Tetra Tech, Inc., 10306 Eaton Place, Suite 340, Fairfax, VA 22030

Phone: (703) 385-6000 Fax: (703) 385-6007

Date: August 20, 2007

To: Carol Nankivel, Minnesota Pollution Control Agency

Re: Final Version of Technical Memorandum #1—Analytical Approaches Used by MS4s

Greetings:

Attached is the final version of Technical Memorandum #1, which addresses Task 1 in the Minnesota Pollution Control Agency's Stormwater Nondegradation Analysis Project. The information provided in this Technical Memorandum summarizes and characterizes the approaches used by the 30 Selected MS4s to comply with the Nondegradation Loading Assessment requirements under the Phase II MS4 Stormwater General Permit. In addition, this document provides analyses and recommendations related to improving the overall nondegradation review requirements for Phase II MS4s and other permitted stormwater sources.

Tetra Tech focused this analysis on the tasks outlined in the scope of work. Therefore, the technical approaches and tools reviewed are limited to only those used by the 30 Selected MS4s. Tetra Tech recognizes that other tools are available for assessing stormwater loads, including those listed in Appendix B of the 2005 Minnesota Stormwater Manual and the National Water Pollution Control Assessment Model (NWPCAM) developed for EPA to support the Phase II stormwater rulemaking effort.

The technical approaches reviewed, summarized, and evaluated by Tetra Tech found that the Selected MS4s are predominantly using simple approaches to conduct Loading Assessments. These approaches are acceptable for estimating the relative changes in average annual flow, total suspended solids loading, and phosphorus loading from the 1988 baseline year and generally comply with the Phase II MS4 General Permit requirements. However, the review of the Loading Assessment requirements, in the context of the overall nondegradation requirements, raises issues related to the usefulness of the Loading Assessment work products in making nondegradation determinations without considering impacts on receiving waters, which we address as part of the recommendations in this document.

The information in Technical Memorandum #1 is organized as follows:



Please review this information at your convenience. In closing out this project, please accept our thanks for allowing us to contribute to your work in this very important water resources policy area. If you have any additional comments or need any additional information from us, please let us know.

Sincerely,

Barry Tonning, Tetra Tech

**Technical Memorandum # 1**

***Nondegradation Loading Assessment Evaluation and Recommendations for Selected Municipal Separate Storm Sewer Systems***

# Introduction

The Minnesota Pollution Control Agency (MPCA) issued a revised Phase II municipal separate storm sewer system (MS4) general permit on March 3, 2006, effective on June 1, 2006, that contains nondegradation requirements for 30 Selected MS4s. Part XI of the Phase II MS4 general permit specifies the list of 30 Selected MS4s subject to the nondegradation requirements contained in Part X of the MS4 general permit. Under Part X, the 30 Selected MS4s must conduct a Loading Assessment to determine if the MS4 meets the definition of a new or expanded discharger because of increases in stormwater runoff and pollutant loads for total suspended solids (TSS) and phosphorus from a 1988 baseline. If a Selected MS4 determines that it has a significant new or expanded discharge, Part X requires the MS4 to develop a Nondegradation Report that specifies what best management practices (BMPs) will be reasonably required to return stormwater discharges to 1988 levels, and to propose modifications to the stormwater pollution prevention plan (SWPPP) to address nondegradation.

The MPCA, working with stakeholders, developed the requirements contained in Part X and Part XI of the revised MS4 general permit on the basis of the MPCA's interpretation of the Minnesota Rules Chapter 7050 nondegradation requirements under the authorities provided in Minnesota Statute § 115.03, subd. 5b(b). Interpretation by the MPCA was necessary because the existing nondegradation requirements under Minnesota Rule Chapter 7050 do not specifically address point source stormwater discharges.

In the Spring of 2007, the MPCA initiated the Stormwater Nondegradation Analysis Project (SNAP) to assess the effectiveness of the approaches used by the 30 Selected MS4s to comply with nondegradation requirements and to provide additional research and recommendations related to the MPCA's nondegradation rule-making process. The MPCA hired Tetra Tech to support activities under the SNAP. Under the first task, Tetra Tech is compiling and analyzing stormwater Loading Assessment information from the Selected MS4s and providing recommendations on how to improve the Loading Assessment process and apply these requirements to other permitted stormwater sources. Under the second task, Tetra Tech is compiling, reviewing, and summarizing existing antidegradation rules, policies, and implementation procedures from 12 states and 5 EPA regional offices for consideration by MPCA during the nondegradation rule-making process. In addition, Tetra Tech is identifying a list of applicable court cases and permit appeals related to antidegradation. The third task involves preparing a set of recommendations on MPCA's nondegradation approaches for a wide variety of permitted point sources and nonpoint sources, including permitted stormwater discharges.

This document, Technical Memorandum #1, contains a summary and evaluation of the stormwater Loading Assessment approaches used by the 30 Selected MS4s to fulfill the nondegradation requirements under Part X of the Phase II MS4 general permit. Understanding the approaches used by the 30 Selected MS4s to comply with existing nondegradation requirements will allow MPCA to refine future nondegradation review requirements and guidance for all permitted stormwater sources—municipal, industrial, and construction. This analysis focused on reviewing the approaches taken by the 30 Selected MS4s to identify opportunities to streamline the analyses for permittees, while ensuring that MPCA gets the best possible data and information for making nondegradation determinations. Although a wide range of tools are available for assessing stormwater loads, including those listed in Appendix B of the 2005 Minnesota Stormwater Manual and the National Water Pollution Control Assessment Model (NWPCAM)

developed for EPA to support the Phase II stormwater rulemaking effort, this analysis is limited to only those used by the 30 Selected MS4s. In addition to assessing current approaches to nondegradation review, the analysis also provided the opportunity to examine the existing nondegradation requirements for the 30 Selected MS4s and determine the effectiveness of these requirements in generating the appropriate types of data and information to make nondegradation determinations for stormwater discharges.

Technical Memorandum #2 presents the findings from the state and EPA antidegradation inventory process, as well as an analysis of recent antidegradation court cases. Technical Memorandum #3 will discuss recommendations for the MPCA's overall nondegradation rulemaking that integrates recommendations from this Technical Memorandum and Technical Memorandum #2.

# I. Overview of Phase II MS4 General Permit Nondegradation Requirements

The Minnesota Court of Appeals ruled in 2003 that MPCA must determine whether discharges from Phase II MS4s covered by a general permit are expanded discharges and if additional controls are necessary to ensure nondegradation of state waters. The MPCA determined that all discharges from MS4s constituted an *expanded* discharge (as opposed to a *new* discharge) and that under the current nondegradation rule, all MS4s would be required to submit information to assist the MPCA in making the determination if the expanded discharge is *significant* as defined in the nondegradation rule. The MPCA developed a ranking system that identified those Phase II MS4s that are likely to constitute *significant* expanded discharges. The screening resulted in the selection of 30 MS4s for a more detailed nondegradation review than the minimum required in the Permit. MPCA based the selection of the 30 cities on the estimated and projected population growth for communities in Minnesota during three time periods: 1990–2000 (on the basis of census data); 2000–2003 (on the basis of projections by the State Demographer and Metropolitan Council); and 2000–2020 (also on the basis of projections from the State Demographer and Metropolitan Council). MPCA considered the size of the community, as represented by the 2000 census, as well as the growth of the community—both factors that MPCA believes to be closely correlated with increased stormwater flows and pollutant loading.

