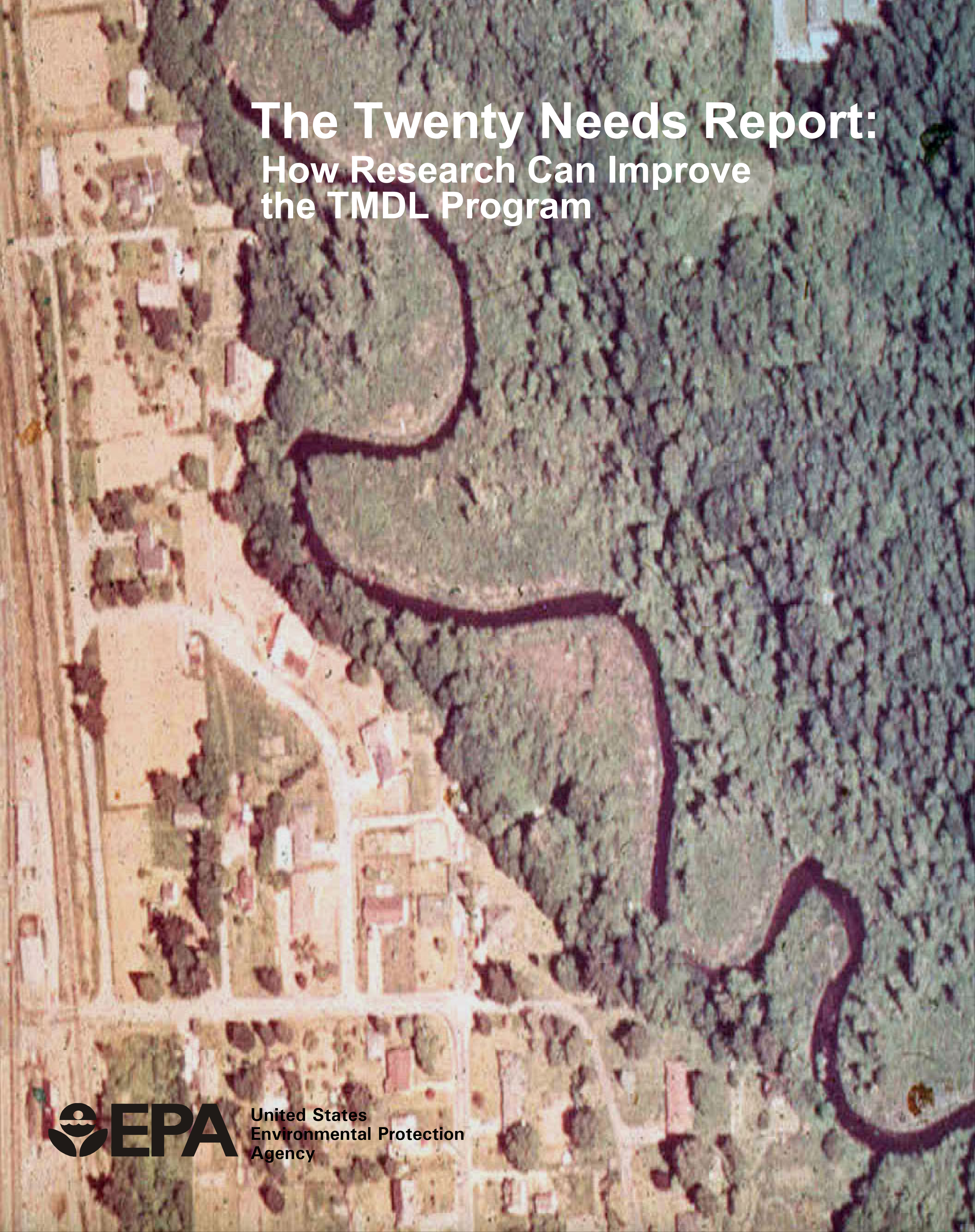


The Twenty Needs Report:

How Research Can Improve the TMDL Program

EPA
United States
Environmental Protection
Agency

The Twenty Needs Report:
How Research Can Improve the TMDL Program

EPA841-B-02-002
July 2002

Assessment and Watershed Protection Division (4503T)
Office of Wetlands, Oceans and Watersheds
Office of Water, US Environmental Protection Agency
1200 Pennsylvania Ave NW
Washington, DC 20460

NOTICE

This document is a technical study that was prepared to aid research planning. It has not been administratively reviewed and its contents do not necessarily reflect the views and policies of the Environmental Protection Agency or of any other organization mentioned in this document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

For additional information on this report please contact norton.douglas@epa.gov

This document should be cited as
USEPA. 2002. ***The Twenty Needs Report: How Research Can Improve the TMDL Program***. EPA841-B-02-002, US Environmental Protection Agency Office of Water, Washington DC (43 pp).

Order a free copy by sending a request with title and publication number to:

USEPA/NSCEP
P.O.Box 42419
Cincinnati,Ohio 45242-0419

or call 1-800-490-9198. *Remember to provide your name and address and indicate that you are ordering publication number* EPA841-B-02-002.

This publication appears on the USEPA website at
http://www.epa.gov/owow/tmdl/techsupp.html

Contents

List of Figures

List of Tables

Executive Summary

The Twenty Needs Report summarizes Total Maximum Daily Load (TMDL) science needs identified by the National Research Council (NRC), States and Tribes, EPA National and Regional TMDL programs, the private sector, and others. The report, written for the Office of Research and Development (ORD) by an Office of Water (OW) TMDL staff scientist on detail during 2001, serves as a guide for EPA researchers who can help improve the scientific basis for restoring and protecting impaired waters. This document does not represent or modify EPA's TMDL program policy or guidance and is limited to analysis and recommendations concerning scientific issues.

The writeup for each need first describes the problem and then offers suggestions on how research might provide solutions. The three main groups of needs compiled in this study relate to 1) interactions about research involving OW, ORD, and EPA Regions (needs 1 - 3, below); 2) the immediate realm of TMDL development and implementation (needs 4 - 12); and 3) the broader Clean Water Act impaired waters program context, within which TMDLs play a central role (needs 13 - 20). Regional TMDL staff indicated that needs 11, 5, 3, 13 and 19 rank among their highest priorities. Below are summaries of the twenty needs and the research opportunities they represent:

1. Develop 'state of the science' syntheses in several high priority subject areas to aid busy TMDL practitioners and decision-makers. As TMDL developers have little time to read large numbers of technical papers, 'state of the science' synthesis papers are of premium value. Academia generally considers a synthesis paper a second-rate publication, but agencies badly need these comprehensive summaries. Synthesis should be embraced as an inherently governmental research responsibility. ORD might raise the stature of synthesis products through national expert promotion requirements, synthesis sabbaticals, STAR synthesis grants, and dialogue on the highest priority synthesis topics with states and regions.

2. Mutually improve networking and access to expertise in ORD, OW, and EPA Regions. Workload pressures in all three organizational units constrain their networking, research planning and exchange of expertise. As a result, program needs are incompletely grasped by many researchers and research products sometimes go unused by regional clients. OW, ORD and the Regions could painlessly improve networking by regularly using topic-specific email distribution lists called Tech Loops, 20 of which have been compiled in the EPA Lotus Notes Directory for top TMDL issue areas. Cross-office input for research planning could be assisted by a permanent (or floating) ORD TMDL Liaison to the regions, and through formalizing use of the Strategic Planning and Research Coordination (SPRC) document and process. Finally, well focused cross-office details have already been proven to accelerate successful teamwork on high priority issues.

3. Provide ORD technical support and technical information transfer. The TMDL program's technical support/technical transfer needs are immense. Over the years, EPA's several ORD technical support centers have effectively provided applied science assistance for Superfund and for some water program support. But, the activity level dropped due to reductions in in-house contracting in the 1990s and the future of technical support centers now seems unclear. Modeling technical support is particularly crucial to TMDLs. A new look at modeling technical support is warranted. More broadly, the transfer of research products to their clients by ORD can be improved by truly understanding the end user's need and using transfer methods familiar to the client. The former calls for site-specific dialogue or involvement with TMDL developers, while the latter often can be aided by using the web to reach clients or, where feasible, offer online product access and support. Further, to publicize its work ORD needs to develop and maintain an office-wide water quality-related research website based on Science Inventory project summaries and ORD project websites.

4. Increase quantity and quality of completed TMDLs. Over 41,800 impairments affecting approximately 20,000 water bodies were reported by states in 1998. Most states lack the resources needed to develop and implement so many TMDLs. Although having EPA researchers do large numbers of TMDLs would be an impractical use of research resources, selective ORD involvement makes sense for practical researcher experience, pilot studies transferrable to similar sites, and in difficult or high-profile TMDLs. Indirectly, ORD may also help increase TMDL production by developing highly efficient modeling and monitoring tools.

5. Improve watershed and water quality modeling. The core of a TMDL is usually a model, and the quality of modeling is one of the essential factors determining the quality of nearly all TMDLs. Yet, modeling in TMDLs is widely criticized. Areas of weakness include: applied modeling technical support, availability of low- to moderate-complexity products, gaps in model applicability, model maintenance, and training. For better technical support, EPA might revitalize its support centers, increase their availability to states, and produce more modeling technical guidance. Products of appropriate complexity might be aided by ORD/Regional collaboration on a practical "Toolbox" concept. Gaps, on the other hand, also call for further investment in modeling research and development of models that address more stressors, biological responses, and control action effects. Model maintenance critics suggest that thorough updating of not only model architecture but also the underlying science would be of great value. And finally, an ORD/OW training program in modeling would significantly improve the quality of many states' TMDLs.

6. Improve uncertainty analysis and statistical techniques for TMDLs.
Shortcomings in statistical technique, particularly related to quantifying uncertainty, need to be addressed in TMDL models and especially in listing decisions. The Margin of Safety (MOS) in TMDLs has usually been estimated subjectively rather than calculated. Limited data is often the cause but a lack of statistical tools, guidance and experience contribute to the problem. Detailed guidance on quantifying uncertainty in the form of MOS estimation tools would be valuable, as would broader statistical training on statistically assessing evidence of impairment, addressing data gaps and limitations, credible extrapolation techniques, and QA requirements for found data.

7. Improve the science base concerning <u>all</u> stressors (pollutants and pollution) and their impacts. The NRC report explicitly stated that "The program should encompass all stressors, both pollutants and pollution, that determine the condition of the water body." This point highlights a significant inconsistency between the Clean

Water Act goal of the integrity of the nation's waters and the limited tools provided to bring about that goal. Given the Act's regulatory limits, it is particularly important that EPA research address the full range of stressors and impacts in order to provide an unbiased science base and a comprehensive understanding of impairment. Existing ORD approaches to stressor research are inclusive, and it is crucial that this comprehensive treatment of exposure and effects research be maintained.

8. Address numerous stressor-specific issues identified through the SPRC. Well beyond the scope of this summary document are thousands of more narrowly defined research needs connected to TMDLs, and many of these have been addressed in the Strategic Planning and Research Coordination (SPRC) process. The SPRC was convened to identify water quality science needs and jointly plan research for a 10-year time frame. TMDL-related chapters address watershed management tools, restoration and BMPs, modeling, sediments, nutrients, toxics, monitoring and assessment, diagnostics, and landscape ecology.

9. Improve consideration of atmospheric deposition in TMDLs. Increasingly, states are finding that atmospheric deposition of mercury, nitrogen and other pollutants can be a significant source of loadings. This requires attention to data and monitoring methods, atmospheric and cross-media modeling, and cross-research-area planning.

10. Improve guidance for allocation development and methods to translate allocations into implementable control actions. Once the linkage is made between pollutant sources and instream water quality, the available assimilative capacity is allocated among the watershed's point and nonpoint sources. Allocation is a critical juncture in the steps of TMDL development from modeling through implementation of point and nonpoint control actions. Social and economic considerations also complicate allocation decision-making. ORD activities such as alternative futures assessment, watershed risk assessment, modeling, sustainable ecosystems, socioeconomic and pollutant trading research are all potentially relevant.

11. Improve information on BMP, restoration or other management practice effectiveness, and the related processes of system recovery. As management practices are typically implemented under limited budgets, post-evaluation is often dropped despite the fact that this is among the most widely cited needs. Practically every type of Best Management Practice (BMP) or restoration technique needs effectiveness research. Researchers must also consider that recovery of impaired systems is intimately linked to effectiveness, and recovery is not just the inverse of degradation. EPA's investment in effectiveness research is substantial, and ORD should continue to closely track the programs and practitioners who are their clients.

12. Develop adaptive implementation approaches for doing TMDLs. The NRC recommended that "TMDL plans should employ adaptive implementation.... foster the use of strategies that combine monitoring and modeling and expedite TMDL development." There is widespread agreement that adaptive management on a watershed basis is a sound and practical approach for TMDLs, but the need for more specific research remains. EPA researchers might develop or evaluate adaptive management strategies, or focus on related tools such as recovery forecasting models, post-implementation monitoring methods, and alternative futures analysis.

13. Make monitoring more program-relevant and results-relevant. State monitoring programs need to detect waters that do not meet standards, provide evidence used for listing impaired waters, provide crucial data for TMDL development, report on the condition of state waters, and evaluate restoration success before de-listing. These multiple roles compete for resources and force tough priority choices. Program goals for monitoring include strong state monitoring programs, sound statewide assessment methodologies, and credible impaired waters lists. ORD could help reach these goals with expanded research on integration of monitoring designs and landscape analysis tools to target and identify impaired waters, better site-specific monitoring requirements for impaired and threatened waters, monitoring methods better linked to water quality standards, monitoring data more useful to common models, more post-implementation monitoring, and addressing monitoring weaknesses such as nonpoint source assessment and ecosystem effects. Landscape analysis methods have begun playing a critical role in extrapolating between broad-scale and site-scale condition.

14. Assist states in monitoring design development. Consistent monitoring designs among all states would vastly improve the detection of emerging problems in water resources management statewide and nationwide. Several states have been assisted by EPA in their development of probability-based sampling designs, and more would welcome ORD support. One of OW's most pressing needs at a national level is ORD assistance in how to integrate independent state monitoring reports with a national monitoring framework ideally capable of incorporating state sampling designs, multiple types of monitoring, decision support, landscape model scenario assessment, prediction, and versatile reporting.

15. Revisit the scientific basis for use designations. The NRC panel called "tiered designated uses" an essential step, claiming that there should be substantial stratification and refinement of uses with scientific, social and economic input about the desired state for each water body. EPA researchers might study the few states that have begun to use tiered uses; ORD might also use their skills in endpoint development to facilitate states' refinement of designated uses. Research in watershed classification and reference condition of different water body types may prove important.

16. Assist states in translating narrative standards into numeric criteria. The uncertainties inherent in evaluating impairment qualitatively rather than quantitatively even affect the top three listed impairments (sediment, nutrients, and pathogens), which in many states have qualitative or weak quantitative criteria. But among TMDL developers, numeric criteria are sometimes but not always preferred. ORD's narrative/numeric translation support could work with states on translators, develop the basis for new numeric criteria (e.g., for effluent dominated streams, odor, aesthetics, fish advisories), further incorporate flow considerations, and support OW in triennial reviews of state water quality standards.

