

*Background Report
and Draft Strategy*

**The District Role
in
Watershed Management
Research**

Ramsey-Washington Metro Watershed District

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Introduction

The Board has recognized that the field of stormwater management is a science, but that it has a number of specific areas where the “science” has not been perfected. The state of the practice of stormwater management is often required to move forward with “best professional judgment” while collecting data and new research to refine our approach and develop new technologies. We recognize that more information is needed to answer many of the difficult management issues and to guide effective decision making.

This paper was initiated to address concerns raised by the Board of Managers and staff regarding the role of the District in completing or sponsoring watershed management research. In an effort to help define the current status of stormwater research, District staff conducted a literature search on existing research efforts to identify existing research projects and programs and also to identify research needs and gaps. This paper and the attachments provide this information. The District contracted with Brooke Asleson in the fall of 2007 to provide the information on current research programs and projects and summarize identified research needs.

The identified objectives of this report are to:

1. Review and summarize the major stormwater and watershed research efforts in the U.S. and Minnesota.
2. Identify ongoing local research efforts (organizations and programs) and any programs that are new (start-up efforts/programs, e.g., Mississippi WMO and Minnehaha Creek WD joint research grant program).
3. Review and summarize Minnesota Watershed Management research needs and identify source of identified need.
4. Identify research gaps in existing programs or shortcomings of the programs when reviewed against identified and proposed Minnesota Watershed Research needs.
5. Discuss research needs that are clearly in the interest of the RWMWD.
6. Develop a proposed RWMWD research strategy for consideration by the Board of Managers, i.e., what type and scope of research should be funded by the District, what research should be cost-shared with other research institutions or organizations, and what type and scope of research should be completed or funded by other organization and institutions.
7. Develop recommendations to be shared with a larger audience of stormwater and watershed management professionals to encourage or promote a systematic and sustainable research program that addresses research gaps and future new issues.

Based on this paper and the attached research summaries, the last section of this paper provides a draft District research strategy for Board discussion. Staff recommends that this paper and the draft strategy be distributed to other watershed management professionals and policy makers to collect comments and opinions prior to taking any final action.

It was my assumption in preparing this report that the District Board of Managers is very interested in continuing to complete and sponsor watershed management research. Based on that assumption, the intent of this report is to provide the Board and staff with information to help develop a strategy to guide District budgeting and research investment. The intent would be for

this strategy to be adaptable to reflect new research findings and shifts in future research priorities.

Summary of Major Stormwater Research

National Efforts

There are several nation-wide research groups conducting on-going stormwater research, two note-worthy organizations are the Center for Watershed Protection (CWP) and the Low Impact Development (LID) Center. In September of 2007 CWP updated their *National Pollutant Removal Database* to include 27 additional studies published through 2006. The updated database was analyzed to determine the median and quartile removal values for each group of stormwater BMPs and various stormwater pollutants. The continued use and update to this database will be invaluable to the stormwater community. There are other on-going projects such as the development of a *Stormwater Maintenance Manual* which will result in a set of web-based tools to assist communities develop maintenance programs and will be a great resource for stormwater practitioners.

The LID Center currently has several published materials available such as the document *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows* which is a policy guide for decision makers on how to use green infrastructure. There are also reports on projects aimed at determining the feasibility of incorporating sustainable development strategies into developments such as the *Arthur Capper Hope VI Housing Study* and *Low Impact Development for Big Box Retailers*. Another publication from the LID Center which may be valuable research is the *Evaluation of Best Management Practices for Highway Runoff Control*.