The Selected MS4s must submit a Loading Assessment, which estimates changes in average annual flow, TSS loading, and phosphorus loading from 1988 to the present (2005) and from the 2005 to 2020 and may include removal of pollutants by BMPs already initiated. The assessment is to be used to help develop a Nondegradation Report. If pollutant loadings and flow cannot be reduced to levels attained in 1988, the Nondegradation Report must describe reasonable and practical BMPs that the MS4 plans to incorporate into its modified SWPPP.

The MS4 must conduct an alternatives analysis and explain which alternatives have been studied but rejected, and why. The report must give high priority to BMPs that address future growth. Where increases in pollutant loading and flow have already occurred because of past development (after 1988), the report must consider retrofit and mitigation options that the MS4 considers to be reasonable, practical, and appropriate to the community. The MS4 is responsible for developing site-specific cost/benefit, social, and environmental information. The proposed modifications to the SWPPP must go to public notice in the local community, allowing time for comment and revision before submittal to MPCA. The public comments must be submitted along with the Loading Assessment, Nondegradation Report, and proposed modifications to address nondegradation.

After considering the Loading Assessment, the Nondegradation Report, public and local water authority comments, the Record of Decision by the Selected MS4, and other pertinent information, the MPCA will make a determination on the preliminary approval of the proposed SWPPP. The MPCA will approve or deny approval of the SWPPP on the basis of the cumulative preponderance of evidence presented in the Nondegradation Report and other sources of information applicable to the MPCA to make its determination. As a result of the review, the MPCA will then file a Notice of Intent to either approve or deny permit coverage for the MS4.

MPCA has developed a draft *Guidance Manual for Small Municipal Separate Storm Sewer Systems* to help permittees comply with the general permit. The document includes a section (Part X. Appendix D) detailing how the Selected MS4s should comply with nondegradation modeling and reporting requirements. Review of the language in Part X. Appendix D, as well as the draft *Guidance Manual for Small Municipal Separate Storm Sewer Systems*, resulted in the identification of key considerations about the overall nondegradation Loading Assessment process as required by MPCA.

The basic requirements are to determine changes in average annual flow and loading of solids and phosphorus. The permit and the associated draft guidance document do not require more complex analyses that address peak flows or other changes in storm hydrographs, site-specific increases in loading, or alterations to the temporal pattern of pollutant loading. While modeling is the preferred approach, the guidance document indicates that other methods, such as the comparison of aerial photography or satellite imagery, could be used if documentation was provided that showed the method to be as effective as modeling if the results are verified by ground inspections and or other collaborative data. The guidance document notes that estimating relative changes in annual loads is more important than accurately measuring actual load increases. In addition, the Loading Assessment does not need to include developing annual rainfall tables or calculating hydrographs and/or storage and release calculation. Finally, the Loading Assessment does not have to demonstrate the pollutant removal from BMPs that have been installed or that might be installed in the future or take into consideration ambient water quality conditions or the assimilative capacity of receiving waters.

# II. Summary and Characterization of the 30 Selected MS4 Loading Assessment Approaches

Under Part X(B), the Phase II MS4 general permit requires Selected MS4s to conduct a Loading Assessment. The Loading Assessment requirements specify the following:

- Assess changes in stormwater discharge loading for permitted area
- Use a pollutant loading water quality model that addresses average annual flow volume, TSS, and phosphorus
- Use either a simple model, a complex model, or an alternate method shown as effective as modeling method
- Assess changes during two time periods: 1988 (defined as 1988–1990) to present (defined as 2000–2005); and Present (defined as 2000–2005) to 2020
- Consider pollutant removal of BMPs already initiated, including BMPs implemented by other parties (optional)

The Loading Assessment serves several purposes, according to the Phase II MS4 general permit and the MPCA's draft *Guidance Manual for Small MS4s*. Results of the Loading Assessment will serve as the basis for determining the following:

- Whether current and future MS4 pollutant loads meet or exceed pollutant loads consistently attained in 1988
- Whether MS4s can implement reasonable control measures to reduce pollutant loads to levels consistently achieved in 1988
- Whether MS4s have *significant* expanded discharges

Under the MPCA SNAP, Tetra Tech staff compiled and analyzed information on the Loading Assessment approaches used by Selected MS4s to comply with the requirements under Part X(B) of the Phase II MS4 general permit. Tetra Tech contacted each of the Selected MS4s to discuss the following technical issues:

- Modeling (or alternative) methodologies for estimating 1988 baseline conditions for flow, TSS and phosphorus
- Information used to estimate land use/land cover during the 1988 baseline year
- Information to account for BMPs in place during the 1988 baseline year
- Weather data used to estimate the baseline conditions flows and loads (e.g., average annual precipitation or time-varying 1988 to 1990 precipitation)
- Approaches for estimating the changes in flow, TSS, and phosphorus
- Changes to key inputs to the model (e.g., weather, BMPs, land use/land cover) for the two time periods (i.e., 1988–present and present–2020)
- Approaches for comparing the modeling data (flow, TSS, and phosphorus) between the two time periods, including routing loads, calculating in-stream loads, in-stream concentrations, average unit area loads, and so on
- Consideration of ambient water quality data and receiving water assimilative capacity

Of the 30 Selected MS4s, 27 had information available on their Loading Assessment methodologies at the time of the MPCA SNAP. Seven consulting firms are supporting the efforts of the 27 Selected MS4s currently preparing Loading Assessments. It is likely that the three Selected MS4s that did not have information on their nondegradation review process will select one of the seven consulting firms to provide this service. Selected MS4s supported by a particular consultant share the same Loading Assessment methodologies; although outcomes will vary on the basis of the available data used in the analysis, the overall process for conducting the analysis is the same. As a result, the compilation of information from Selected MS4s was conducted on a consultant basis and is presented as such in this Technical Memorandum.

On the basis of the time frame of the SNAP and the time frame for which the Loading Assessments are due to the MPCA, not many of the consultants had written documentation or reports to share with Tetra Tech staff. Draft Loading Assessment reports were provided for the city of Maple Grove (WSB) and the city of Woodbury (Bonestroo). The city of St. Cloud (Houston Engineering) shared preliminary documentation related to the Loading Assessment approach developed for its MS4.

This section presents a summary of the Loading Assessment approaches compiled and assessed through consultant discussions and document review.