17. Clarify and quantify selected parameters used in criteria definitions. On this issue the NRC panel stated, "All chemical criteria and some biological criteria should be defined in terms of magnitude, frequency, and duration." Even beyond clarifying these three key parameters, criteria can and should go farther (in definition and in application) when necessary to establish a more reliable relationship between the designated use and the criterion meant to protect it. Temporal considerations are particularly in need of improvement, and regionalized syntheses of episodic stressor behavior would be useful. Researchers might also address flows at which standards must be met, wet weather conditions, and sediment lethality.

18. Develop and improve biocriteria, address other criteria gaps, and evaluate the potential for ecological water quality standards. Standards and criteria still fall short of adequately representing, in just a few parameters, complex watershed ecosystems and the multiple uses they sustain. EPA researchers should undertake an exploratory reinvention of ecologically-based standards in the interest of better linkages among watershed management, designated uses, criteria, and measurements of watershed condition. ORD should also continue to assist progress on new types of criteria that are more ecologically relevant including biocriteria, habitat, sediment, and channel/riparian structure. EPA regional feedback has placed biocriteria development among states' greatest needs for new criteria and cited pathogen criteria among the most in need of refinement. EPA researchers should support and participate in the ongoing bioassessment program framework development effort. Other criteria development and refinement needs concern sediment dynamics; stream and riparian habitat; flow; relating fish advisories to numeric criteria; estuarine water quality standards such as marine DO and nutrients, coral reef-related standards; water quality standards for intermittent streams; wildlife and invasive species, wetlands, and new chemicals.

19. Evaluate defensible scientific standards for listing and de-listing. Specifically, the NRC panel's recommendation of a two-part impaired waters list (preliminary and final lists) has implications for monitoring research, sampling methods development and statistical analysis, usually occurring in a data-limited environment. Strengthening the scientific basis might include statistical guidance for listing decisions, methods for combining multiple lines of evidence (e.g. biomonitoring and chemical monitoring), improving the analysis of the role of flow as ultimately affecting the designated uses, and methods for uncertainty analysis.

20. Improve support for protecting unimpaired waters from degradation. The "other half of the job" along with addressing waters that are impaired is protecting waters that are not impaired. Four challenges that state programs face are integrating protection and restoration, setting and balancing priorities, monitoring threatened waters, and scientifically supporting their protective actions. Although a significant EPA research investment is needed to address impairments, research support for protecting the unimpaired systems may be of greater benefit to sustaining designated uses nationally. ORD research that reveals the critical ecosystem processes that provide watershed goods and services, including many benefits well beyond those found in standards, is crucial. Unimpaired systems research can help EPA consider regional-scale and watershed ecosystem sustainability as a routine part of doing business. Other useful research directions include integrative protection/restoration strategies, priority-setting tools, monitoring or methods attuned to threatened waters, and greater certainty about thresholds for the onset of common impairments.

The Twenty Needs Report:
How Research Can Improve the TMDL Program

The high level of science activity surrounding the TMDL program in recent years (see Appendix A) has prompted many opinions on the program's scientific needs. Sources of these recommendations include the National Research Council (NRC); the EPA regional TMDL coordinators; States and Tribes; professional associations such as the Water Environment Federation (WEF); non-governmental organizations and private industry; the Strategic Planning and Research Coordination (SPRC) research planners from EPA research and water offices; and others. Together these sources (Table 1) reflect many of the most recent and carefully considered insights on TMDLs. Thus it is an opportune time to consolidate these statements on TMDL science needs to help EPA address these needs on many fronts, including EPA research. In order to aid EPA's response to TMDL program needs, this document has considered all of the NRC report's listed recommendations as well as needs mentioned by states, EPA regions and other sources. This document does not represent or modify EPA's TMDL program policy or guidance and is limited to analysis and recommendations concerning scientific issues.

EPA's Office of Research and Development (ORD) supports lines of research that can provide a better science base for the TMDL program and other Office of Water (OW) programs. As recent opinions of TMDL needs have come from many different sources, a summary of the most consistent messages would help set research priorities. The purpose of this document is to analyze TMDL needs and provide a consolidated summary as guidance for research managers and scientists who can help improve the TMDL program. This analysis revealed that the needs identified by many sources appear to be consistent, with few differences of opinion.

Table 1: Recent Sources of TMDL Science Needs Information Used to Compile this Document.

- **Nat'l Research Council TMDL Report to Congress 6/01**
- **EPA/HQ TMDL Tech Support Strategy Draft of 12/00**
- **TMDL FACA Committee Report 1998**
- **EPA Regional TMDL Coordinators Nat'l Meeting 6/01**
- **Responses to ORD survey of TMDL needs 6/01**
- **St Louis WEF Conference on TMDL Science 3/01**
- **SPRC OW/ORD Joint Research Planning 1999 - 2001**
- **EPA Draft water quality standards Strategy 4/02**
- **Additional sources of regional, state, ORD, and OW communications**

Twenty TMDL science needs identified by the NRC, EPA regions, states and other sources are listed and briefly analyzed in this report, along with suggested ways that research can help meet each need. The list (see Table 2) is organized into three parts, related to 1) interactions about science and research involving OW, ORD, and EPA regions; 2) the immediate realm of TMDL development and implementation; and 3) the broader Clean Water Act impaired waters program context, within which TMDLs play a central role.

Table 2: The 20 Primary TMDL Science Needs Covered in this Document.

Needs concerning interactions among OW, ORD, and Regions

1. **Develop 'state of the science' syntheses in several high priority subject areas, to aid busy TMDL practitioners and decision-makers.**
2. **Mutually improve networking and access to expertise in ORD, OW, and EPA Regions.**
3. **Provide ORD technical support and technical information transfer.**

Immediate TMDL development and implementation science needs

4. **Increase quantity and quality of completed TMDLs.**
5. **Improve watershed and water quality modeling.**
6. **Improve uncertainty analysis and statistical techniques for TMDLs.**
7. **Improve the science base concerning all stressors (pollutants and pollution) and their impacts.**
8. **Address numerous stressor-specific issues identified through the SPRC.**
9. **Improve consideration of atmospheric deposition in TMDLs.**
10. **Improve guidance for allocation development and methods to translate allocations into implementable control actions.**
11. **Improve information on BMP, restoration or other mgt practice effectiveness, and the related processes of system recovery.**
12. **Develop adaptive implementation approaches for doing TMDLs.**

Science needed to support impaired waters program improvements

13. **Make monitoring more program-relevant and results-relevant.**
14. **Assist states in monitoring design development.**
15. **Revisit the scientific basis for use designations.**
16. **Assist states in translating narrative standards into numeric criteria.**
17. **Clarify and quantify selected parameters used in criteria definitions.**
18. **Develop and improve biocriteria, address other criteria gaps, and evaluate the potential for ecological water quality standards.**
19. **Evaluate defensible scientific standards for listing and delisting.**
20. **Improve support for protecting unimpaired waters from degradation.**

The appendices provide additional detail on the TMDL program, issue-specific contacts, and water program data bases and websites that may be useful for TMDL-related research planning.

All twenty should be considered high priority needs, but no rank or order is implied in their listing. To gain a sense of the highest priorities, EPA regional TMDL coordinators and staff were asked for their top five of the twenty needs. Although most of the twenty were selected at least once, needs 11, 5, 3, 13 and 19 were the top choices overall.

TMDL Science Needs

Part I. Needs concerning interactions among OW, ORD, and Regions

Addressing science needs always involves interaction among scientists and their customers. EPA has a formal process to help identify research areas through dialogue with client program offices and regions and make available to them the appropriate research products, including technical support as well as research advances. This process alone does not fully meet communication needs. Beyond the formal process, researchers and clients alike need to invest effort in networking to make these interactions successful. Concerning TMDL science support, three main needs are evident:

1. Develop 'state of the science' syntheses in several high priority subject areas to aid busy TMDL practitioners and decision-makers.

The downside of the major expansion in environmental sciences in recent decades is the increasing difficulty of keeping up with the state of the science, even in what were formerly manageable topics. As a rule, TMDL developers and program staff operate in a high-pressure programmatic (as compared to academic) environment and have little time to read numerous technical studies and analyze their collective significance for a given TMDL decision. Demanding, court-ordered schedules for TMDL development, for example, can compete for time with the need for sound science-based decisions if the TMDL developers, policy makers and decision officials need to track relevant scientific advancements in the literature by themselves, paper by paper. Literature synthesis papers and other synthesis products take on immense importance in such circumstances as they provide the most feasible way to be time-efficient and yet keep one's actions scientifically informed.

As the volume of published research continues to grow, the importance of synthesis products becomes ever greater but remains underemphasized. Academia traditionally grants limited recognition or credit for synthesis papers as compared to original research, thus proliferating more narrow papers and fewer state-of-the-science syntheses. Government research sometimes appears to reflect the same position on synthesis as academia. In the absence of needed syntheses, some Region 10 states have reportedly tried to add synthesis development into already heavy workloads. Whereas academic emphasis on original research may be appropriate, agency-supportive research clearly would be justified in endorsing synthesis products as an inherently governmental contribution and one of ORD's valued roles within the research establishment.

Meeting this need: ORD could consider targeting prime topics with state and regional help and then developing more water quality research synthesis products. The many synthesis products listed in the Water Quality Research Multi-Year Plan (USEPA 2001e), including white papers on suspended solids and sediment, nutrients, pathogens, toxics, and flow, are a step in the right direction. Organizational changes that favor synthesis could include:

- develop specific synthesis product requirements associated with GS14 and 15 'national expert' recognition and promotions;
- develop short-term details called 'synthesis sabbaticals' during which researchers would develop a critically needed synthesis product as well as update their own knowledge of the state of science underlying their own specialization;
- offer targeted funding within existing research programs for more synthesis extramural support;
- create a cross-office working group specifically attuned to identifying priority synthesis needs and product types – this group could match lab expertise with priority needs and also help evaluate synthesis sabbatical proposals;
- maintain or increase front-loading of Goal 2 and Goal 8 multi-year research plan projects with synthesis deliverables, to provide useful short-term products, improve the quality of the original research to follow, and build research clientele;
- creatively use some of the resources of the STAR grants program to make the academic synthesis products in TMDL-relevant subject areas more attractive.

2. Mutually improve networking and access to expertise in ORD, OW, and EPA Regions.

This is a three-way need involving ORD's scientific experts, OW's scientific and policy specialists, and regional experts in the application of science in TMDL development. Among regions, labs, and headquarters programs, any one can be a valued source of expertise for the others, and all must be accessible and responsive for best results. In all three settings, however, substantial workloads take a toll on the degree of interaction along these critical networking pathways. As a result, basic awareness of where to find EPA expertise on a given subject sometimes suffers. Detailed knowledge of the TMDL program is limited in ORD, and in OW and the regions there is little depth of understanding on ORD's TMDL-relevant projects.

Further, our offices could engage each other more effectively in planning processes. Parts of the research planning process that involve cross-office dialogue engage comparatively few people and, as a result, have been called difficult to influence by regional staff (USEPA 2001a). Regional involvement in research planning remains very minor, yet they may have some of the most applied insights on research needs. Likewise, strategic planning within OW involves the regions but could engage ORD representation more consistently.

Meeting this need: Heavy workloads are unlikely to change, but this need may be addressed by more actively and creatively facilitating within-EPA networking and the degree of involvement of regions, OW, and ORD in various research planning activities. Some possibilities include:

- "apprenticeship" concepts should be explored, including detailing OW or regional TMDL staff to ORD modeling or other appropriate lab programs and ORD or regional detailing to OW or regional offices for experience in program and policy development and implementation;
- "Tech Loops" (subject-specific EPA contact lists formatted as email distribution lists) compiled from contacts made during this study are now available EPA-wide in the

Agency's Lotus Notes Domino Directory to aid networking/information flow on specific TMDL issues (see Table 3 and Appendix C);

- One regional suggestion was to assign a permanent ORD TMDL Liaison. This individual would facilitate among the ten regional TMDL coordinators, the national program office and the researchers with TMDL-related work across ORD;
- Formalize as an element of ORD planning the Strategic Planning and Research Coordination (SPRC) effort, which has successfully brought together ORD and OW scientists for three years in joint water quality research planning;
- Clarify the manner in which ORD gains input from the regions. Build more regional participation into the SPRC, regional technical workshop series, and similar activities that supplement ORD process in a more accessible, user-friendly manner;
- Increase ORD involvement in more national water quality strategic planning efforts. ORD could help guide the development of tools for establishing TMDLs, and identify the inherent links between TMDLs and the closely related activities of watershed restoration, source water protection, watershed-based permitting, non-point source management, and other watershed-focused programs. This interaction will help identify specific needs for guidance and methods to build State and Tribal capacity for TMDL development and to improve the technical soundness of TMDLs.

Table 3: Tech Loops (within-EPA contact lists for specific TMDL issues) that were developed to aid ORD, OW and regional networking. These appear in the Lotus Notes Domino Directory for EPA-wide use (all listings begin with the prefix "techloop-")

based on top impairments		***based on TMDL process***
clean sediment	**contaminated sediment**	**modeling**
water temperature	**bio-impairment**	**restoration/BMPs**
metals	**habitat impairment**	**targets/endpoints**
pH	**invasive species**	**economics/trading**
flow	**pesticides**	**sources/diagnostics**
ammonia	**mercury**	**listing/delisting**
pathogens	**nutrients**	

3. Provide ORD technical support and technical information transfer.

Few EPA programs have as great a need of active technical support as the TMDL program, which will be responsible for tens of thousands of TMDLs over the coming several years. TMDL technical support as used here includes direct involvement in developing TMDLs, parts of TMDLs, TMDL-relevant data sets or operational methods. Historically, ORD has played a major role in assisting Superfund and water programs through its several technical support centers. Although most technical support during the 1980s was hazardous waste-related, water program support was a compatible use of the ORD skills at the same centers. The size and activity level of technical support centers has gone down, however, mainly due to major reductions in the use of onsite contracting during the 1990s. Support in ORD for the remaining centers appears uneven and the future role of technical support centers in TMDL assistance is currently unclear. ORD modeling technical support, which is particularly critical to TMDLs, is discussed separately in an upcoming report section.

A related support issue is technical information transfer by ORD researchers as a routine matter of research product delivery. Many researchers are uncertain about what constitutes effective transfer, and could use help in how to design technical transfer products for appropriate audiences. One effect of this uncertainty is that many potential collaborators in regions and states remain disconnected from ORD's efforts; in commenting on desired technical transfer from ORD, the regions said that fixing weak ORD communication should be a top priority (USEPA 2001d). OW and regional water programs could better communicate their needs to ORD as well.

