** Total Maximum Daily Loads for the Stillwater River Basin

**Watershed /waterbody name:** Stillwater River Basin

**Watershed size:** Approximately 673 square miles (OEPA, 2004)

**EPA approval of TMDL:** 6/15/04 (EPA)

**Modeling approach:** Habitat destruction through channelization, and organic and nutrient enrichment are the primary sources of impairment. Ohio water quality standards include numerical biological criteria, but lack numerical nutrient standards. Intermediate nutrient targets were identified to complement the biocriteria and to help evaluate the impact of nutrient loadings. Target values for total phosphorus were based upon the

drainage area, designated use of a given stream segment, and an appropriate reference stream concentration.

Nutrient loading and flow in the Stillwater River watershed from agricultural management practices and WWTPs was simulated using the Soil and Water Assessment Tool (SWAT). SWAT is a river basin-scale model developed by USDA. The results of the model suggest that existing nitrogen loads can be assimilated; however, phosphorus loads exceed the assimilative capacity by an order of magnitude. Agricultural fertilizers account for approximately fifty to eighty-five percent of the phosphorus load depending on the season.

The Qualitative Habitat Evaluation Index (QHEI) is a quantitative composite of six physical habitat variables used to 'score' a stream's habitat. For the Stillwater River TMDL, the QHEI was used as a guide to direct restoration efforts for habitat and provide a monitoring tool to measure progress towards habitat goals (OEPA, 2004).

**Margin of safety:** The margin of safety is incorporated implicitly into these TMDLs. One implicit safety factor is the use of nutrient targets that are based on data from relatively unimpacted reference sites (OEPA, 2004).

**TMDL allocations:** The dynamics of phosphorus sedimentation and resuspension were considered in developing TMDL allocations. Based on observed low flow conditions of hyper-eutrophy and studies confirming a connection between excessive loads and the subsequent season's release of these nutrients into the water column, Ohio EPA was compelled to apply the nutrient targets *to each season* of the entire year. Agricultural fertilizers need to be reduced by approximately eighty percent during the winter and spring months. Similarly, loads from stormwater and on-site sewerage systems need to be

reduced by seventy percent in the winter and spring. Loads from municipal wastewater need to be reduced by sixty-five percent across all seasons (OEPA, 2004).

**Implementation plan:** The following recommendations are suggested to affect full recovery of aquatic life uses:

- Comprehensive nutrient management plans for all animal feeding operations,
- Encourage the use of best demonstrated technologies for managing animal waste through cost sharing and other incentive programs,
- Increase the number and width of grass filter strips on maintained ditches through cost sharing and other incentive programs,
- Increase the number of agricultures acres in no-till or conservation tillage through cost sharing and other incentive programs,.
- Develop criteria for allowing ditch maintenance,
- Establish a Darke County Sewer District, and
- Establish residential on-site sewerage inspection programs in Darke and Miami Counties.

Draft timelines extending to 2007 are outlined for the above actions (OEPA, 2004).

The Stillwater River Basin is also part of the Great Miami River Watershed Water Quality Trading Pilot Program, a newly formed point-nonpoint source trading program managed by the Miami Conservancy District (Breetz *et al*., 2004; MCD, 2005).

**References:**

Breetz HL, Fisher-Vanden K, Garzon L, Jacobs, H, Kroetz K, Terry R; Dartmouth College (2004). 'Water Quality Trading and Offset Initiatives in the US: A Comprehensive Survey'. Available at http://www.dartmouth.edu/%7Ekfv/waterqualitytradingdatabase.pdf. Accessed in March 2005.

Miami Conservancy District (MCD) (2005). Great Miami River Watershed Water Quality Credit Trading Program – Operations Manual.
Ohio Environmental Protection Agency (OEPA) (2004). Total Maximum Daily Loads for the Stillwater River Basin.

"Total Maximum Daily Loads," *USEPA*. Available at http://www.epa.gov/owow/tmdl/. Accessed in March 2006.