To date, 27 of the 30 Selected MS4s have initiated their nondegradation Loading Assessment with assistance from a consulting firm. None of these Selected MS4s are currently conducting this analysis in-house with local staff. The remaining three Selected MS4s have indicated they intend to also hire consultants to support this effort. The consulting firms working with the Selected MS4s to date include the following: Barr Engineering; Bonestroo, Rosene, Anderlik & Associates (Bonestroo); Houston Engineering; Short Elliott Hendrickson, Inc. (SEH); Systech Engineering; Wenck Associates, Inc. (Wenck); and WSB & Associates, Inc. (WSB). A description of the approach for each component of the Loading Assessment used by the seven consultants is provided below. Table 1 presents this information for each Selected MS4, grouped according to consultant.

### METHODS FOR ESTABLISHING THE 1988 BASELINE STORMWATER LOADS

Establishing the 1988 baseline stormwater loads involves collecting pertinent information to estimate the conditions that characterized an MS4's stormwater runoff from 1988 to 1990. Key information includes land use information and planning tools to recreate 1988 land use/land cover; location, type, and relevant design standards of BMPs in place during 1988; and precipitation data. Tools to process and analyze this information to calculate an estimated baseline load range from simple spreadsheet tools to more complex modeling tools. A summary of the tools and information used by Selected MS4s and their consultants to establish the 1988 baseline stormwater loads is provided below.

#### MODEL SELECTION

The requirements in Part X(B) of the Phase II MS4 general permit state that Selected MS4s can use either simple or a complex model to conduct the nondegradation Loading Assessment. Two consultants, Barr Engineering and WSB, are using the Center for Watershed Protection's Simple Method to conduct the Loading Assessment for 12 Selected MS4s. Two consultants, Bonestroo and Houston Engineering, are using PondNet to conduct the Loading Assessment for eight Selected MS4s. Two consultants, SEH and Wenck, are using the P8 model for seven Selected MS4s. Systech Engineering is using the WARMF watershed model to estimate stormwater loads for one Selected MS4.

It is important to understand how each of these methods and modeling tools work to generally determine the effectiveness of each tool in establishing the 1988 baseline stormwater loading. Therefore, a brief description of each method and modeling tool is provided below.

- **The Simple Method** estimates annual average stormwater runoff pollutant loads for urban areas and requires a modest amount of information, including the subwatershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation. Stormwater pollutant concentrations can be estimated from local or regional data, or from national data sources. The Simple Method estimates pollutant loads for chemical constituents as a product of annual runoff volume and pollutant event mean concentration. In the Simple Method, the runoff coefficient is calculated on the basis of impervious cover in the subwatershed. The Simple Method – and other methodologies based upon its principles – is most appropriate for assessing and comparing the relative stormflow pollutant load changes of different land use and stormwater management scenarios. In addition, the Simple Method estimates only pollutant loads generated during storm events (CWP, undated). It does not consider pollutants associated with baseflow; however, this component is not likely to be significant for TSS and phosphorus.

**Table 1. Modeling methods used by Selected MS4s for completing nondegradation Loading Assessments**

| Selected MS4s (Appendix E) | Estimating 1988 baseline | | | | Estimating changes | | Values compared to determine loading changes over time |
|---|---|---|---|---|---|---|---|
| | Method for estimating flow and pollutant loads | Land use/ land cover | BMPs considered? | Weather data | Method for estimating changes in flow and pollutant loads | Changes to key inputs | |
| **Barr Engineering** | | | | | | | |
| Bloomington<br>Edina<br>Minnetonka<br>Lakeville<br>Plymouth<br>St. Louis Park | Simple Method | 1984 land use coverage from Metropolitan Council; 1992 USGS[a] land cover database for rural areas | No | Average annual precipitation from the metro area | Simple Method | Land Use: Local land use planning tools to project future<br><br>BMPs: Developing BMP databases for each MS4 that includes applicable design requirements; uses P8 model to estimate BMP efficiency on the basis of documented design standard; assumed future BMPs and design requirements | Average annual loads and volumes |
| **Bonestroo** | | | | | | | |
| Apple Valley<br>Chaska<br>Cottage Grove<br>Eagan<br>Farmington<br>Rochester<br>Woodbury | PondNET Wisconsin Lake Modeling Suite (WiLMS) | Local comprehensive plans; MLCCS[b]; verified against 1990 aerial photography | Yes, non-pond BMPs (e.g., street sweeping, infiltration, phosphorus fertilizer use reduction). | Average annual precipitation for the period 1976–2005 | PondNET Wisconsin Lake Modeling Suite (WiLMS) | Land Use: Varied on the basis of local land use maps for current and projected future land use.<br><br>BMPs: Added detention ponds for existing and future conditions | Average annual volume and pollutant loads by subwatershed |

| Selected MS4s (Appendix E) | Estimating 1988 baseline | | | | Estimating changes | | Values compared to determine loading changes over time |
|---|---|---|---|---|---|---|---|
| | **Method for estimating flow and pollutant loads** | **Land use/ land cover** | **BMPs considered?** | **Weather data** | **Method for estimating changes in flow and pollutant loads** | **Changes to key inputs** | |
| **Houston Engineering** | | | | | | | |
| St. Cloud | PondNET with modifications (Crystal Ball and TR-55[c] methodologies) | GAP[d] land cover and 1990 University of Minnesota percent impervious data | No | Statistically derived daily precipitation data on a seasonal basis using local, 56-year rainfall records | PondNET with modifications (Crystal Ball and TR-55 methodologies) | Land Use: Adjusted curve numbers for major land use types on the basis of soil type and season; 2006 University of Minnesota percent impervious, LandSat satellite imagery, 2050 city zoning, estimated percent impervious<br><br>BMPs: no information available | |
| **SEH** | | | | | | | |
| Blaine | P8 using GIS[e] automation | 2007 land use and zoning maps compared to high resolution aerial photos to estimate baseline imperviousness | No | 1976–2005 USGS Coon Creek weather station daily total precipitation | P8 using GIS automation | Land Use: 2007 land use and zoning maps<br><br>BMPs: Considered BMPs in place since 1988 | Average annual volume and pollutant loads |
| Burnsville | | | | | | | |
| Maplewood | | | | | | | |
| **Systech** | | | | | | | |
| Duluth | WARMF watershed model (includes pollutant build up and wash off algorithms of SWMM[f]) | 2004 land use cover with adjustments on the basis of records of construction permits; 2001 NLCD[g] for outlying areas | Yes. (however, conducting a model run that excludes all BMPs to predict the *base* loading) | 1990–2005 hourly precipitation and temperature data from Duluth Airport | WARMF watershed model | Land use: changes for 1998, current, 2020<br><br>BMPs: Using city's BMP database to alter factors such as street sweeping frequency<br><br>Six modeling runs (one for each time period, with and without BMPs) | Average runoff yield (m/yr), precipitation ratio (average precipitation/runoff yield), and average daily pollutant loads for 43 streams and other lumped discharge areas |