Meeting this need: Revitalizing ORD technical support centers could be a substantial aid to TMDL programs in states and regions. The past use of the same technical support centers to assist both hazardous waste and water programs remains an effective model for how to provide needed support with enough (i.e. multiple program) critical mass to sustain the centers long-term. Whereas the use of in-house contracting at centers may have changed, there are new options for technical support. For example, ORD might fund applied TMDL science centers through the STAR grants program or involve fellowship and post-doctorate staff in appropriate TMDL issues. ORD could reevaluate the skills of each center relative to TMDL technical needs while also considering the potential role of STAR and other programs.

Technical support needs voiced by regions at the Albuquerque coordinators' meeting included the generation of actual TMDLs; hands-on training using the data regions have now; better assessment tools; statistical training; monitoring methods relevant to listing and delisting; and training and updates of existing models. One national program manager commented, "The best thing to do would be to re-institute the Center for Exposure Assessment Modeling, CEAM; it's a big hole in the water research program which has never been refilled." (USEPA 2001d).

Two keys to more effective technical transfer are clear understanding by each researcher of desirable, useful types of products, and the ability to utilize the pathways of information familiar to the client. For the former, the early stages of project planning in ORD should ensure that the proposed research products have considered the needs of the end user. Concerning the latter, the Internet should be considered for technical transfer uses because it is becoming one of the preferred means for States, Territories, and Tribes to find EPA information for developing TMDLs. For example, EPA is sharing information on impairments by geo-referencing the 1998 303(d) list and showing maps of impaired waters as part of a national tracking system. Appendix D contains several main sources of web-based water program information that are heavily used by states; these sites could be browsed for ideas about research needs and technical transfer.

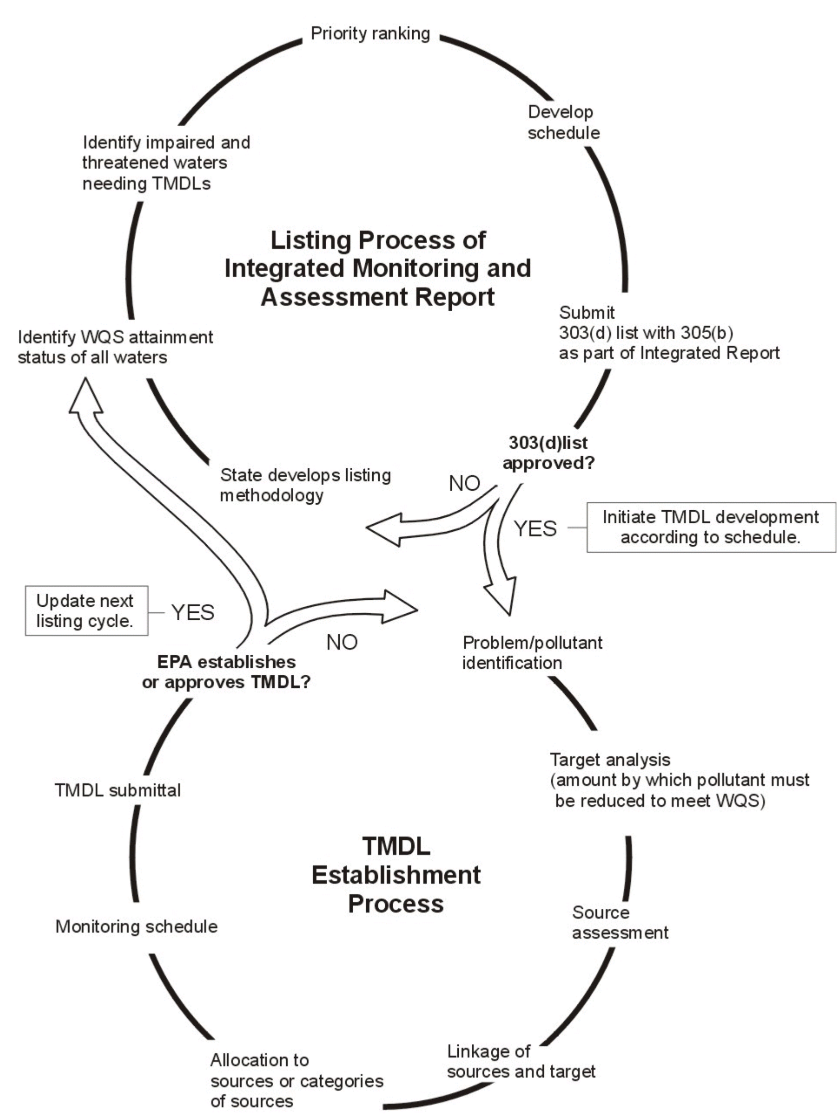
ORD's ongoing research summaries in the Science Inventory, as well as the growing number of ORD project-specific websites, could become a powerful search and retrieval resource if a few modifications are made and agreement is reached on cross-ORD consistency. A portal-style ***ORD Water Quality-Related Research Website*** would enable regional and program staff to find current ORD research projects, experts, and existing tools in appropriate disciplines related to the most pressing TMDL issues. NRMRL scientists have already developed a pilot site with Environmental Information Management System (EIMS) and OW collaboration. For such a site to reach its full potential, a database management system should house all the Science Inventory entries and be able to provide links to other appropriate ORD project websites in addition to the Inventory holdings.

Part II: Immediate TMDL development and implementation science needs

Figure 1 shows the sequence of steps carried out in identifying and listing impaired waters (upper loop) and developing TMDLs (lower loop). In the listing process represented in the upper loop, a state carries out its biennial responsibilities of monitoring and assessing the condition of state waters. Following an accepted listing method, a state proceeds through monitoring and assessing the water quality standards attainment status of all its waters, identifying the impaired waters (303(d) list), and setting TMDL development priorities and schedules. The 303(d) list approval by EPA moves the process down to the steps in the lower loop, where TMDLs are developed and approved according to schedule. TMDL implementation and adaptive management (not shown) follow the establishment of an EPA-approved TMDL.

Figure 1

Impaired Waters Listing and TMDL Establishment Processes



Needs 4 through 12 in Part II relate to the scientific basis for the steps in TMDL establishment and implementation. Several are points raised in the review by the National Research Council (NRC 2001). Part II begins with four top-priority needs that pervade the entire process – completing TMDLs, improving modeling, improving uncertainty analysis, and researching the full complement of stressors. The group then concludes with five other needs that follow the TMDL step sequence.

4. Increase quantity and quality of completed TMDLs.

Over 41,800 impairments affecting approximately 20,000 water bodies were reported by states in the 1998 303(d) listing cycle (USEPA 2001a). An estimated 36,000 TMDLs for these waters may need to be completed in the next 8 to 13 years; many states are subject to even shorter, court-ordered schedules for their TMDLs. Many states lack the resources needed to develop and implement so many TMDLs, and some appear to be facing an unmanageable number of TMDLs in a limited time. What's more, tribal TMDL programs are just beginning to become active. When states or tribes do not develop TMDLs, EPA is required to backstop them and produce the TMDLs. The need to complete large numbers of TMDLs ultimately drives most other EPA TMDL needs.

Meeting this need: Although this would not be a typical research activity, some direct involvement by ORD scientists in developing certain TMDLs has merit for ORD scientists themselves as well as for the states. ORD could become involved by either helping states directly or helping EPA meet its backstop obligation when states do not complete TMDLs. Researcher involvement in specific TMDLs that match their abilities could build familiarity with TMDL development within ORD and improve the technical input for the regions and states. ORD's active role in the Neuse River is an example, and more projects point to likely ORD involvement in developing specific TMDLs. A good source of high-profile TMDLs that may have interesting applied research components can be found in the list of FY2001 regional TMDL PACE funded projects, which totaled $ 7.5 million in FY2001. These funds support regional involvement in dozens of high-priority TMDLs that are either technically challenging, exemplary of common impairment settings, of high visibility, or other concern.

Short of actual involvement in doing TMDLs, ORD can help increase TMDL completion by generating TMDL-streamlining products such as automated tools for technical analysis associated with TMDLs. Numerous downloads of the ***Stressor Identification Guidance Document*** (USEPA 2001c) and a variety of EPA models by state agencies, for example, attest to the immediate value of making practical tools available in the right places. Technical support centers might make significant contributions in providing operational tools as well as direct involvement in TMDLs. To help increase the quality of TMDLs, ORD could become more active in water quality modeling or statistics training for regions and states that need capacity building in both these subjects.

5. Improve watershed and water quality modeling.

One principal feature of a TMDL is the identification of the loading capacity of a water body for a particular pollutant. The core of a TMDL is usually a model that estimates the relationships between the condition of the water body, the identified pollutant sources, and/or the alternatives for loading reduction. The quality of modeling is one of the essential factors determining the quality of nearly all TMDLs. Modeling shortcomings within EPA and the states, and the state of modeling science in general, were criticized in the NRC review, state and regional meetings, and Water Environment Federation's St. Louis TMDL conference. Modeling is also the only topic where this study found major differences in opinion about the nature of the TMDL program's need (i.e., uses of empirical vs. process-based modeling).

Better water quality modeling is among the most significant of all TMDL-related science needs reviewed in this study. OW managers have repeatedly pointed to modeling technical support as one of the greatest TMDL-related research needs in response to ORD support requests since the early 1990s. The 1998 TMDL FACA report recommended that EPA's highest priorities for science and tool development include improving monitoring and modeling capabilities, and providing related technical assistance and training (USEPA 1998). Yet, despite the magnitude and immediacy of TMDL modeling needs, the willingness of ORD to assist, and the central role of modeling in TMDLs, ORD's modeling efforts do not meet several key regional and state TMDL program needs that may be within reach. These include:

- *Applied modeling technical support.* ORD's current investment in water quality modeling and applied modeling research is more diffuse in ORD than a decade ago and thus may now involve more researchers, laboratories, and subject areas, but ORD modeling technical support at NERL/ERD (Athens) has decreased from 1990 levels. As discussed under need # 3, in-house technical support contracts appear out of favor, but a substitute at an equivalent level of effort as yet has not been established. The need remains high. A critical mass of modeling technical support capable of advising model users, maintaining modeling tools, and providing modeling services is needed.

- *Development of products of appropriate complexity.* A research and development orientation toward models and modeling tools of low to moderate complexity would better meet state needs. For example, a message to this writer from a PhD modeler in one state claimed "Making a model more complex does not necessary mean making it better.... In routine calculation of TMDLs the Department probably won't be able to use [a complex model] frequently since resources available for water quality studies are insufficient for its implementation, and time for completion of a final report is very limited."

- *Filling gaps in model applicability.* An adequate water quality model does not exist for every pollutant on the 303(d) list. Some common models need to be updated to better reflect recent scientific findings. Models that link stressors to biological responses are particularly needed.

- *Public domain model maintenance.* Consistent updating and maintenance of public-domain water quality models in frequent use by states would not only be useful, but expected of EPA and other federal agencies as the originators of many water quality models.

- *Training in modeling.* More widespread training for state and regional personnel is a nearly universal recommendation among recent TMDL program reviewers.

Meeting this need: The suggestions below parallel the five elements identified above.

- *Applied modeling technical support.* A firm commitment by ORD to reinvest in technical support for model users, do more applied modeling, and support public domain models would be immeasurably helpful to states and regions. Mechanisms for carrying this out could include offsite contracts, which successfully covered many technical support tasks during the 1990s; reassessing use of staff for modeling research vs. technical support; increased use of the STAR program in competing cooperative agreements for one or more water quality modeling support centers; and better-defined and funded use of new ORD modeling locations in technical support related to their own modeling products and specialties. Program office funding has been used to put NRMRL/SPRD's groundwater technical support "on retainer" for the Brownfields program; use of PACE TMDL funds might be used similarly to give regions access to the expertise in ORD-managed modeling support contracts.

Many areas are ripe for technical support – for example, web-based tools to assist with model selection. Clear guidance on model use is needed; a model selection/decision tree would be useful. Regions emphasize the need for assistance in making impairment decisions with limited data. Researchers could publish case studies on their new TMDL-related model applications. ORD might also develop guidance on how to translate model results such as continuous simulations into load and wasteload allocations which meet programmatic requirements. Guidance on optimizing monitoring data collection for modeling is also an essential element of technical support.

- *Development of products of appropriate complexity.* The limited resources available to the majority of TMDL developers determine the type of research products they can use. Low to moderate cost and complexity constraints are an added challenge to researchers' creativity, but do not imply an absence of modeling research potential.

In a recent address to Congress about TMDLs, Assistant Administrator for Water Tracy Mehan chose to mention ORD's collaboration on cost-effective modeling and restoration development as an example of progress toward TMDL improvements. Regional requests often cite the mantra "faster/cheaper/better, pick any two" and emphasize streamlining modeling tools rather than new data- and labor-intensive models. Region 4's "TMDL Toolbox" has proven easy to use, is technically defensible, provides fast results, and favors consistency in modeling approach. Models linked into the Toolbox include WASP 6.0, EFDC (I-D, 2D/3D), LSPC, WCS sediment, WCS SWMM, WCS Mercury, WAM, WRDB, WCS; these can be tied to BASINS and ArcView (USEPA 2001a). ORD involvement with the Region could make further enhancements and help take this TMDL Toolbox concept nationwide.

- *Filling gaps in model applicability.* Despite the emphasis on technical support in this discussion thus far, there is widespread belief that EPA should also re-energize its modeling research program. Recent reviews of model applicability can help ORD address gaps and help the states improve their awareness of appropriate tools for different settings, but these review findings should be accessible and formatted usefully for modelers' assistance.

One very prominent need is the development of models that can more effectively link environmental stressors (and control actions) to biological responses. NCER/STAR's RFP on improving stressor/response modeling in watersheds is commendable for directly addressing this need. Better models are also in high demand for nonpoint source loadings, aerial deposition, contaminated sediment, groundwater and wet weather events. Models addressing economic aspects of TMDL implementation alternatives could be a growth area in research. Other gaps that ORD could address include better integration of landscape information with models, and development of models for metals simulations that include a sediment interface. It would also be very useful to develop a database on pollutant export coefficients for common non-point sources. Another major modeling-related gap – improved uncertainty analysis – is addressed in this report separately due to its heightened importance.

Although there is widespread agreement that more modeling support and technical advancement is needed, significant differences of opinion exist concerning the types of modeling appropriate for most TMDLs. Two basically different approaches favor either empirical (statistical) modeling, or process-based (mechanistic) modeling. Neither is likely to fully meet all TMDL needs, and continued application of each in various TMDL settings is likely. ORD, OW and regional TMDL coordinators should jointly review many different TMDLs to become certain of the appropriate settings for using different modeling approaches and determine to what degree each should be the focus of ORD's research and technical support. Generally the reason that empirical or statistical models aren't used more widely is that there is often insufficient ambient information to operate these models.