| Selected MS4s (Appendix E) | Estimating 1988 baseline | | | | Estimating changes | | Values compared to determine loading changes over time |
|---|---|---|---|---|---|---|---|
| | **Method for estimating flow and pollutant loads** | **Land use/ land cover** | **BMPs considered?** | **Weather data** | **Method for estimating changes in flow and pollutant loads** | **Changes to key inputs** | |
| **Wenck** | | | | | | | |
| Andover | P8 Model | 1990 land use maps | No | Modeled precipitation record for each MS4 during 1992–2002 and took average | P8 Model | Land Use: Future land use projects from comprehensive plans<br><br>BMPs: Addressing ponds in new and redevelopment since 1988 | Average annual volume and pollutant loads |
| Chanhassen | | | | | | | |
| Coon Rapids (portion) | | | | | | | |
| Eden Prairie | | | | | | | |
| **WSB** | | | | | | | |
| Brooklyn Park | Simple Method | GIS system that integrates aerial photography and planning documents for the Twin Cities | No. | Average annual precipitation from ten years of data from airports and MN climatology gauging stations | Simple Method | Land Use: aerial photography and land use planning tools and projections<br><br>BMPs: Modified on the basis of changes to BMP standards/ rules currently in place and projected changes | Average annual volume and pollutant loads |
| Coon Rapids (western portion) | | | | | | | |
| Maple Grove | | | | | | | |
| Prior Lake | | | | | | | |
| Rosemount | | | | | | | |
| Shakopee | | | | | | | |
| **No Consultant** | | | | | | | |
| ElkRiver | No nondegradation Loading Assessment information available to date. Approach not yet determined. | | | | | | |
| Inver Grove Heights | No nondegradation Loading Assessment information available to date. Approach not yet determined. | | | | | | |
| Savage | No nondegradation Loading Assessment information available to date. Approach not yet determined. | | | | | | |

**Notes:**

a. USGS = U.S. Geological Survey

b. MLCCS = Minnesota Land Cover Classification System

c. TR-55 = Technical Release 55

d. GAP = Gap Analysis Program

e. GIS = geographic information system

f. SWMM = Storm Water Management Model

g. NLCD = National Land Cover Data

- **The PONDNET model** is an empirical spreadsheet-based model (i.e., based on measured data points) developed to evaluate flow and phosphorous retention in Pond Networks. The following input parameters are defined by the user in evaluating the water quality performance of a pond: watershed area (acres), runoff coefficient, pond surface area (acres), pond mean depth (feet), period length (years), period precipitation (inches); and phosphorous concentrations (parts per billion [ppb]). The spreadsheet is designed so that the phosphorous removal of multiple ponds in series can be evaluated. The algorithms are based on empirical relationships from EPA's Nationwide Urban Runoff Program (NURP) that describe both settling of the particulate fraction of phosphorus and biological uptake of the dissolved fraction during quiescent times between storm events on an annual time scale (MSSC 2006). Loading from the land surface is estimated on the basis of total precipitation, a runoff coefficient or Soil Conservation Service (SCS) curve number approach, and an event mean concentration. PONDNET is thus similar to the Simple Method with the addition of an accounting of trapping in ponds.
- **The Program for Predicting Polluting Particle Passage through Pits, Puddles & Ponds (P8 Urban Catchment Model)** is a simple but physically based model (i.e., based on particle distribution size and sedimentation processes) to predict the generation and transport of stormwater runoff pollutants in urban watersheds. The model simulates runoff and pollutant transport for a maximum of 24 watersheds, 24 stormwater BMPs, 5 particle size classes, and 10 water quality components. Runoff is calculated using an SCS curve number approach, sediment concentrations are assigned to runoff on the basis of a rating curve, and phosphorus loading is estimated as a function of sediment load. The model simulates pollutant transport and removal in a variety of BMPs including swales, buffer strips, detention ponds (dry, wet, and extended), flow splitters, and infiltration basins (offline and online). Model simulations are driven by a continuous hourly rainfall time series. P8 has been designed to require a minimum of site-specific data, which are expressed in terminology familiar to most engineers and planners. An extensive user interface providing interactive operation, spreadsheet-like menus, help screens and high-resolution graphics facilitate model use (MSSC 2006).
- **Watershed Analysis Risk Management Framework (WARMF)** is a complex watershed model organized into five linked modules under one, geographic information system (GIS)-based graphical user interface. The Engineering Module is a GIS-based watershed model that calculates daily runoff, shallow groundwater flow, hydrology and water quality of a river basin. A river basin is divided into a network of land catchments (including canopy and soil layers), stream segments, and lake layers for hydrologic and water quality simulations. Land surface is characterized by land use/land cover, and precipitation is deposited on the land catchments to calculate snow and soil hydrology and resulting surface runoff and groundwater accretion to river segments. Water is then routed from one river segment to the next, from river segments to reservoirs, and then from reservoirs to river segments, until the watershed terminus is reached. Instead of using export coefficients, a complete mass balance is performed starting with atmospheric deposition and land application as boundary conditions. Pollutants are routed with water in throughfall, infiltration, soil adsorption, exfiltration, and overland flow. The sources of point and nonpoint loads are routed through the system with the mass balance, so the source of nonpoint loading can be tracked back to land use and location. The Data Module contains meteorology, air quality, point source, reservoir release, and flow diversion data used to drive the model. It also contains observed flow and water quality data used for calibration. The data is accessed through the map-based interface and can be viewed and edited in both graphical and tabular format. The Knowledge Module stores supplemental watershed data, documents, case studies, or reports of past modeling activities for easy access by model users (USEPA 2005).

Consultants took steps to modify modeling tools as necessary to perform the Loading Assessment. For example, Houston Engineering and Bonestroo both modified PondNet to calculate and track TSS loads, in addition to phosphorus. Houston Engineering linked PondNet to a Monte Carlo simulation and analysis program to quantify uncertainty by defining a probability distribution for pollutant loads, precipitation, and BMP performance. In addition, Houston Engineering incorporated methodologies used in TR-55 (i.e., a series of simple procedures developed by the U.S. Natural Resources Conservation Service to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes) to calculate daily and annual runoff volumes for each land use type in an individual subwatershed through the use of area-weighted curve numbers. SEH integrated GIS data with the P8 model. Barr Engineering also used the P8 model to estimate BMP pollutant removal efficiency and integrated this information with the estimates calculated using the Simple Method.

Of the 27 MS4 applications, 20 used either the Simple Method or PONDNET, both of which estimate annual pollutant loads on the basis of a runoff coefficient (or curve numbers) and event mean concentrations. This type of application is generally sufficient to establish relative changes in average annual loads in response to land use changes; however, absolute estimates of load are only as good as the estimates of the event mean concentrations. These simple models do not provide meaningful results for time periods shorter than annual. They also do not yield information on changes in peak flow in receiving channels.

The Simple Method/PONDNET applications are easily and cost-effectively implemented and meet the stated minimum requirements for the Loading Assessments. They might not, however, fully address the potential for degradation associated with MS4s. In particular, a major impact of uncontrolled urban runoff is often changes in the flood hydrograph, with consequent changes in channel morphology including deepening or widening. Sediment generated from channel degradation often far outweighs that generated from upland runoff; however, neither changes in the flood hydrograph nor impacts on channel morphology can be addressed with these methods.

The P8 model potentially supplies additional sophistication. When run with hourly precipitation, changes in the flood hydrograph can—at least partially—be examined, although full routing of flows is not included, and sediment generation from bank failure and other changes to channel morphology are not simulated (except insofar as implicitly included in the sediment rating curves driving the model). The increased sophistication of the P8 approach results in additional data requirements, because sediment rating curves ought to be developed from data appropriate to the site and might change in response to land use changes.

The WARMF application used by Duluth is an outlier among the models used, because WARMF is a detailed and reasonably comprehensive watershed simulation model. Its detail far exceeds MPCA's minimum requirements for the Loading Assessments. Apparently, it has been used in this case because a WARMF application was already under development for Duluth-Superior harbor planning.

### 1988 Land Use/Land Cover

Consultants conducting the nondegradation Loading Assessment for the Selected MS4s used a variety of approaches and data to re-create 1988 land use/land cover. Data sources used to re-create 1988 land use/land cover include the following:

- Local comprehensive plans
- Local land use and zoning maps
- Local construction permit records

- Aerial photography
- Minnesota Department of Natural Resources (DNR) GAP Land Cover data
- Minnesota DNR Minnesota Land Cover Classification System
- University of Minnesota 1990 impervious surface area maps
- Metropolitan Council GIS data and maps
- U.S. Geological Survey National Land Cover Data (for outlying areas).

#### BMPs

Of the seven consultants, five stated that the approach for estimating the 1988 baseline stormwater loads did not account for BMPs already in place at the time. Many of the consultants not including BMPs in the estimate of 1988 baseline stormwater loads based this decision on the fact that the Metropolitan Surface Water Management Act requirements related to stormwater conveyance, ponding, and treatment did not go into effect until 1992. Therefore, consultants assumed that MS4s would have very few, if any, BMPs in place in 1988 that would affect TSS and phosphorus loads or flow.

Two consultants are including BMPs in the estimated 1988 baseline stormwater loads. The MS4s supported by Bonestroo have non-pond BMPs, such as street sweeping, infiltration, and phosphorus fertilizer use reduction, factored into the 1988 baseline stormwater loads. Systech Engineering is also including BMPs in the 1988 baseline for Duluth but is also conducting a modeling run without BMPs to predict the *base* loading.

#### Precipitation Data

Consultants used precipitation data over varying time frames from various sources to estimate 1988 baseline stormwater loads, as well as stormwater loads for current and future conditions. In general, consultants obtained local precipitation data and calculated the average annual precipitation, although the method for doing so differed by consultant. Two consulting firms, Bonestroo and SEH, used a 30 year precipitation record (1976–2005) to calculate the average annual precipitation to use in their respective load assessment approaches. Approximately three consulting firms used a 10–15 year precipitation record to calculate the average annual precipitation. Wenck modeled the 10-year precipitation record for a 10-year period to determine the average annual precipitation. Houston Engineering conducted a more complex analysis that involved dividing the local, 56-year rainfall record into seasons and statistically deriving daily precipitation values.

### Methods for Estimating Changes to Stormwater Loads Since 1988 (Current and Future Conditions)

Approaches for modeling and estimating the 1988 baseline stormwater loads essentially remained the same, with changes to key inputs to reflect current and future conditions. No consultants determined that a different approach or modeling tool was necessary to estimate the changes in pollutant loads and flow. Descriptions of how consultants changed key inputs and compared outcomes for each time frame are provided below.

#### Land Use/Land Cover

Consultants used the land use/land cover data sources mentioned above to determine changes from the 1988 baseline to the present. To make future land use projections, consultants relied upon comprehensive plans and other land use planning tools (e.g., projected city zoning).

The May 2007 review draft of the city of Woodbury's Loading Assessment Report, developed by Bonestroo, highlights an interesting challenge in re-creating 1988 land use/land cover and determining changes from that baseline with respect to agricultural land uses. The draft report notes that, while land use data can determine which parcels fall into an agricultural land use category, it is not clear what type of agricultural practices took place on specific parcels. Therefore, Bonestroo made assumptions about agricultural land uses for the 1988 baseline and the current land use, using the same proportions of row crop, hay, and pasture.

Where current or future urban land use includes significant conversion of former agricultural land, loading rates from agriculture might be an important part of the 1988 baseline. In some cases, urban stormwater can contribute smaller pollutant loads than row crop agriculture. The answer is, however, dependent on the status of conservation, tillage, and fertilization practices in place in 1988. None of the consultants appear to be attempting a detailed simulation of agricultural practices or land use conversion as part of the baseline determination.

### BMPS

Collecting information on BMPs from the 1988 baseline year to present appears to be one of the more challenging activities of conducting the Loading Assessment. Consultants, working closely with municipal staff, are compiling and verifying information about the location and type of BMPs installed between 1988 and the present condition to estimate reductions in TSS, phosphorus, and flow. If current and projected BMPs are able to reduce stormwater loads to levels consistently attained in 1988, no additional BMPs or modifications to the Phase II MS4 stormwater management program are necessary. Therefore, Selected MS4s have a strong incentive to comprehensively inventory BMPs and estimate removal efficiencies.

The information needed to accurately incorporate the affect of BMPs on stormwater loads over time is significant. In addition to location and type, Selected MS4s and consultants must also obtain information such as year of installation and corresponding design standard; surface area; standing water *pool* volume of ponds at normal water level; number of pond cells; infiltration capacity (if designed with an infiltration bench); upstream and downstream waterbody connections; and a description of BMP configurations and conditions.

Estimating BMP pollutant removal efficiencies vary from approach to approach. Consultants using PondNet and P8 modeling tools are able to model BMP pollutant removal efficiencies using assumptions contained in the respective models. Data are generally not available to validate the applicability of these assumptions on specific sites. WSB, the consultant using the Simple Method, determined pollutant removal efficiencies for stormwater ponds using a variety of sources, including U.S. Department of Agriculture, Natural Resources Conservation Service's *Urban Hydrology for Small Watersheds,* the *Hydrology Guide for Minnesota*, and other literature values. Because the literature on BMP removal efficiencies vary widely, the estimates of removal—and consequent effects on the nondegradation findings—are largely guesswork, regardless of whether the removal efficiency is modeled (PondNet, P8) or estimated directly from the literature.