- *Public domain model maintenance.* A good many modeling tools exist, but these tools need to be updated to the point where they are useful in the development of TMDLs. A set of well-supported, updated, public domain models will significantly increase consistency in TMDL determinations, while also providing states an alternative to proprietary models they often cannot afford. The current TMDL situation shows that users expect the originators of water quality models to maintain and update their products. As the well-known developer of several models, ORD faces this widespread expectation to update both model architecture and underlying science. ORD should keep its most widely used models current by incorporating latest science into the model code; for example, CEAM-distributed models and the HSPF parameter database should be consistently updated and maintained. Existing core models like WASP, HSPF, EFDC, SWMM and others should be updated; plans by NRMRL/WSWRD to take responsibility for SWMM maintenance and NERL/ERD's recent updates of WASP are commendable steps in the right direction. Moreover, as new ORD locations are becoming involved in modeling they should embrace a long-term commitment to technical transfer and maintenance support for whatever they develop.

- *Training in modeling.* Water quality models are frequently misused, and there is a shortage of trained water quality modelers throughout state and federal government. If training was provided specifically on how to develop TMDLs using modeling approaches, the quality of TMDLs would be greatly enhanced. Region 4 TMDL staff claim that training has brought the greatest return for the dollar spent. Training exposes their states to methodologies, approaches and models that can be used in the development of TMDLs.

One widespread suggestion is to undertake a major training program at the state level for model users; although training is often a program office role, ORD's close ties to the development and maintenance of several models argues for their involvement as well. ORD might also consider supporting the development of a professional certification for modelers, and could strengthen academic programs in water quality modeling with grants; both actions could help counteract an observed decline in universities' water quality modeling coursework. Opportunities exist to work with OW on web-based modeling training to meet some of the more elementary training needs and prepare trainees with exercises in advance to help them get more out of live courses.

(see more modeling-related comments under needs # 4, 6, 9, 10 and 12)

6. Improve uncertainty analysis and statistical techniques for TMDLs.

Shortcomings in statistical technique, particularly related to quantifying uncertainty, were a major concern of the NRC panel. Their report commented, "Uncertainty must be explicitly acknowledged both in the models selected to develop TMDLs and in the results generated by those models.... The TMDL program currently accounts for the uncertainty embedded in the modeling exercise by applying a margin of safety (MOS); EPA should end the practice of arbitrary selection of the MOS and instead require uncertainty analysis as the basis for MOS determination....EPA should endorse statistical approaches to defining all waters, proper monitoring design, data analysis, and impairment assessment." (NRC 2001).

In practice, TMDL developers often strive for sound TMDL decisions in the face of sparse data availability. Their statistical technique can be weak due to the lack of sufficient data to perform a given analysis, but this shortcoming is worsened by limited EPA statistical guidance, tools, and requirements. Further complicating the issue is the potential cost of quantifying uncertainty at numerous points in the process. Little guidance on testing model adequacy or reliability is available, and as a result the ability to link sources to water quality effects with certainty is hindered.

Meeting this need: EPA procedures for conducting uncertainty analysis should mainly address two points in TMDL development: (1) uncertainty or inherent error in the model calculations and (2) quantification of the MOS. It is generally feasible to approximate uncertainty in modeling steady state assumptions, but new research challenges lie in conducting uncertainty analysis in the dynamic settings of the ambient environment, and propagating an error analysis from one model domain to another (e.g., runoff model to receiving water body model).

TMDL developers need statistical tools and detailed guidance on MOS development, incorporation into modeling assumptions, estimation within the allocation process, and quantifying effects on the outcome of the TMDL analysis. ORD's most valuable contribution might be to develop a general MOS estimation tool and, where necessary, address MOS estimation specifics for each of its supported water quality models. As the ability to reduce uncertainty will be limited in many situations, advances in post-TMDL monitoring and adaptive management *(see needs 11, 12, 13)* are an alternative.

ORD could also help the TMDL program develop technical guidance or training on proper use of a variety of statistical tools and techniques in TMDLs. For example, states need approaches to address data gaps, credible statistical extrapolation techniques, statistical approaches and QA requirements for incorporating found data sources, guidance on choosing Data Quality Objectives for TMDLs, and technical guidance that addresses acceptable error in data interpretation. Statistically sound approaches also are badly needed by many states for determining impairment and listing or delisting impaired waters *(see need # 19).*

7. Improve the science base concerning <u>all</u> stressors (pollutants and pollution) and their impacts.

"The program should encompass all stressors, both pollutants and pollution, that determine the condition of the water body" (NRC 2001). This recommendation from the NRC panel pinpoints the need to overcome a significant inconsistency between the Clean Water Act's goal – "to restore and maintain the physical, chemical, and biological integrity of the Nation's waters" – and the statutory tools provided to achieve that goal. The TMDL program aims for bringing about the recovery of impaired waters by considering all contributing sources of impairment comprehensively, on a watershed basis. Yet, limits in the Clean Water Act that discern "pollutants" from "pollution" (see Table 4) mean that some stressors do not require 303(d) impairment listing and TMDL development. Reports from many states, however, do voluntarily list many "non-pollutant" impairments, revealing that they are not a minor problem and in fact affect thousands of water bodies.

Table 4: Pollutant and pollution concepts

<u>Pollutant</u>: a substance added to waters due to human activity.

Examples: sediment, nutrients, pathogens, pesticides, heat.

<u>Pollution</u>: man-induced alteration of water body integrity (this concept encompasses all pollutants and several non-pollutant causes of impairment)

Examples (pollution but not pollutant): habitat degradation, flow alteration, channelization, loss of riparian zone.

> Section 303(d) requires identifying ***pollutants***, and TMDLs allocate reduced loads among ***pollutant sources***, to reattain water quality standards.

If water quality research as a whole is to provide an unbiased and comprehensive scientific understanding of water body impairment and a watershed approach to restoration and recovery, research cannot be constrained by the limited federal recognition of stressors as potential causes for 303d listing and TMDLs. The limits in

TMDL program scope notwithstanding, EPA research must consider all stressors in order to understand sources and effects of the stressors EPA can or can't control, and continue to inform EPA, states, Congress and the public of the whole impairment picture as it may affect future policies and regulations.

Research limited to conventional pollutants may never fully enlighten or be able to support remedies for some forms of water body impairment. In fact, the history of federal water pollution law reveals that earlier limits in statutory scope were largely due to the insufficient state of science to support broader comprehensive protections for the ambient aquatic environment (NRC 2001). The limited scope of existing criteria (see need # 18) is one example. Reaching the holistic Clean Water Act goal will require research designed for a comprehensive science base that can support addressing any cause of impairment.

Meeting this need: At its root, this need will require some very broad and strategic thinking about the scope of ORD's stressor-response research in the context of all water quality research. Key questions might include:

- Is any significant cause of impairment (pollutant or non-pollutant) poorly understood and prone to major research gaps?
- How comprehensive can ORD's water quality research program be?
- What stressors (pollutant or non-pollutant) are the most essential for EPA research?
- What are the alternative sources of stressor research not carried out by EPA?
- How should multi-stressor and cumulative effects research on aquatic systems address pollutants and non-pollutants?

There are good signs that ORD stressor research will remain unencumbered by the pollutants-vs-pollution issue. The ***Aquatic Stressors Framework*** (USEPA 2001f) is a major research effort that addresses some common, conventional pollutants but goes well beyond in exploring areas such as habitat alteration. The ***Stressor Identification Guidance Document*** (USEPA 2001c) provides a methodology for analyzing causal linkages between sources, stressors and biological effects without a limited, pollutant focus. Although these are positive developments, ample opportunities also exist for research in other topics that go beyond conventional pollutants.

8. Address numerous stressor-specific issues identified through the SPRC.

In contrast to need #7's call for big-picture stressor research planning, this need focuses on the specifics of stressor research. If examined pollutant by pollutant or step by procedural step, the amount of TMDL science needs number in the thousands and would clearly exceed the scope of this document. Fortunately, many more specific needs have been addressed in the much longer and more detailed Strategic Planning and Research Coordination (SPRC) document. For example, whole chapters address multiple research needs concerning sediment, nutrients, and pathogens. Readers who seek a more project-level treatment of water quality science needs than this document are referred to the SPRC (draft document in press).

Meeting this need: Through regular cross-office, scientist-to-scientist planning meetings, the SPRC effort has matched specific ORD projects, goals and milestones with specific program needs concerning specific stressors on a finer level of detail than this report. Due to its high profile and priority during the SPRC meeting years of 1999 to 2002, the TMDL program had a significant influence on several planning sessions and TMDL needs are well represented in several chapters. The SPRC document's chapters, in near-final draft as of this writing, include:

- ***Watershed Management Tools, Restoration and TMDLs***
- ***TMDLs and Modeling***
- ***Critical Areas Research and Water Programs***
- ***Microbial and Pathogen Criteria***
- ***Harmful Algal Blooms & Marine Disease***
- ***Nutrient Criteria***
- ***Suspended Solids and Sediments***
- ***Assessment of Toxic Chemicals***
    - ***Toxic Chemicals***
    - ***Wildlife Criteria***
- ***Monitoring and Assessment***
- ***Ecological Assessments and Restoration***
    - ***Biological Assessments and Criteria***
    - ***Diagnostics***
    - ***Landscape Ecology Applications for Aquatic Systems***

Ultimately, the Office of Water needs to influence the ranking process of the Research Coordination Team (RCT) for water to ensure that the high priority TMDL research needs documented in the SPRC workshops are addressed.

9. Improve consideration of atmospheric deposition in TMDLs.

This need is highlighted separately because it signifies a need to depart from media-specific water research planning in some cases to properly address some forms of impairment. Increasingly, states are finding that atmospheric deposition of mercury and other pollutants can be a significant source of loadings to water bodies. Mercury in particular is believed to affect nearly all Northeastern lakes, and aerial nitrogen loadings affect large water bodies in several regions of the country. Despite the widespread occurrence of aerial deposition of water pollutants, many states have not had experience working with air models and data in the context of TMDLs.

Meeting this need: Improving this shortcoming requires attention to data and monitoring methods, atmospheric modeling, cross-research-area planning, and technology transfer. As a start, OW should review whether the Office of Air and Radiation (OAR) emissions/monitoring data now gather the right data for use in airborne pollutant TMDL development. ORD and OW could then coordinate with OAR on research to improve air deposition monitoring data and emissions data. Air and Water offices have already begun joint development of an Air-Water Interface Work Plan and committed to more effective integration of their statutory authorities, specifically working with states to support atmospheric deposition-focused TMDLs.

Modeling tools are needed for identifying and quantifying loadings from atmospheric deposition, predicting load reductions needed from air sources (e.g., linking air and water models), and for identifying the sources of air deposition to a water body. Mercury modeling should be able to track this pollutant from source through atmospheric pathways to the water body, and on through fish, human consumption, and assess the implications for water quality standards. Finally, consistent with earlier modeling recommendations, states would find training and technical transfer in these methods extremely valuable.

10. Improve guidance for allocation development and methods to translate allocations into implementable control actions.

Once the linkage is made between pollutant sources and instream water quality, the available assimilative capacity is allocated among the watershed's point and nonpoint sources. The primary aim of the allocation process is that the allocations result in reduced loads sufficient to reattain the water quality standard. Current TMDL guidance is sparse in the area of allocation development, largely because the allocation of loads is considered a state decision. Yet, states need better science for supporting allocation decisions and guidance on the various methods for making these decisions.

Allocation is a critical juncture in the steps of TMDL development (see Figure 1, lower loop), affected by and affecting the steps from modeling through implementation of point source and nonpoint source control actions. Model scenarios often provide the raw material for load allocation decisions. Allocation development considers different combinations of allocations that appear feasible and collectively can meet a TMDL's desired load reductions, and TMDL implementation carries out the best combination of control actions related to each allocation. Efforts to improve understanding of control action (i.e., BMP and restoration) effectiveness, then, are crucially important to allocation as well as to implementation. Further, social and economic considerations also complicate allocation decision-making and add new dimensions to the technical assistance tools that are needed to move from a purely scientific allocation scenario to implementable control actions with reasonable assurance of successful implementation.

Meeting this need: ORD could address allocation in two ways: directly focus research on scientifically sound allocation decision strategies, and more actively consider the allocation process in relation to their research on modeling and BMPs. As it straddles the transition from risk characterization to risk management and it potentially integrates technical, social and economic factors, allocation research may present opportunities for multiple ORD laboratories and perspectives. For example, ORD activities as diverse as alternative futures assessment, watershed risk assessment, landscape ecology, vulnerability assessment, modeling, sustainable ecosystems, socioeconomic and pollutant trading research are all potentially relevant. Some specific allocation issues that could be researched include:

- better address dynamic environmental changes in developing methods to balance allocations between continuous and intermittent (event-driven) sources of the pollutant, or to allocate wet-weather and dry-weather loads;
- improve methods for translating point source wasteload allocations into NPDES permits;
- review the underlying scientific weaknesses and strengths of common allocation methods and develop guidance on the process of evaluating and choosing among alternative allocation scenarios;
- develop decision-support tools for allocating loads among various point and non-point sources;
- develop better guidance on integrating pesticide application rates into wasteload allocations; and
- develop procedures for handling allocations that involve legacy sources.

11. Improve information on BMP, restoration or other management practice effectiveness, and the related processes of system recovery.

This widely-cited need recognizes the value of research to develop or evaluate conventional Best Management Practices (BMPs) for nonpoint pollution control as well as innovative research into restoration techniques that employ natural system processes as management tools. The 1998 TMDL FACA report stated this FACA committee's opinion that BMP effectiveness research ranks among EPA's second-highest priorities for science and tool development (USEPA 1998).

As management practices are typically implemented under very limited budgets, performance evaluation is often dropped from the plans and an effectiveness track record is left wanting. Practically every type of BMP or restoration practice needs effectiveness research – even widely-used agricultural BMPs, conventional forestry BMPs, and urban runoff controls. This research is critically needed as the technical basis to support TMDL guidance on reasonable assurance related to nonpoint source management methods that lie beyond EPA's direct control. For EPA approval of a given TMDL, there needs to be a reasonable assurance that BMPs and other management practices exist, that can be feasibly implemented in an allocation scenario, and will accomplish the necessary loading reductions. Moreover, in 'blended' waters impaired by both point and nonpoint sources of the same pollutant, the NPDES permit (for point sources) requires that the water must meet the standard, and thus is potentially affected by the predicted effectiveness of the nonpoint controls as well.

It is important to note that, whereas improved modeling may be the most critical need in light of EPA's legal obligation to complete TMDLs, in fact BMP and restoration research success may be more important in actually changing the condition of the nation's waters. For best results, risk management research must also thoroughly understand the recovery of impaired systems as intimately linked to effectiveness (e.g. time scales needed to regain specific conditions and reestablish certain natural processes, as well as methods for predicting and verifying levels of recovery). Recovery is not the simple mirror image of decline, and deserves much careful study that can translate into management choices, approaches and expectations.