Although most consultants acknowledged the impact of nonstructural BMPs on reducing stormwater loads, only two approaches actually developed methods to account for the treatment impact of additional BMPs. Additional BMPs included street-sweeping activities, infiltration, and phosphorus fertilizer use reduction. As a result, it is possible that Loading Assessment approaches underestimate the actual pollutant load reductions from BMP implementation, particularly those associated with some of the six minimum control measures under the Phase II MS4 stormwater management program requirements.

To project BMP pollutant removal in the future condition, consultants made assumptions about future BMP design standards on the basis of recently passed designed requirements or anticipated changes to design requirements.

#### APPROACH FOR COMPARING VALUES TO DETERMINE CHANGES OVER TIME

The basic approach for determining changes in stormwater loads over time is a comparison of average annual loads and volumes from each time period (e.g., 1988 baseline, 1988–present, and present–2020). Consultants using the Simple Method (Barr and WSB) first compare 1988 baseline land use/imperviousness to present conditions to determine if land use/imperviousness has changed over time. Where land use has not changed, it is assumed that stormwater loads have not changed, and the nondegradation standard has been met. Where the land use/imperviousness analysis indicates changes have occurred, these consultants continue in the Loading Assessment process to determine annual average runoff from land use using applicable curve numbers and apply event mean concentrations to determine average annual TSS and phosphorus loads from each land use.

Approximately three consultants are comparing total average annual loads and volumes for the MS4, as well as average unit area loads. For example, the review draft Loading Assessment Report for the city of Woodbury, conducted by Bonestroo, provides results on a subwatershed basis. This approach demonstrates where additional BMP implementation might facilitate reducing stormwater loads to 1988 baseline levels. Systech stated that the report generated for the city of Duluth would present average daily pollutant loads for 43 streams and other lumped drainage areas. The draft report for the city of Maple Grove, prepared by WSB, presents average annual loads and volumes for each type of land use generated using the Simple Method.

The way in which some consultants generated information for comparison in each time frame is interesting to note. WSB compared average annual loads and volumes for each type of land use from the 1988 baseline year to the present condition without initially including BMPs, to see if changes in land use over time resulted in higher or lower loads and volumes from the 1988 baseline. Where loads were found to have increased from the 1988 baseline, WSB then applied BMP pollutant removal estimates from stormwater ponds. The approached used by Houston Engineering generated a total of six scenarios using the WARMF model: modeling runs for the three time periods with BMPs and modeling runs for the three time periods without BMPs.

# III. Evaluation of the Effectiveness of Loading Assessment Approaches

Objectives of this activity under the MPCA's SNAP include determining the relative effectiveness of the methods used to generate the Loading Assessment reports, assessing the adequacy of work products for MPCA to use in making nondegradation determinations, and evaluating whether the Loading Assessment approaches are transferable to other permitted stormwater sources for meeting nondegradation requirements. This section addresses these issues related to the effectiveness of the Loading Assessment approaches and the adequacy of the Loading Assessment results in making nondegradation determinations.

### EFFECTIVENESS OF THE METHODS FOR ESTABLISHING THE 1988 BASELINE DISCHARGES

Establishing the 1988 baseline stormwater loads for Selected MS4s is contingent on re-creating the 1988 baseline land use and imperviousness using data from 1988 to 1990, per the Phase II MS4 permit requirements for conducting the Loading Assessment. Re-creating the 1988 land use/imperviousness that

existed for Selected MS4s required consultants to take different approaches according to the availability of data for a specific MS4. One consultant was able to use the 1984 land use coverage that covers the seven-country metro area, available from the Metropolitan Council, to generate 1988 baseline land use. Some consultants started with current land use and compared existing information with past high-resolution aerial photography to assess changes to imperviousness. Other consultants were able to use 1989 land use coverages and verified this information against aerial photography from relatively the same time period. Consultants working for MS4s with rural or outlying areas not addressed by existing land use coverages chose to rely on out-of-state data from federal sources that did not fall within the 1988 baseline time frame (e.g., 1992 USGS land cover) or local land use coverages outside the 1988 baseline time frame (e.g., 2001 National Land Cover Database coverages). Consultants commented that recreating the 1988 land use/imperviousness is difficult for some MS4s because of limited data and that a more recent time frame might help to alleviate this challenge. Many of the Selected MS4s are in or near the Twin City area and are able to access electronic land use data through the University of Minnesota or the Metropolitan Council. However, MS4s outside the Twin City area might have difficulties accessing this type of information or will have to identify other sources for this type of data.

### EFFECTIVENESS OF THE MODELING AND THE CHANGES IN MUNICIPAL STORMWATER DISCHARGES

The approaches used by the consultants supporting the Selected MS4s range from simple (Simple Method) to complex (WARMF watershed model). There are strengths and limitations associated with each methodology and modeling tool. Consultants have attempted to address limitations of individual methods and modeling tools by integrating other methodologies and tools. For example, one consultant used the Simple Method with the P8 modeling tool to estimate BMP efficiencies. Another consultant using P8 enhanced this modeling tool with GIS automation. A consultant using PondNet linked this modeling tool to a computer program that applies a Monte Carlo approach to account for uncertainty associated with specific variables. To account for the influence of lakes on downstream TSS and phosphorus loads, another consultant used a lake water quality model to calibrate Loading Assessment results generated using PondNet.

Factors and variables potentially affecting assessment methods and associated outcomes include the following:

- *Lack of observed data for use in calibrating models*. Several consultants cited the challenges associated with calibrating modeling approaches because of limited data, particularly for the 1988 baseline year. The review draft of the city of Woodbury's Loading Assessment report states that Bonestroo used in-lake monitoring data to run a lake water quality model to calibrate PondNet results. Another consultant, Systech, calibrated the WARMF model to current conditions and projected back to 1988 conditions to establish the baseline.
- *Selecting Event Mean Concentrations to estimate pollutant loads from various land uses.* Approximately two consultants used MPCA's 2000 manual *Protecting Water Quality in Urban Areas* that recommends mean pollutant concentrations from EPA's 1983 NURP. Other sources used by consultants include MPCA's *2005 Minnesota Stormwater Manual*, as well as other studies and papers that the Minnesota Stormwater Manual also cited. One consultant cited the Metropolitan Council Watershed Outlet Monitoring Program as a source to help develop event mean concentrations.
- *Deriving runoff coefficients for specific land uses.* The review draft of the city of Woodbury's Loading Assessment report states that the runoff value (Rv) for urban land uses was derived from the impervious coverage using a relationship from the NURP study. Consultants using the P8 model, as well as some others including WSB's approach (documented in the Maple Grove draft report) and Houston Engineering's preliminary documentation prepared for the city of St. Cloud

used SCS curve numbers (TR-55 methodology) to evaluate runoff. This approach has the advantage of a long history and extensive documentation. The review draft of the city of Woodbury's Loading Assessment report discusses challenges associated with selecting an appropriate runoff value (Rv) for row crop agriculture and other types of agricultural land uses. Consultants performing a Loading Assessment that also address agricultural land uses might also experience similar challenges in determining an appropriate Rv for the analysis. However, in all cases, the runoff estimates are subject to considerable uncertainty due to site-specific variables.

- *BMP removal efficiencies*. A finding of nondegradation will, in many cases, be directly dependent on the assumed removal efficiencies of BMPs. If BMPs do not meet the assumed efficiencies, loading will be greater than estimated. Because the efficiencies of even well-studied BMPs vary widely, this can raise considerable question about the validity of a finding unless site-specific data are collected to verify assumptions.

For the 27 MS4s for which Loading Assessments were underway, the methods used, although varying by consultant, are adequate to meet the basic requirements prescribed by MPCA. There are some advantages to methods that provide an explicit simulation of BMPs relative to the Simple Method, which does not. However, the Simple Method can provide comparable estimates if external evidence on BMP efficiency is well documented. The major source of uncertainty in most of the estimates is due to a lack of calibration data. Therefore, explicit consideration of uncertainty via Monte Carlo analysis is a potentially useful addition. Where more sophisticated models can be applied and calibrated (e.g., WARMF for the city of Duluth), it is likely that greater confidence can be placed in results.

While the approaches taken all seem to meet basic requirements imposed by regulation, the larger question is whether they are adequate to determine whether degradation of water quality has occurred. This is addressed in the next section.

### ADEQUACY OF LOADING ASSESSMENT RESULTS IN MAKING NONDEGRADATION DETERMINATIONS

The work products from the Loading Assessment process provide an estimate of the relative changes to annual average stormwater flow, TSS, and phosphorus loads over the three required time frames. Although not all consultants were able to provide examples of draft and final Loading Assessment work products, the description of the approaches and the available draft documentation indicate that the information generated by consultants are adequate to determine relative increases or decreases in stormwater loads from the Selected MS4s.

The key question, however, is not the adequacy of the Loading Assessment work products to evaluate relative changes in stormwater loads, but the adequacy of the work products in developing the required Nondegradation Report. The issue related to answering this question is how the MPCA intends to evaluate results from the Loading Assessment and Nondegradation Report with respect to changes in ambient water quality conditions of receiving waterbodies. This analysis was not part of the modeling conducted by the municipalities, i.e., their work focused on the flow and quality of the stormwater discharges, not impacts on the receiving waters. When using a parameter-by-parameter approach, degradation of a receiving waterbody is usually indicated by increased concentrations of pollutants of concern (e.g., TSS, phosphorus) and/or lower measurements of beneficial parameters (e.g., dissolved oxygen, indices of biotic integrity). An increase in stormwater loads from the 1988 baseline does not necessarily translate into degraded water quality conditions because some waterbodies receiving those discharges are large and have capacity to assimilate pollutants of concern. In fact, a hypothetical urban development of 100 acres of mixed housing and commercial structures could cause serious degradation of a small, receiving waterbody and virtually no degradation of a larger receiving water. One of the shortcomings of the current approach is that it is based solely on analyses of changes in the stormwater discharges (i.e., flow, TSS, and phosphorus) over time, rather than their impacts on the receiving waters.

The work products from the Loading Assessment will be useful in determining the overall level of degradation from stormwater runoff if MPCA intends to analyze this information in conjunction with receiving water quality information (e.g., baseline water quality and the assimilative capacity of the waterbody).

Parameters not evaluated as part of the existing Loading Assessments also have the potential to cause degradation. Urban stormwater is often associated with increased loads of criteria pollutants such as copper, which could be a concern but is not addressed. Other pollutants from impervious surface runoff, such as polyaromatic hydrocarbons (PAHs) can be stored in sediment and contribute to toxicity to benthic biota and degradation of aquatic life support. Many other issues are of potential concern but difficult to address within the prescribed permit review requirement.

A key issue in the existing modeling approach is the lack of requirements to consider impacts to channel stability and habitat in stream channels that receive storm flows. One of the most significant impacts of urbanization on aquatic life use support is through habitat modification that causes changes in stream morphology, bank failure, increased in-channel sediment loads, substrate quality, and smothering of benthic habitat. Various other jurisdictions attempt to address these kinds of issues by requiring close consistency between the pre- and post-development storm hydrographs, an approach that Minnesota is taking through the post-construction runoff control design requirements in its current general stormwater permit for construction sites. The simplest approaches require maintaining existing peak flows—but this is likely inadequate to protect habitat because of the effects of prolonged bankfull flows resulting from peak–flow-based, runoff-control design approaches. More sophisticated approaches to nondegradation from urban stormwater require approximating the shape of the predevelopment hydrograph, approaches that emphasize the type of site-level infiltration, detention, and design standards embraced by low impact development. For an expanding MS4, a more thorough determination of nondegradation should include some sort of evaluation of the potential for deleterious channel morphology and habitat changes that can occur as a result of increased impervious runoff. Some states are addressing the need for a more robust approach to nondegradation by requiring the adoption of rigorous low impact development standards for municipalities and the implementation of strict no-exposure practices for industrial stormwater permittees.

## TRANSFERABILITY OF APPROACHES TO OTHER PERMITTED STORMWATER SOURCES

Through evaluation of the Loading Assessment approaches used by the Selected MS4s, MPCA might determine if other permitted stormwater sources (e.g., other Phase II MS4s, industrial stormwater permittee, construction stormwater permittee) can apply the same type of approach to meet nondegradation requirements.

### MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4S)

As noted above, the Loading Assessments underway do not fully address the issue of nondegradation because they consider only annual average flow and loading of TSS and phosphorus—ignoring other potential causes of degradation. While other MS4s can conduct the same type of simplified analysis performed by the Selected MS4s, a concern is that smaller Phase II MS4s will not have in-house technical capabilities to conduct this type of assessment, nor will these communities have the necessary resources to hire consultants. It is likely that the remaining Phase II MS4s that will eventually have to conduct a nondegradation review will fall outside the Twin Cities area and have less data and information necessary to conduct a Loading Assessment. For some of the remaining small MS4s, it might be more useful and practical to assess water quality trends for the waterbodies that receive the stormwater runoff to determine whether degradation has actually occurred. If water quality has remained constant—or improved—over time for the relevant suite of parameters of concern (e.g., TSS, P, DO, turbidity), a determination could be made that no degradation occurred during the 1990–2005 period. In these cases, the stormwater permittees would be required to assure that future development would not cause degradation, through

compliance with the post-construction controls in Minnesota's construction general permit, the Phase II MS4 general permit conditions regarding post-construction runoff controls, and other locally required or site-specific measures. Any development that might result in degradation would be required to submit information regarding an analysis of less-degrading alternatives that were reviewed and rejected—and the reasons for rejection, and the economic and social benefits linked to the new development.