Meeting this need: In addressing this need ORD should continue their substantial support for BMP effectiveness research and their research program in watershed restoration. Also ORD could coordinate with OWOW (Nonpoint Source Control Branch, Watershed Branch) on projects to compile information on BMP effectiveness, as NRMRL has collaborated on an evaluative inventory of restoration projects with OWOW. The two offices could also develop geo-referenced databases as a result of these projects to provide easy access to BMP effectiveness information that can be updated as more information is gathered.

ORD restoration research targets understanding damaged ecosystems, identifying and refining restoration methods; riparian zones and wetlands are priority areas for study. Regional comments on restoration research concur with this approach, and also suggest:

- keep a watershed focus to be more effective in riparian restoration; need more to make operational programs aware of restoration research findings;
- need more work within-channel; research on BMP/restoration effectiveness needs to be translated into Use Attainability Analysis implications;
- need better scientific basis for water body and watershed recovery processes and recovery potential, as a huge and relatively open research arena.

Also needed are better measures of physical habitat characteristics and means for interpreting these measures in evaluating BMP effectiveness, and research on NPS control through manipulating natural watershed processes and areas with key natural functions, as compared to more artificial construction of BMPs.

12. Develop adaptive implementation approaches for doing TMDLs.

The NRC report stated, "TMDL plans should employ adaptive implementation.... In order to carry out adaptive implementation, EPA needs to foster the use of strategies that combine monitoring and modeling and expedite TMDL development." In a similar vein, an article reviewing the March 2001 TMDL science needs conference stated, "The TMDL program is best implemented through an adaptive watershed management approach." and noted that strong watershed management is central to this aim. Both sources infer that complex, uncertain analyses call for an adaptive management process to speed initial remediation and fine-tune pollution controls as implementation proceeds.

But, in the absence of good examples, more adaptive approaches are not as likely to occur. Problems that continue to occur include modeling "analysis to paralysis" with little implementation, or at the other extreme, proceeding directly to implementing BMPs and restoration on impaired watersheds without modeling. Research into adaptive management strategies may help identify the most favorable approaches.

Meeting this need: ORD could evaluate adaptive management strategies in general, or could develop specific products that aid the process. For example, ORD could:

- develop allocation and forecasting models that predict the temporal component of recovery. Better predictions of recovery time and expected sequence of recovery stages would complement existing allocation models and help address one NRC recommendation to 'do adaptive implementation.' These models could also factor in social elements that may delay or accelerate recovery in addition to the ecological recovery processes already at work;

- develop allocation and forecasting models that assess possible changes in loads from each source in the watershed instead of just forecasting whether the allocation will achieve the target when implemented; these would help TMDLs address potential future growth and help set the scene for adaptive implementation of the TMDL;

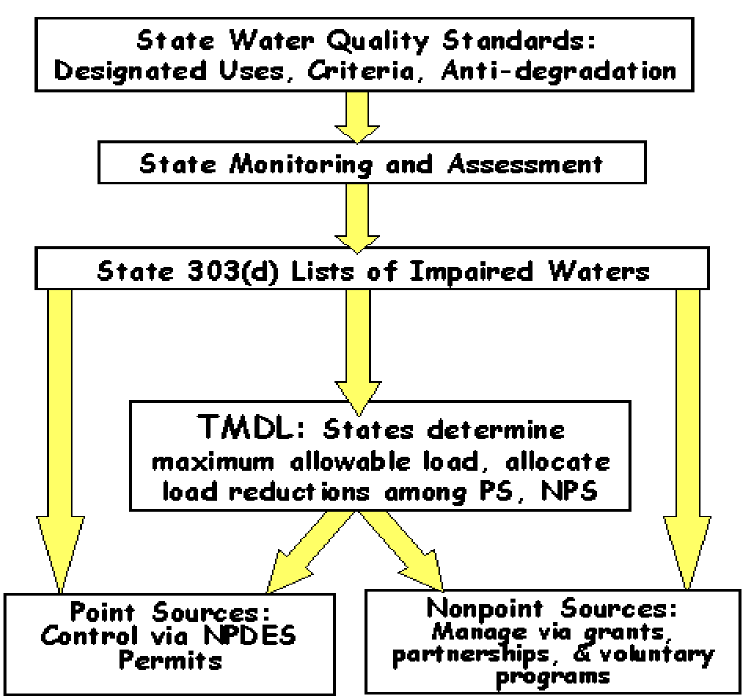
- one component of adaptive implementation involves considering costs; better guidance on determining costs of TMDL analysis steps, and the relative costs of alternative management practices, would be useful components of phased implementation; and

- better post-implementation monitoring methods should be used to continually review and refine individual TMDLs as time goes on.

Part III: Science needed to support impaired waters program improvements

The third category includes eight research needs that go beyond the immediate TMDL process. These needs relate to the Clean Water Act's steps for detection and assessment of impaired waters (Figure 2), which are instrumental to the TMDL role of restoring impaired waters to good condition. Two are monitoring needs, five are related to water quality standards, and one concerns unpolluted but threatened waters. The standards-related needs are covered only briefly in this TMDL-oriented report, and for more detail readers are referred to the ***Draft Strategy for Water Quality Standards and Criteria*** recently issued by the Office of Water (USEPA 2002a).

Figure 2: The Clean Water Act's basic steps for identifying and restoring impaired waters



13. Make monitoring more program-relevant and results-relevant.

The critical roles of monitoring are evident in figures 1 and 2: state monitoring programs need to detect waters that do not meet standards, provide the evidence used for listing impaired waters, and provide crucial data for modeling and TMDL development. Monitoring programs are also expected to report biennially on the overall condition of state waters, and detect emerging problems. Moreover, waters undergoing restoration need to be monitored to guide adaptive management and to determine when they can be de-listed after reattaining standards. These multiple roles compete for limited resources at the state level. Some states are compelled to weigh the relative priority of targeted, site-specific monitoring against statewide monitoring. Although tradeoffs do happen, all of the monitoring roles are indispensable. Our challenge is to develop monitoring strategies that meet these multiple objectives efficiently and effectively.

Larger monitoring budgets and less expensive monitoring techniques would help the states, and research to provide the latter is a perennial need. A more immediate issue, however, is the relative amount of ORD research emphasis on each of monitoring's multiple roles stated above. During the last five years, much of ORD's efforts focused on helping states fill gaps in meeting statewide water quality assessment needs. ORD is now challenged to design monitoring strategies that allow states to use the larger-scale statewide and watershed-level assessment results to target watersheds or sub-watersheds needing more intensive or finer-scale monitoring. Reasons include the need for more reliable data for listing and delisting impaired waters and heightened emphasis on TMDL development at finer scales.

Recently, landscape analysis methods have begun playing a critical role in extrapolating between broad-scale and site-scale condition. Landscape analysis tools are showing promise in helping identify waters most likely to be impaired by combining remotely sensed land cover and other GIS data with water quality data to develop predictive models of the relationships among landscape indicators and water quality. These predictive relationships help analysts gain more from their landscape data for use in monitoring watershed and riparian changes and indicators of condition (e.g., Mehaffey et al 2001). Landscape data support monitoring and assessments ranging from regional to site-specific scales due to their comprehensive coverage. Landscape analysis tools can be used to predict geographical locations of impairment under different land use change scenarios and various ecological trend scenarios. Landscape analysis research is particularly important for monitoring programs because of its potential to provide a relatively low cost tool to fill gaps in ambient water quality monitoring data coverage and to improve the understanding of non-point sources, stressors, exposure pathways and effects.

Meeting this need: Water program goals for monitoring include strong state monitoring programs, sound statewide assessment methodologies, and credible impaired waters lists. The TMDL program's current needs also include increasing support for targeted, site-specific monitoring and assessment techniques. These techniques above all should be cost-efficient, appropriate for widespread use, and clearly related to specific water quality criteria in order to be program-relevant. In particular, ORD could:

- *focus research on monitoring methods that better relate to water quality standards.* Ambient monitoring is expected to provide the means to identify the deviation between the water quality standard and current conditions, provide a sound basis for 303d listing, and track standards re-attainment. Many criteria represent less-than-optimal measurement endpoints relative to the designated uses they are intended to reflect; clean sediments and pathogens are just two of the common impairments where available monitoring measures don't track optimally with designated uses. Moreover, as the NRC review noted, water quality standards themselves should be measurable by reasonably obtainable monitoring data; thus researchers could focus on the standards end of this relationship (see also need # 18) as well as the monitoring methods end. ORD could contribute with continued research on appropriate indicators of designated use attainment status with an emphasis on reasonably obtainable monitoring (including landscape) data. Potentially this might range from chemical-specific methods to ecological assessments to more versatile application of landscape analyses. Research might focus on indicators (biological communities) and pollutant/media combinations (e.g., fish tissue) with low spatial and temporal variability.

There are also numerous opportunities to focus on developing and testing monitoring methods for specific pollutants needing new or improved water quality standards, particularly nutrients, clean sediments and pathogens. These pollutants may be good candidates for application of landscape analysis, e.g., in nitrogen modeling or assessing the state-wide likelihood of exceeding pathogen criteria (Smith et al. 2001).

-continue research on monitoring designs to assess WQS attainment status of all waters. Efforts to support this need include developing monitoring designs and landscape analysis tools appropriate for assessing the condition of key indicators of designated uses for each type of water resource. EPA's research in monitoring is substantial and already makes major contributions related to these goals. ORD's monitoring is roughly divided between EMAP's regional- or landscape-level activities driven by probability-based sampling to determine general condition of water bodies across large areas such as regions or states (discussed separately in need # 14, below), and more generally site-scale development of indicators oriented toward Clean Water Act diagnosis and listing needs.

-expand research on integration of monitoring designs and landscape analysis tools to identify impaired waters. Landscape information can be applied at any scale and ORD/NERL scientists have completed a number of landscape analyses at state, regional (i.e. multi-state areas) and national scales. These broad-scale analyses are useful for even fine-scale, site specific assessments as they provide context and insights into the progression of stressors across the landscape (e.g. non-indigenous species, land use change) and risk propagation between adjacent watersheds (Wickham et al. 2002). Landscape assessments might also be used to provide targeted monitoring to help identify waters vulnerable to impairment as well as to identify reference sites. Furthermore, landscape models can also provide insights into potential future conditions around threatened waters and offer decision support through trade-off analyses of alternative management actions.

- *make monitoring data more useful for models to support TMDL development*. In addition to ensuring that monitoring methods gather data most relevant to standards, the field methods must also be aligned toward filling modeling input requirements wherever possible. Verification data collection is needed for assessing model prediction error. This premise is consistently true for a wide assortment of model types.

- *focus on more post-implementation monitoring to verify results of management practices.* States need more results-related measurements to directly link pollution controls (e.g., BMPs) and recovered water bodies. In the restoration science community, performance evaluation of still-new restoration approaches is essential but often left undone. Again, monitoring studies by ORD can help answer one of their most frequently-heard pleas for knowledge about "What works?"

- *strengthen weaker areas of monitoring.* ORD could contribute to methods and technical guidance on monitoring and data interpretation for any of the phases of TMDL development and implementation. It will be essential to improve the techniques and data for monitoring the sources, the specific pollutants in nonpoint source pollution and the water quality measures used in nonpoint source-dominated watersheds. Also useful research is needed to improve the measures of direct and indirect ecosystem effects from nonpoint sources, and to develop improved, diagnostic indicators of biological impairment. Substantial progress has been made on the sources-stressors-exposure end of nonpoint assessment. Continuing ORD research into documenting the associations among easily monitored landscape patterns and aquatic impairment remains one of the greatest opportunities for improving the scientific framework that supports monitoring and water programs in general.

14. Assist states in monitoring design development.

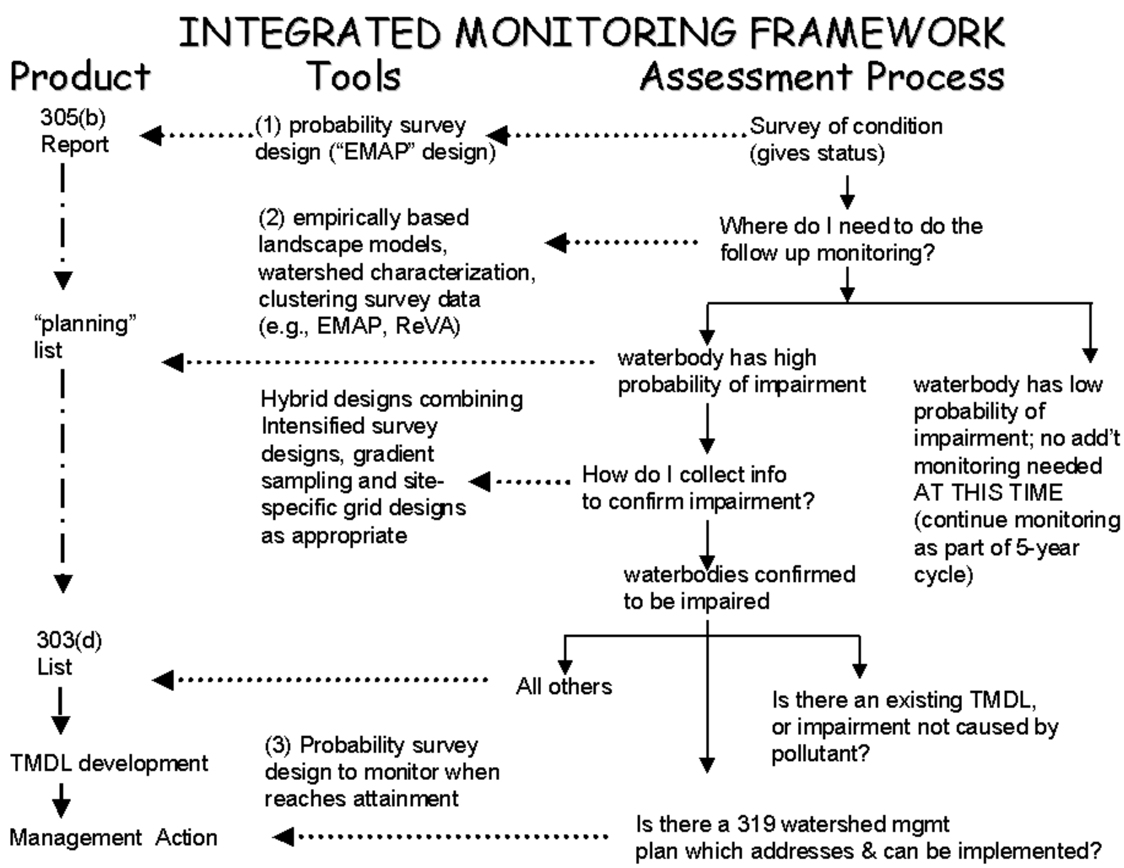
Consistent monitoring designs among all states would vastly improve the detection of emerging problems in water resources management statewide and nationwide, but EPA has generally resisted imposing very specific design requirements on states. The TMDL FACA report in 1998 recommended promoting standardized monitoring methods (USEPA 1998). Probability-based statewide monitoring designs have been implemented by many states in recent years, and more have indicated their interest, yet significant differences in states' approaches will likely persist. The absence of consensus among states on monitoring methods and designs has had a cost on the national scale as well, in that it has hindered EPA's ability to evenly assess water quality problems across the nation and strategically plan its assistance to specific regions and states. As a result, one of OW's most pressing needs at a national level is assistance in how to integrate independent state monitoring reports with a sound, cohesive national monitoring framework.

<u>Meeting this need:</u> Several states have been assisted by NHEERL in their development of probability-based sampling designs; this is one of the most significant recent ORD monitoring contributions in support of water programs. More states have stated at EPA meetings that they, too, would clearly welcome this assistance. States and others also need guidelines for data collection and data management systems.

ORD might follow the progress of the CALM (Consolidated Assessment and Listing Methodology) monitoring guidance (see Appendix D) to track state capacity for and interest in probability-based design.

ORD help in state-scale monitoring design assistance has been extremely helpful to individual states and to the national water program as it urges states to adopt sound scientific monitoring approaches. Without standardized state monitoring or a heavily funded nationwide program, developing a national framework represents a substantial research challenge. An integrated national monitoring framework (see Figure 3) should be capable of incorporating state designs, supporting multiple types of monitoring,

Figure 3. A representation of how an integrated monitoring framework can support a variety of water program products (after Brown et al. 2002)



decision support and landscape model scenario assessment, prediction, and versatile reporting, all ultimately keeping national management activities well-informed and on target. Opportunities exist for substantial roles in landscape analysis as well as in probability-based and targeted design development.

15. Revisit the scientific basis for use designations.

The current water quality standards program has been called 'scientifically weak' in that the established designated uses (DUs) need to be more specific (Freedman 2001). The NRC panel characterized DUs as generally flawed and in need of refinement, but noted that expressing uses as narrative rather than quantitative statements remains appropriate; they felt that use concepts such as "recreational support", "aquatic life support" or "fishable-swimmable" represent only a beginning of proper use definition (NRC 2001). Regional program staff have also commented that DUs are too vague, and in some cases aren't sensitive to downstream effects of an upstream use.

This is a need partially based on policy limitations (i.e. descriptions of uses could be better articulated) but also based on needing better underlying science supporting use designations. Some state DUs lack a written rationale for how and why the use was selected, a trait which does little to help evaluate DU suitability after the fact. EPA assistance to states in revisiting questionable DUs, refining them through more detailed scientific deliberation, and documenting the outcome and rationale would provide useful examples for other states that may need to do the same.

Meeting this need: The NRC panel called "tiered DUs" an essential step, claiming that there should be substantial stratification and refinement of uses with scientific, social and economic input about the desired state for each water body (NRC 2001). The establishment of more detailed, defensible use concepts clearly calls for a wide array of supporting science, into which ORD might contribute. Some appropriate research activities may include:

- study states that have begun to implement tiered DU concepts (e.g. Ohio) and develop a general or even regionalized guidance to help other states refine their aquatic life support uses;
- for state decisionmakers, facilitate DU development from the paradigm of social/ecological value > assessment endpoint > measurement endpoint, as in risk assessment's early stages
- continue/enhance the multidisciplinary component of the STAR grants Water and Watersheds research, where such grants may stimulate or support improved DUs;
- assist tribes with DU development related to their ceremonial uses;
- provide OW help on developing water supply DU targets/criteria;
- ORD scientists specializing in reference condition could analyze problematic DU's in connection to reference conditions as part of suggesting DU improvements;
- take a fresh look at Use Attainability Analysis methods development.

16. Assist states in translating narrative standards into numeric criteria.

Developing TMDLs based on narrative criteria in existing standards is a current and widespread challenge. Many water quality standards were set in the 1960s and need to be revisited, particularly relative to updating old, qualitative concepts with more recent quantitative science. The 1998 TMDL FACA report recommends that development of additional numeric criteria ranks among EPA's second-highest priorities for science and tool development (USEPA 1998). The uncertainties inherent in evaluating impairment qualitatively rather than quantitatively even affect the top three listed impairments (sediment, nutrients, and pathogens), which in many states have weak quantitative criteria. Over 10,000 TMDLs are scheduled to be done for clean sediments and nutrients, which are generally based on narrative translators. Moreover, flow and habitat impairments have no criteria or guidelines supported by EPA (Freedman 2001).

Among TMDL developers, numeric criteria are sometimes but not always preferred. Proponents note that a numeric criterion that is well-supported scientifically often simplifies the selection of TMDL targets and helps justify proposed allocation decisions. In fact, the opinion exists that narrative concepts cannot be translated and therefore TMDLs cannot be done for them. On the other hand, a generalized numeric criterion can overshadow local, reach-specific considerations for meeting water body-specific designated uses; in these situations, some prefer to apply their detailed local knowledge with the flexibility afforded by a narrative criterion. The concept of "translators" – methodologies to guide the calculation of site-specific numeric targets (not criteria) based on a given narrative standard – has potential to become a popular substitute for using rigid, pass/fail numbers in numeric criteria. This concept needs to establish a defensible track record, possibly with the help of EPA research, and be addressed in policy or guidance.

Meeting this need: As with the aforementioned designated uses and criteria needs, the underlying research opportunities are very broad and span a wide variety of impairment settings. Opportunities exist for ORD to develop projects of regional or national scope as well as participate with states in water body-specific efforts. For example, narrative/numeric translation support could include:

- working with states on continuing to refine or develop new numeric targets and translators for use with biological endpoints, sediment, and nutrients. In particular, ORD could continue work on the National Nutrient Strategy, which will result in ecoregion-based criteria for nutrients for lakes, rivers/streams, estuaries and coastal waters, and wetlands, and should collaborate on an effort to develop national sediment criteria similar to the above;
- developing the basis for numeric criteria on effluent-dominated streams, general guidance on quantifying odor and aesthetics, quantifying the relationship between fish advisories and appropriate numeric criteria, and numeric targets for contaminated sediment;
- developing the scientific arguments in favor of translators;
- quantifying the role of flow in relation to the effects on DUs from other criteria;
- testing common EPA-supported models against the predicted outcomes that would result from different numeric target alternatives;
- assisting OW in the narrative/numeric issues arising as part of the 60-day triennial reviews of state water quality standards.

17. Clarify and quantify selected parameters used in criteria definitions.

Many criteria incompletely reflect current scientific understanding of the stressors they address, particularly with regard to the complex behavior of certain pollutants through time. On this issue the NRC panel stated, "All chemical criteria and some biological criteria should be defined in terms of magnitude, frequency, and duration." Even beyond clarifying these three key parameters, criteria can and should go farther when necessary to establish a more reliable relationship between the designated use and the criterion meant to protect it. The temporal components of criteria are particularly good candidates for scrutiny, to determine whether concepts such as 5-day average, 4-day minimum, monthly average, "7Q10" and other semi-quantitative measures make ecological sense and are filling their intended purpose.

Incomplete treatment of all the terms of a criterion also has negative impacts on states' listing and delisting procedures and their use of defensible statistical methods *(see also needs 6 and 19)*. For example, some states use only instantaneous sample values without considering magnitude of exceedance, frequency, or duration, when evaluating whether 10% of samples exceed the criterion and a water body should be listed.

Meeting this need: ORD laboratories might consider projects that can:

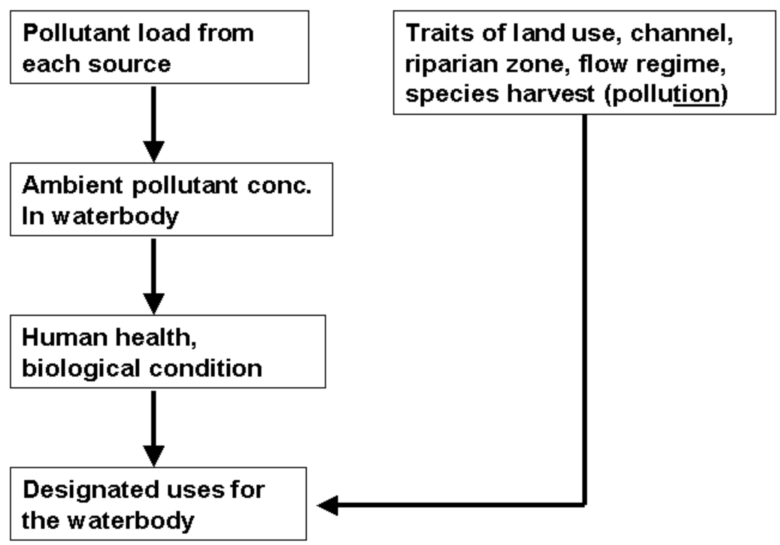
- compile regionalized literature syntheses on the complex, episodic behavior of all major stressors as a resource for state or EPA review and refinement of the duration and frequency components of criteria;
- assist state decisions on when standards are supposed to be met, at what flows, and determine how to technically translate the standards into TMDLs and permits and show examples (acute, chronic, numeric, criteria, narratives, daily average, uses);
- interpret standards for wet weather conditions (episodic flows, unique hydraulic regimes, etc.);
- provide data and methods on sediment lethality to biological life. Which is worse, for example – high concentration/short duration or long/lower concentrations?

18. Develop and improve biocriteria, address other criteria gaps, and evaluate the potential for ecological water quality standards.

Water quality standards establish the key environmental endpoints used to measure the success of Clean Water Act programs. The increasing complexity of water quality problems, however, has outpaced the ability of EPA and states to continually revise their standards and criteria and keep up with evolving science and implementation demands, including watershed-based TMDLs (USEPA 2002a). The earliest criteria of the 1970s focused narrowly on the predominant point source problems of the times, but today's water quality standards and criteria are expected to be relevant to a wide array of point and non-point sources and protective of complex aquatic ecosystems and multiple designated uses.

There are many different types of potential water quality criteria, only some of which have been used in water quality standards to indicate a breakpoint in conditions that no longer support a given designated use. Traditionally, chemical and physical criteria have predominated. The existing types of criteria vary significantly in their 'conceptual distance' from the pollutant source (NRC 2001) and from the designated uses they are intended to protect (see Figure 4). Greater distance from either end potentially implies increasing uncertainty, and thus different types of criteria have strengths and weaknesses relative to stressor sources or designated uses.

Figure 4. Potential types of water quality criteria relative to sources and designated uses (after NRC 2001).



One shortcoming of conventional water quality standards is their reliance on a numeric measure of one or a few parameters to represent, and be fully protective of, a highly complex and variable watershed ecosystem with multiple designated uses. To overcome this problem, EPA and many states have gradually continued to develop and add more varied criteria and explore methods for their joint application. The ***Draft Strategy for Water Quality Standards and Criteria*** lists "eco-criteria" to establish measures of watershed health and condition among its strategic actions for linking standards to watershed approaches at the state and local levels (USEPA 2002a). An important current emphasis in EPA and many states is on developing biocriteria to complement existing chemical criteria. Other current advances in more ecologically relevant physical criteria include the development of habitat and sediment criteria.

An alternative to the approach of gradually adding more types of criteria is to explore the concept of ecological water quality standards. These might be arrived at eventually through accumulating a sufficiently comprehensive variety of criteria types and focusing on developing methods for applying them. Alternatively, ecological standards could be approached by design as a holistic reinvention of water quality standards from the ground up in an effort to better protect complex natural systems and beneficial uses. Both approaches merit significant exploration by ORD and OW together.

There is a growing interest in biocriteria among many states, and EPA guidance recommending bioassessment dates back ten years. Biota are affected by and respond to the sum total of chemical, physical, and biological factors in their environment (Bauer and Ralph, 2001), and thus biological measurements are more often suitable for indicating water body condition than chemical parameters alone

(NRC, 2001). Yet, the NRC panel also noted that biocriteria are not as informative about the pollutant sources, and whereas they may tell more about the impairment they may reveal less about potential control at the source. They suggested that using multiple types of criteria in assessment could compensate for the weaknesses in a criterion used alone, specifically recommending that, "Biological criteria should be used in conjunction with physical and chemical criteria to determine whether a waterbody is meeting its designated use" (NRC, 2001). EPA regional feedback has placed biocriteria development among states' greatest needs for new criteria and pathogen criteria among the most in need of refinement (USEPA, 2001d).

Meeting this need: The research opportunities below are summarized as they relate to ecological water quality standards, criteria development or refinement in general, or to biocriteria specifically.

- *Ecological Water Quality Standards.* Whether assuming that ecological standards might be addressed by accumulating diverse criteria or by a wholesale reinvention of water quality standards, a significant effort by researchers is warranted to evaluate standards' ability to protect watershed ecosystems and their uses. In either case, such efforts would need to start with a sound, science-based concept of watershed condition, addressed by focusing on relevant watershed processes and the beneficial uses derived from fully functional watersheds. Clearer relationships between watershed processes and better-defined designated uses can probably be identified, regardless of whether these are ecological or human-use oriented. These relationships should provide a better basis for selecting suites of appropriate criteria and selecting consistently applicable measurement protocols. In particular, ecological standards would go beyond biocriteria alone and also integrate abiotic characteristics such as sediment dynamics, channel structure and function, flow and habitat. Further, the links from these criteria and measures to sources of specific stressors should be evaluated for their potential to support management plans and restoration decisions.

Another approach to ecological standards would develop holistic system-level indicators of ecosystem health, to determine the ecological integrity of the entire system instead of assessing its parts independently. EPA started exploring the concept of ecological integrity and its application to the physical, chemical, and biological components of aquatic ecosystems in a symposium held shortly after the passage of the Federal Water Pollution Control Act Amendments of 1972. A conclusion from the symposium was that ecological integrity applies to whole ecosystems and cannot be easily assigned to the separate components. Ecological integrity can be defined as a condition of ecosystems that is fully developed when the network of biotic and abiotic components and processes is complete and functioning optimally (Campbell, 2000). A system-level approach was developed for Green Bay,Wisconsin by identifying ecosystem properties (structural and functional) that served as operational guides for the management of the Bay (Harris, et al., 1987). Hagy et al. (2001) use steady-state trophic network models and indicators to assess the effects of nutrient enrichment on food webs in Chesapeake Bay by comparing them to reference trophic networks. Campbell (2000) used energy systems theory to assess ecological integrity of *Spartina alterniflora* marsh ecosystems affected by hot water effluent and control ecosystems in Crystal River, Florida. The Science Advisory Board (2002) recommends a framework of essential ecological attributes for assessing ecological condition in a systematic way across regions. EPA researchers could contribute to protecting entire ecosystems by supporting development of system-level indicators for use as ecological standards.

In revising or reinventing designated uses, criteria, and measurement protocols, researchers could also make significant contributions by highlighting advances in watershed science and the role of newer tools in landscape modeling. The case study approach could be used in significantly different watersheds to gain insight into the sufficiency of current assemblages of criteria vs. a reinvented standards concept. Ultimately the potential of ecological standards may be clearer relationships between uses, criteria, stressors, and the key features of sustainable watershed ecosystems upon which the designated uses depend.