It should be noted that the May 2007 Minnesota Supreme Court decision in *Cities of Annandale & Maple Lake NPDES/SDS Permit* reinforced the notion that MPCA has flexibility in determining whether pollutant load increases that are offset by commensurate load decreases prevent degradation of receiving waters and meet regulatory requirements. In assessing the receiving water impacts from *presumed* (i.e., modeled) load increases linked to higher stormwater flows from expanding development vs. *actual* (i.e., monitored) receiving waterbody load reductions indicated by improving water quality trends, MPCA might determine that increased MS4 loads from 1988–2005 have been offset by greater load reductions from other pollutant sources and *restart the clock* on nondegradation for municipalities that demonstrate those improving water quality trends to the time when permit coverage was provided.

#### INDUSTRIAL AND CONSTRUCTION STORMWATER DISCHARGES

The concept of conducting a Loading Assessment to evaluate nondegradation for industrial and construction stormwater discharges has the potential to be applied in a manner similar to the approach used by the Selected MS4s, with some modification. Unlike MS4s, it is unlikely that all industrial facilities covered by the multisector general permit existed in 1988 and have an expanded significant discharge, per Minnesota's existing nondegradation rules. This is also true for construction activities covered under the Construction General Permit that are relatively temporary in nature. Therefore, determining 1988 baseline stormwater loads might not be a necessary or rational exercise for industrial facilities covered by the multi-sector general permit (MSGP) and construction activities covered by the construction general permit. It might be more appropriate for industrial and construction stormwater permittees to estimate current stormwater loads from the permitted area and determine the impact on water quality conditions by examining the subsequent reduction in the assimilative capacity of the receiving waterbody for the specific parameters in the facility's stormwater runoff. Depending on the amount of assimilative capacity consumed by the estimated stormwater loads, industrial and construction stormwater permittees can identify and implement additional control measures to achieve load reductions.

### ALTERNATIVE APPROACHES TO THE 1988 BASELINE CONDITION TO DRIVE WATER QUALITY IMPROVEMENTS

The SNAP scope of work requires an examination of the effectiveness of selecting 1988 as the water quality baseline for nondegradation determinations for MS4s. The choice of 1988 results from technicalities in rule adoption and is essentially arbitrary. In many cases, water quality degradation associated with urban stormwater may have occurred between the date of the Clean Water Act and 1988.

Under the basic requirements of the Clean Water Act, beneficial uses that existed, or could potentially exist, as of 1975 should be protected. Where this has not occurred, and where reinstatement of water quality to support the lost use(s) is not feasible, a Use Attainability Analysis should (at least in theory) be conducted to justify the revision of uses. In contrast, antidegradation review is usually undertaken in the context of an individual permit, requiring a finding that issuance of the permit to specific entities will not cause degrade existing water quality.

Because of the difficulties in applying antidegradation reviews via assimilative capacity based analyses, states have adopted a BMP-based approach that presumes a certain level of receiving water protection by requiring management practices that target the parameters of concern (e.g., flow, sediment, etc.). This

approach provides a workable and adequately protective procedure if the BMPs are appropriately selected, sited, installed, operated, and maintained for each stormwater-generating area.

In practice, an MS4 antidegradation review should focus on measures that can mitigate existing impacts and prevent future degradation. A baseline is required to make this determination, but the choice of 1988 is largely arbitrary. Further, its usefulness is dubious because limited data exist for this year. It might be more practical to use a period for which comprehensive statewide land use coverage exists as the baseline (e.g., 1989–90 land use). However, a case could also be made for accepting the year in which an individual permittee obtained permit coverage under the MS4 program as a more appropriate baseline to make nondegradation determinations.

# IV. Conclusions and Recommendations

After the review and evaluation of the Loading Assessment approaches used by consultants supporting the Selected MS4s, it appears that all the approaches are adequate for generating technically acceptable estimates of relative stormwater loads for the baseline, current, and future conditions. While no single approach stands out as technically superior, approaches that use a routing method and incorporate some type of calibration on the basis of observed data are likely to produce more robust results compared to simplified methods. In addition, relatively simplified modeling tools provide an adequate level of detail and analysis for purposes of the Loading Assessment; more complex water quality and watershed models are likely too complex and too expensive for estimating relative changes in stormwater loads over time. The evaluation did not produce specific recommendations for improving the Loading Assessment process for MS4s.

The review and evaluation of the Loading Assessment approaches did raise issues on the overall Loading Assessment requirements and how MPCA would ultimately use the results to make nondegradation determinations. A brief discussion of these issues, and associated recommendations, is provided below.

### LIMITED FOCUS ON TSS, PHOSPHORUS, AND FLOW

Stormwater runoff can generate increased loads for a wide variety of pollutants, including pathogens, metals, nutrients, and sediment. In addition, stormwater runoff can contribute to physical and biological impacts that have the potential to degrade overall watershed health, especially by destabilizing stream channel morphology resulting from changes to the storm runoff hydrograph. The Loading Assessment process does not encourage Selected MS4s to address other pollutants of concern and other critical impacts from stormwater runoff. MPCA should consider broadening the Loading Assessment process to encourage stormwater permittees to identify and justify the pollutants and impacts of concern relevant to land uses in the permitted area and local water quality conditions. MPCA should specifically consider requirements to preserve the baseline hydrograph shape unless evidence is presented that changes in the hydrograph resulting from MS4 expansion will not result in degradation of habitat and existing aquatic life use support.

### LACK OF CONNECTION TO LOCAL WATER QUALITY CONDITIONS

Noticeably absent from the Loading Assessment requirements is consideration of or a link to local baseline and current water quality conditions. Nondegradation determinations should focus on the impact of permitted discharges on water quality conditions on the basis of a receiving waterbody's assimilative capacity. Although a selected MS4 might exhibit increased stormwater loads from 1988 to the present, this increased stormwater load might not result in water quality degradation due to waterbody conditions (e.g., assimilative capacity) and decreases in other pollutant sources (e.g., other point and nonpoint

sources present in the watershed). The draft permit guidance document does state that the MPCA might take water quality data and assimilative capacity into consideration when making nondegradation determinations. This linkage is essential to making effective nondegradation determinations. Therefore, the MPCA should either require permitted stormwater sources (and other point source dischargers) to include this connection in the nondegradation review process or make it a component of the nondegradation evaluation and determination process, providing details on the evaluation criteria in the nondegradation rules or future nondegradation implementation methods guide.

The cumulative effects that multiple MS4 permittees have on receiving waters also should be considered. This can be of particular concern for changes in the flood hydrograph as a result of increased impervious area in adjacent municipal jurisdictions. Impacts of MS4s on more sensitive downstream waters (e.g., a lake that ultimately receives runoff from an MS4) should also be addressed. For these reasons, the antidegradation analysis might be more effectively conducted at the level of watershed management organizations, with implementation of the necessary BMPs and other controls enacted through requirements directed at individual municipal permittees.

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