- *General.* Other criteria development and refinement needs concern clean sediment dynamics (a current OW priority); riparian habitat measures; flow issues; translation of fish advisories' relationship to numeric criteria; marine and estuarine water quality standards such as marine DO and nutrients, coral reef-related standards; water quality standards for intermittent streams; wildlife and invasive species, wetlands, pharmaceuticals and new chemicals (USEPA, 2001a). According to states, chemical water quality criteria to protect aquatic life and human health are good but need to cover some new chemicals. Other needs include numeric criteria related to nutrients, source water contaminants, sediment, wildlife, habitat and endangered species (USEPA2000b). From the OW water quality standards strategy fact sheet (USEPA, 2001b), the following initial strategic directions center on prioritized work plans for criteria, analytical methods, and water quality standards policy and technical guidance for the next 5-7 years that reflect the most important environmental results sought. The specifics on criteria include:

- develop additional guidance and new ecoregional and waterbody type-specific documents for nutrient criteria and for bacteria criteria;
- implement the waterborne microbial disease strategy;
- update parts of aquatic life criteria methodology, develop new and revised aquatic life criteria for approximately 10 pollutants;
- technical guidance for implementing new and revised human health criteria
- additional guidance for contaminated sediment, wetlands, wildlife criteria;
- update analytical methods to enable detection of ambient concentrations at criteria levels, for new and existing criteria as needed;
- develop clean sediment criteria as related to aquatic life effects;
- establish a joint OST-OGWDW work plan for 304(a) criteria that protect consumers of drinking water.

- *Biocriteria.* EPA researchers should support and participate in the ongoing bioassessment program framework development effort, which engages many states and academic experts including ORD participation. EPA labs could:

- become involved in state-level biocriteria development efforts;
- develop databases for water quality managers that will aid the development and use of bioassessment;
- develop diagnostic indicators of biological impairment;

- continue to develop stressor identification guidance to explain relationships between biological endpoints and pollutants that can be addressed by TMDLs;
- assist OW in developing additional biocriteria technical guidance (statistics, large rivers, wetlands, coral reefs) and implementation assistance (streams and small rivers implementation, guidance for tiered aquatic life uses) (USEPA, 2001b);
- a dialogue on the concept of ecological criteria should be initiated, given the limits of existing types of criteria alone and their potential when considered together.

19. Evaluate defensible scientific standards for listing and de-listing.

Listing and delisting share many of the criteria-related science needs discussed under numbers 13 through 18. Specifically, the NRC panel's recommendation of a two-part impaired waters list (preliminary and final lists) has implications for monitoring research, sampling methods development and statistical analysis, usually occurring in a data-limited environment. November 2001 TMDL and monitoring program integrated guidance (USEPA 2001g) does outline a framework along which states may partition their lists based on data availability, quality, and other considerations.

Some states are taking steps to change their listing procedures, either through use of a two-part list or through more specific requirements for listing. Some states separate their "planning" list and "verified" list on the basis of number and frequency of samples, thresholds (of samples in exceedance), and monitoring requirements. The recent EPA national guidance on integrated monitoring and listing also addresses a general framework for multi-part listing. Improvements in listing can also be based on data quality, trained assessors, and magnitude of exceedances. Despite some improvements, there continue to be numerous opportunities for use of existing statistical methods capable of reliable detection of impairments using existing data.

Meeting this need: A number of factors might strengthen the scientific basis for listing and delisting:

- statistical guidance on appropriate methods for making scientifically defensible listing decisions may be the most widespread need;
- methods for using multiple lines of evidence in making listing decisions (e.g. combining bioassessment with chemical assessment) when each exhibits different sensitivities;
- improving the data collection analysis for flow as it affects exceedances of other pollutant criteria;
- specific case studies to improve the steps for listing and delisting relative to fish tissue advisories;
- relate statistical methods in uncertainty analysis *(see #6)* to listing as well as to modeling; and
- explore the use of models that can fill data gaps to increase preliminary listing accuracy despite limited data (NRC 2001).

20. Improve support for protecting unimpaired waters from degradation.

At the 2001 EPA TMDL/NPS/Monitoring regional Coordinators' meeting a senior manager called protecting unimpaired waters "the other half of the big job we face [in addition to restoring impaired waters]" (USEPA 2001a). States and EPA face challenges in:

- how to integrate protection of healthy waters with restoring impaired waters;
- how to balance protection priorities with restoration priorities;
- how to monitor threatened waters in particular; and
- how to take protective actions that are soundly defensible in science.

In addition, implementing antidegradation – the third element of water quality standards that guards against further decline in water quality – remains an area in which states request more guidance and technical assistance (USEPA 2000b, USEPA 2001a, USEPA 2001d). Yet another concern is whether the magnitude of the problems facing impaired waters may overshadow protection of healthy but threatened waters.

Two premises largely define the challenge to take scientifically defensible actions in protecting waters in good condition. First, it is most evident in unimpaired waters that these are functional, natural systems whose management and protection must stem from the maintenance of their natural processes to preserve the benefits we gain from them. Second, it is evident that the Clean Water Act tools for protection and their supporting science base both need to be improved in order to support systems-ecology-based watershed management and protection. These closely linked research and policy needs call for EPA's water and research programs to address them jointly and comprehensively, from revisiting water quality standards from the ground up through implementation and long term evaluation of management plans.

Meeting this need: ORD already contributes to the scientific basis for protection of watershed ecosystems through extensive research in watershed and aquatic ecosystem natural processes. These research activities help justify water body protection and restoration generally by increasing the state of our understanding of valuable ecological goods and services from the nation's waters and watersheds, and specifically by revealing how ecological processes support the designated uses that drive water regulations. Research possibilities related to the challenges above are:

- *integrating protection and restoration*. Work with regions and states on program strategies that are sensitive to overall condition, not protection or restoration alone; include economic/social factors as well as human health and ecology in various strategies; take part in pilot projects that address antidegradation in whole-watershed TMDLs that have some unimpaired segments.

- *setting and balancing priorities*. Establish sound methods and data to support regional-scale critical ecosystem protection, which is already gaining popularity in several regions as an essential part of doing EPA business; work with states on the basis for priority setting strategies; demonstrate strengths and gaps of priority-setting options available; provide decision tools for setting priorities; emphasize strategies that merge protection and restoration, resulting in the best condition for the most resources;

document the scientific rationale underlying any priority-setting tools that are made available.

- *monitoring threatened waters.* Develop efficient methods to verify existing designated use support under several common threat settings (e.g., how should states monitor for aquatic life support in mid-western agriculture-dominated watersheds); sampling design considerations for threatened waters; work with OW on developing scientifically stronger antidegradation guidance; improve indicators' sensitivity to onset, trajectory of change and early stages of common types of impairment.

- *scientific support for protective actions*. Reduce uncertainty about thresholds for impairment by better relating ecological process and changes to specific designated uses; build weight of evidence for how common impairments progress through stages; use the above in decision support tools that address relevant lines of evidence and supporting statistics as available.

References

Bauer, S.B. and S.C. Ralph. 2001. Strengthening the use of aquatic habitat indicators in Clean Water Act programs. In: *Fisheries* 26 (6):14-24.

Brown, B.S., N. Detenbeck and R. Eskin. 2002. Integrating 305(b) and 303(d): how EMAP aids in monitoring and assessment of state waters. In: *Environmental Monitoring and Assessment* (in review).

Campbell, D.E. 2000. Using Energy Systems Theory to Define, Measure, and Interpret Ecological Integrity and Ecosystem Health. In: *Ecosystem Health* 6(3):181-204.

Chadderton, R.A., A.C. Miller and A. J. McDonnell. 1981. Analyses of Waste Load Allocation Procedures. In: *Water Resources Bulletin* 17(5):760-766.

Freedman, P. 2001. The CWA's New Clothes. In: *Water Environment & Technology* 13(6): 28-32.

Hagy, J.D., W.R. Boynton, W.M. Kemp, R.E. Ulanowicz. 2001. Effects of Hypoxia on Food Web Structure and Efficiency During Summer in Mesohaline Chesapeake Bay: An Assessment Using Network Analysis. In: *ERF 2001 Conference Abstracts,* p. 54.

Harris, H.J., P.E. Sager, S. Richman, V.A. Harris, and C.J. Yarbrough. 1987. Coupling Ecosystem Science with Management: A Great Lakes Perspective from Green Bay, Lake Michigan, USA. In: *Environmental Management* 11(5); 619-625.

Mehaffey, M.H., Nash, M., Wade, T.G., Edmonds, C.M., Ebert, D.W., Jones, K.B., and Ragar, A. 2001. A Landscape Assessment of the Catskills/Delaware Watersheds, 1975-1998: New York City's Water Supply Watersheds. EPA/600/R-01/075. United

States Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Las Vegas, NV.

National Research Council (NRC). 2001. Assessing the TMDL Approach to Water Quality Management. Washington, DC: National Academy Press. 109 pp.

Rankin, E.T. and C.O. Yoder. 1990. A comparison of aquatic life use impairment detection and its causes between an integrated, biosurvey-based environmental assessment and its water column chemistry subcomponent. Ohio Water Resource Inventory (Volume I). Columbus, OH: Ohio EPA, Division of Water Quality Planning Assessment.

Science Advisory Board. 2002. A Framework for Assessing and Reporting on Ecological Condition. Washington, DC: US Environmental Protection Agency, Science Advisory Board (unpublished draft, online at http://www.epa.gov/sab).

Smith, J. H., J.D. Wickham, D.J. Norton, T.G. Wade and K.B. Jones. 2001. Utilization of landscape indicators to model potential pathogen-impaired waters. In: *J. Amer. Water Res. Assn.* 37 (4), 805-814.

US Environmental Protection Agency (USEPA). 1998. Report of the FACA Committee on the TMDL Program. EPA-100-R-98-006. Washington, DC: US Environmental Protection Agency, Office of the Administrator.

USEPA. 2000a. Strategic Plan for TMDL Technical Support (unpublished draft). Washington, DC: US Environmental Protection Agency, Office of Water.

USEPA. 2000b. Perceptions on TMDL Technical Support: Input from State, EPA, Discharger Organizations and Clean Water Action Network. In: Strategic Plan for TMDL Technical Support (unpublished draft). Washington, DC: US Environmental Protection Agency, Office of Water.

USEPA. 2001a. Annual Meeting of EPA Regional Water Quality Program Coordinators (meeting notes, unpublished). Albuquerque, NM: US Environmental Protection Agency, Office of Water.

USEPA. 2001b. Strategy for Water Quality Standards and Criteria (draft fact sheet, October 2001, unpublished). Washington, DC: US Environmental Protection Agency, Office of Water.

USEPA. 2001c. Stressor Identification Guidance Document. EPA/822/B-00/025. Washington, DC: US Environmental Protection Agency, Office of Research and Development and Office of Water.

USEPA. 2001d. Survey of Office of Water Headquarters and Regional TMDL Research Needs (unpublished). Albuquerque, NM: US Environmental Protection Agency, Office of Research and Development.

USEPA. 2001e. Water Quality Multi-Year Research Plan. Washington, DC: US Environmental Protection Agency, Office of Research and Development (internal planning document).

USEPA. 2001f. Aquatic Stressors Framework. Washington, DC: US Environmental Protection Agency, Office of Research and Development (internal planning document).

USEPA. 2001g. November 19, 2001 guidance, 2002 Integrated Water Quality Monitoring and Assessment Report Guidance. Unpublished program guidance, online at http://www.epa.gov/owow/tmdl

USEPA. 2002a. Draft Strategy for Water Quality Standards and Criteria: Strengthening the Foundation of Programs to Protect and Restore the Nation's Waters. EPA-823-R-02-001; Washington, DC: US Environmental Protection Agency Office of Water, Office of Science and Technology.

USEPA 2002b. The TMDL Tracking System. USEPA website at http://www.epa.gov/owow/tmdl

Wickham, J.D., Wade, T.G., Riitters, K.H., O'Neill, R.V., Smith, J.H., Smith, E.R., Jones, K.B, and Neale, A.C. 2002. The effect of risk propagation and scale on use of nutrient export coefficients for watershed management. In: *Landscape Ecology,* accepted (pending revision).

Appendix A:
A Brief History of TMDL Milestones

• **1972**: Clean Water Act enacted with Section 303(d) calling for state lists of impaired waters (those not attaining water quality standards) and development of a Total Maximum Daily Load for the pollutant causing the impairment.

• **1985**: First regulations issued, which included nonpoint source pollutants and load allocations within the TMDL.

• ***1992***: Revised TMDL regulations published in Federal Register requiring state lists every two years. This is the rule that still effectively guides the TMDL program today.

• ***Mid-1990s:*** A growing number of lawsuits against EPA are filed, most charging that states were not developing lists quickly enough and that EPA was not fulfilling its obligation to get the state lists and to backstop states by developing lists and TMDLs when a state failed to do so.

• ***Mid- to late-1990s:*** Many settlement agreements concerning the above lawsuits commit EPA to work with states in developing thousands of TMDLs

• ***Late 1990s:*** An EPA-funded FACA group studies the TMDL program and makes recommendations to revise the regulations under which the program operates.

• ***1998:*** In the latest biennial section 303(d) listing of their impaired waters needing TMDLs, states report that approximately 20,000 water bodies nationwide are impaired, requiring development of an estimated 40,000 TMDLs.

• ***1998 - 2000:*** Based on FACA group recommendations, EPA develops a revised TMDL rule (referred to below as 'the 2000 rule').

• ***July 2000:*** Congress prohibits EPA's implementation of the rule through October 2001. The 1992 TMDL regulation is the authority for continued operation of the TMDL program.

• ***June 2001:*** National Research Council (NRC) issues a report to Congress on the 2000 rule and the TMDL program after their review.

• ***August 2001:*** EPA proposes to delay the effective date of the rule for 18 months. A final rule delaying the effective date is expected sometime before the end of October. The NRC recommendations will be studied at the same time there is a public process to consult with all interested parties.

• ***October 2001:*** EPA Administrator Christine Todd Whitman signs a final rule establishing April 30, 2003 as the effective date of the 2000 rule. Having already undertaken a broad public process to determine what substantive changes should be made to the 2000 rule and to the TMDL program as a whole, EPA expects to make decisions regarding these changes over the next 18 months. In the interim, EPA and the states will continue to identify impaired waters and develop TMDLs under existing regulations.

Appendix B

Overview of the Current Total Maximum Daily Load (TMDL) Program and Regulations

The Need: Quality of Our Nation's Waters

Over 40% of our assessed waters still do not meet the water quality standards states, territories, and authorized tribes have set for them. This amounts to over 20,000 individual river segments, lakes, and estuaries. These impaired waters include approximately 300,000 miles of rivers and shorelines and approximately 5 million acres of lakes -- polluted mostly by sediments, excess nutrients, and harmful microorganisms. An overwhelming majority of the population - 218 million - live within 10 miles of the impaired waters.

Section 303(d) of the Clean Water Act

Under section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters.

What is a TMDL?

A TMDL specifies the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and allocates pollutant loadings among point and nonpoint pollutant sources. By law, EPA must approve or disapprove lists and TMDLs established by states, territories, and authorized tribes. If a state, territory, or authorized tribe submission is inadequate, EPA must establish the list or the TMDL. EPA issued regulations in 1985 and 1992 that implement section 303(d) of the Clean Water Act - the TMDL provisions.

Litigation

While TMDLs have been required by the Clean Water Act since 1972, until recently states, territories, authorized tribes, and EPA have not developed many. Several years ago citizen organizations began bringing legal actions against EPA seeking the listing of waters and development of TMDLs. To date, there have been about 40 legal actions in 38 states. EPA is under court order or consent decrees in many states to ensure that TMDLs are established, either by the state or by EPA.

<u>EPA Actions to Implement the TMDL Program</u>

Federal Advisory Committee

In an effort to speed the Nation's progress toward achieving water quality standards and improving the TMDL program, EPA began, in 1996, a comprehensive evaluation of EPA's and the states' implementation of their Clean Water Act section 303(d) responsibilities. EPA convened a committee under the Federal Advisory Committee Act, composed of 20 individuals with diverse backgrounds, including agriculture, forestry, environmental advocacy, industry, and state, local, and tribal governments. The committee issued its recommendations in 1998.

The July 2000 TMDL Rule

These recommendations were used to guide the development of proposed changes to the TMDL regulations, which EPA issued in draft in August, 1999. After a long comment period, hundreds of meetings and conference calls, much debate, and the Agency's review and serious consideration of over 34,000 comments, the final rule was published on July 13, 2000. However, Congress added a "rider" to one of their appropriations bills that prohibited EPA from spending FY2000 and FY2001 money to implement this new rule until October 2001. In October, the EPA Administrator signed a final rule establishing April 30, 2003 as the effective date of the 2000 rule. Having already undertaken a broad public process to determine what substantive changes should be made to the 2000 rule and to the TMDL program as a whole, EPA expects to make decisions regarding these changes over the next 18 months. In the interim, EPA and the states will continue to identify impaired waters and develop TMDLs under existing regulations.

Current TMDL Program

The current rule remains in effect until 30 days after Congress permits EPA to implement the new rule. TMDLs continue to be developed and completed under the current rule, as required by the 1972 law and many court orders. The regulations that currently apply are those that were issued in 1985 and amended in 1992 (40 CFR Part 130, section 130.7). These regulations mandate that states, territories, and authorized tribes list impaired and threatened waters and develop TMDLs.

Overview of the 1992 TMDL Regulations, Under Which the Current Program Operates

- ***Scope of Lists of Impaired Waters***
  States, territories, and authorized tribes must list waters that are both impaired and threatened by pollutants.
  The list is composed of waters that need a TMDL.
  At the state's, territory's, or authorized tribe's discretion, the water body may remain on the list after EPA approves the TMDL, or until water quality standards are attained.
- ***2-Year Listing Cycle***
  States, territories, and authorized tribes are to submit their list of waters on April 1 in every even-numbered year, except in 2000. In March 2000, EPA issued a rule removing the requirement for the 2000 list - though some states are choosing to submit such lists on their own initiative.
- ***Methodology Used to Develop Lists***
  States, territories, and authorized tribes must consider "all existing and readily available water quality-related information" when developing their lists.
  Monitored and evaluated data may be used.

The methodology must be submitted to EPA at the same time as the list is submitted.

At EPA's request, the states, territories, or authorized tribes must provide "good cause" for not including and removing a water from the list.

- ***Components of a TMDL***

  A TMDL is the sum of allocated loads of pollutants set at a level necessary to implement the applicable water quality standards, including -

  Wasteload allocations from point sources, and

  Load allocations from nonpoint sources and natural background conditions.

  A TMDL must contain a margin of safety and a consideration of seasonal variations.

- ***Priorities/Schedules for TMDL Development***

  States, territories, and authorized tribes must establish a priority ranking of the listed water bodies taking into account the severity of pollution and uses to be made of the water, for example, fishing, swimming, and drinking water.

  The list must identify for each water body the pollutant that is causing the impairment.

  States, territories, and authorized tribes must identify waters targeted for TMDL development within the next 2 years.

- ***Public Review/Participation***

  Calculations to establish TMDLs are subject to public review as defined in the state's continuing planning process.

- ***EPA Actions on Lists and TMDLs***

  EPA has 30 days in which to approve or disapprove a state's, territory's, or authorized tribe's list and the TMDLs.

  If EPA disapproves either the state's, territory's, or authorized tribe's list or an individual TMDL, EPA has 30 days to establish the list or the TMDL. EPA must seek public comment on the list or TMDL it establishes.

- ***1997 Interpretative Guidance for the TMDL Program (additional guidance on listing is under development)***

  EPA issued guidance in August 1997 to respond to some of the issues raised as the program developed. The guidance includes a number of recommendations intended to achieve a more nationally consistent approach for developing and implementing TMDLs to attain water quality standards. These recommendations include:

  \- States, territories, and authorized tribes should develop schedules for establishing TMDLs expeditiously, generally within 8-13 years of being listed. EPA Regions should have a specific written agreement with each state, territory or authorized tribe in the Region about these schedules. Factors to be considered in developing the schedule could include:

  - Number of impaired segments;
  - Length of river miles, lakes, or other water bodies for which TMDLs are needed;
  - Proximity of listed waters to each other within a watershed;
  - Number and relative complexity of the TMDLs;

- Number and similarities or differences among the source categories;
- Availability of monitoring data or models; and
- Relative significance of the environmental harm or threat.

- States, territories, and authorized tribes should describe a plan for implementing load allocations for waters impaired solely or primarily by nonpoint sources, including -
  - Reasonable assurances that load allocations will be achieved, using incentive-based, non-regulatory or regulatory approaches. TMDL implementation may involve individual landowners and public or private enterprises engaged in agriculture, forestry, or urban development. The primary implementation mechanism may include the state, territory, or authorized tribe section 319 nonpoint source management program coupled with state, local, and federal land management programs and authorities,
  - Public participation process, and
  - Recognition of other watershed management processes and programs, such as local source water protection and urban storm water management programs, as well as the state's section 303(e) continuing planning process.

Appendix C:
"Tech Loops,"
A Networking Resource for ORD, OW and Regional Collaboration

A **Tech Loop** is simply a list of the EPA/OW, ORD, and regional personnel working on or interested in a specific, water quality-related or TMDL-related scientific topic. About 20 Tech Loops (below) were compiled to help staff within EPA network with others working on the same water quality issues. This idea originated as a way to help TMDL-related networking within EPA by providing all the people active in an issue area a pre-made email distribution list accessible to anyone in EPA through EPA's Lotus Notes Domino Directory.

The main purpose is to provide a quick contact source for anyone in EPA who:

- encounters a science issue and wants to discuss others' experiences
- needs sound scientific advice or insights on a specific topic
- wants to suggest a research idea or support need concerning the topic
- has relevant material to share and distribute (e.g., via email distribution list)
- wants to invite the right people for a given issue to an Agency-wide activity

Tech Loops available in the Lotus Notes Domino Directory
(each directory entry is a one-word name that begins with the prefix "techloop-")

based on top impairments		***based on TMDL process***
nutrients	**pathogens**	**modeling**
water temperature	**bio-impairment**	**restoration/BMPs**
metals	**habitat impairment**	**targets/endpoints**
pH	**invasive species**	**economics/trading**
flow	**pesticides**	**sources/diagnostics**
ammonia	**mercury**	**listing/delisting**
clean sediment	**contam. sediment**	

Why are Tech Loops needed? Keeping everyone informed is a constant challenge in a busy agency. Most EPA staff face tough choices between becoming involved in 'yet another team or task' and accomplishing the substantial work already on their plates. Membership in working groups, teams, etc. often incompletely reflects the people involved in a given issue throughout the Agency. As a result, an individual's decision to limit their meetings, calls and other group activities can sometimes leave them 'out of the loop' on information for an area of interest.

Tech Loops are intended to address this problem by providing a way to improve the reach of information while minimizing time demand. Tech Loops are not new workgroups or teams, nor do they duplicate these units. For example, a Tech Loop for a topic with an existing workgroup would include all its members plus several others who have enough interest or involvement in the topic to want to be listed, and kept informed. Where a group exists, Tech Loops facilitate networking among the immediate working group and an outer circle of people interested in their work. Where no group currently exists, a Tech Loop can help individuals share information and work together individually without a formal and more time-consuming structure.

What information is compiled in a Tech Loop? A Tech Loop will list only a member's name and Office or Regional affiliation; more can be found via Lotus directories if needed. Among the people listed, one initial point of contact each from ORD and from OW or a region is identified for each Tech Loop; these would be people very involved in the topic's research or application. These POCs would occasionally update the list with added/deleted names as needed. A Loop may decide to have everyone write briefly how they work with the topic, have conference calls, or other activity, but this is up to the Loop's members.

Tech Loop Points-of-Contact: Each Tech Loop contact list has one point of contact for ORD and one for OW/regions. These are individuals who have a higher involvement or interest in the subject and have agreed to be a POC for their subject area. Thus they represent a good starting point for anyone seeking more specific information than could be posed in an email to the whole list in general. There are no specific duties linked to the POC role, but POCs are requested to update their contact list from time to time as needed.

Tech Loop Subject	*ORD contact*	*OW/REG contact*
clean sediment	**Joe Williams, NRMRL (Ada OK)**	**Bill Swietlik, OST(DC)**
contam. sediment	**Walter Berry, NHEERL (Narragansett RI)**	**Heidi Bell, OST (DC)**
nutrients	**Marie O'Shea, NRMRL (Edison NJ)**	**Bob Cantilli, OST (DC)**
water temperature	**Steve McCutcheon, NERL (Athens GA)**	**Doug Norton, OWOW (DC)**
bio-impairment	**Susan Cormier, NERL (Cincinnati OH)**	**Bill Swietlik, OST (DC)**
habitat impairment	**Bob Lackey, NHEERL (Corvallis OR)**	**Doug Norton, OWOW (DC)**
metals	**Dave Mount, NHEERL (Duluth MN)**	**Cindy Roberts, OST (DC)**
invasive species	**Henry Lee, NHEERL (Newport OR)**	**John Heisler, OWOW (DC)**
pH	**Roger Wilmoth, NHEERL (Duluth MN)**	**Mary Beck, Region 3**
pesticides	**Ann Pitchford, NERL (Las Vegas NV)**	**Dave Macarus, Region 5**
flow	**Iris Goodman, NERL (Las Vegas NV)**	**Christine Ruf, OWOW (DC)**
mercury	**Teri Richardson, NRMRL (Cincinnati OH)**	**Ruth Chemerys, OWOW (DC)**
ammonia	**Russ Erickson, NHEERL (Duluth MN)**	**Brian Thompson, Region 5**
pathogens	**Yolanda Olivas, NRMRL (Ada OK)**	**Robin Oshiro, OST (DC)**
modeling	**Bob Ambrose, NERL (Athens GA)**	**Russ Kinerson, OST (DC)**
restoration/BMPs	**Tim Canfield, NRMRL (Ada OK)**	**John McShane, OWOW (DC)**
economics/trading	**Randy Bruins, NCEA (Cincinnati OH)**	**Bill Painter, OWOW (DC)**
targets/endpoints	**Anne Sergeant, NCEA (Wash DC)**	**Marge Wellman, OST (DC)**
sources/diagnosis	**Sue Norton, NCEA (Wash DC)**	**Doug Norton, OWOW (DC)**
listing/delisting	**Charles Stephan, NHEERL (Duluth MN)**	**Mike Haire, OWOW (DC)**

Appendix D:
Website Information Useful in Tracking the TMDL Program

OW maintains the following website to help ORD track recent guidance, TMDL needs, and watershed issues:

• **WATERS – Watershed Assessment, Tracking and Environmental Results System**: is an integration of current OW water quality database systems and tracking tools, all geosynched through the National Hydrography Dataset and searchable. http://www.epa.gov/waters/

• **CALM (Consolidated Assessment and Listing Methodology)** newest monitoring guidance available at http://www.epa.gov/owow/monitoring/calm.html

• **Non-Point Source 319 program** newest guidance available at http://www.epa.gov/owow/nps/Section319/fy2002.html

• **2002 Integrated Water Quality Monitoring and Assessment Report Guidance:** Integrated guidance for 2002 305(b) and 303(d) lists, available at http://www.epa.gov/owow/tmdl/2002wqma.html

• **The TMDL Tracking System** provides states and EPA with a comprehensive system for tracking listed waters and TMDLs and obtaining information for review and management of information and for comparisons. It doesn't appear to be a database to the user. Rather it is a Graphic User Interface that directly hits the data and creates outputs. The following links exemplify the system's features:

- http://www.epa.gov/owow/tmdl/ (Main TMDL home page) This is the general public site which doesn't look or feel much like a database (intentionally); however, it is hitting off the TMDL tracking system as you click into the national, state or regional reports. From there you can drill down to individual listings or TMDLs. Within this site there are some additional neat features:
- http://www.epa.gov/waters/tmdl/tmdl_document_search.html This site can help you search several hundred electronic versions of TMDL reports (many have multiple pollutant-water body combinations addressed / TMDLs within one report) via whole text/keyword searches.
- To see high resolution interactive maps of listed waters, you must enter an enviromapper session (available from the watershed reports) then drill down to a ~15m resolution and turn on the impaired waters coverages. We are working on this tool; however, it does get us one step closer to an internet based mapping tool not available to average users. Using this tool, you will NOT be able to see impaired waters at a county/state or large watershed level; it's like bird watching with a high powered telescope. For example: http://map8.epa.gov/scripts/.esrimap?name=NHDMapper&Cmd=ZoomInByCat&qc=3&th=6&lc=002200022_&fipsCode=02070010

- http://intranet.epa.gov/waters/tmdl/tmdl_index.html (Intranet version) The actual database is housed internally on the inTRAnet for security purposes. The inTERnet version cited as the TMDL home page (above) is refreshed on a nightly basis to keep it current and available to the public. From the Intranet version you can access more information.
- http://intranet.epa.gov/waters/tmdl/training/ This is a training page to provide users with an overview of the system and links to documentation, structure diagrams, and lastly a link to a play version of the database which users can try before they start inputting data to the live real version. The password and user ID for this practice system are regX/regX where X is a regional number.

Publication Number EPA841-B-02-002, July 2002
also online at *http://www.epa.gov/owow/tmdl/techsupp.html*

Assessment and Watershed Protection Division (4503T)
Office of Wetlands, Oceans and Watersheds, USEPA
1200 Pennsylvania Ave NW
Washington, DC 20460