There are currently several stormwater research facilities through University programs which have and continue to conduct stormwater research which has relevance to Minnesota's research objectives: University of New Hampshire (UNH) Stormwater Center, Villanova Urban Stormwater Partnership (VUSP), and The Cooperative Institute for Coastal and Estuarine Technology (CICEET) just to name the larger programs. VUSP and UNH Stormwater Center both have demonstration sites constructed for the purpose of research on stormwater BMPs and will provide water quality performance and stormwater volume reduction rates for various rainfall events as well as long-term efficiency and design improvements. The CICEET on-going and completed projects include those evaluating stormwater BMP water quality and quantity effectiveness, the development of monitoring systems, using bioretention to capture pathogens, urban growth and predictions of water quality impacts, and science translation for non-point source control (development of a cultural model). In addition to conducting several research projects the CICEET has a great database system containing all of their research information which may be a useful example for a central database that the Minnesota-Wisconsin area could develop (<http://ciceet.unh.edu/>).

There are also national organizations such as Water Environment Research Foundation (WERF) and the American Society of Civil Engineers (ASCE) participating in stormwater research projects. An exhaustive list of specific projects and information about those projects has been created as part of this project (see Appendix A).

Local Efforts

There are currently a significant number of organizations involved in stormwater research efforts occurring in Minnesota and Wisconsin. A detailed list of these projects can be found in Appendix B. Some of the on-going and recently completed efforts which are worth noting include several projects at the University of Minnesota (U of M). The development of the *Stormwater BMP Assessment Manual* and its extension to include the *Maintenance of Stormwater BMPs* will assist in filling a gap in stormwater research needs locally.

Another project waiting approval from the Environmental Protection Agency (EPA) through the Minnesota Stormwater Steering Committee is the *Performance of Low Impact Development Practices on Stormwater Pollutant Load Abatement*, a large research project contributing to the needs of stormwater practitioners. Some recently completed projects from the U of M include: *Cost and Effectiveness of Stormwater BMPs*, *Enhanced Sand Filtration for Stormwater Phosphorus Removal*, *Source Reduction*, *Water Quality Performance of Dry Detention Ponds with Under-drains*, and the *Impact of Alternative Stormwater Management Approaches on Highway Infrastructure*. The Minnesota Stormwater Steering Committee has funded several projects one of which resulted in the MN Stormwater Manual. Their research efforts can be found at their website: <http://proteus.pca.state.mn.us/water/stormwater/stormwater-research.html>.

Wisconsin has conducted and continues to conduct a significant amount of research in the area of stormwater management with the United State Geological Survey (USGS). Most of the projects continue to be on-going and there are scientific reports available for three of them through the USGS. A complete list of WI DNR and USGS projects can be found in Appendix B. A few of the projects have significant implications for stormwater management include: *Evaluation of street sweeping as a Stormwater-Quality-Management Tool in three Residential Basins*, *Lawn Fertilizer and Runoff*, *Evaluation of the Effectiveness of Low-Impact*, and *Critical Periods of Pollutant Loading*. There are additional studies that will provide Minnesota stormwater practitioners with valuable information.

Through this search several on-going local efforts are being made to better understand stormwater BMPs. There are several studies examining the impact of infiltration practices on ground water quality. The Metropolitan Council and the USGS are studying the impacts of infiltration on the shallow water table in seven locations around the Twin Cities. The first phase report was published in 2005 (SIR 2005-5189) and a second phase report is due in 2008. The Metropolitan Council is also involved in a particle-size distribution project in Shingle Creek, as well as a wetland buffer study examining the distance of buffers and the impact on water quality. The U of M Duluth campus is part of a paired neighborhood study looking at residential stormwater BMPs.

The draft 2008-2012 Nonpoint Source Management Program Plan for the Minnesota Pollution Control Agency (MPCA) has indicated several goals and timelines for conducting additional research in stormwater related areas that will be lead by various state agencies. The complete list can be found in Appendix C. The overall goals include: Jurisdictions responsible for unregulated Municipal Separate Storm Sewer Systems (MS4s) develop comprehensive runoff management programs; Additional BMPs and Better Site Design (BSD) techniques advanced in Minnesota; Address load allocation reductions for Total Maximum Daily Loads (TMDL) established due to

stormwater runoff impacting impaired water or maintaining water quality of a water body threatened by urban runoff; Establish an effective technical assistance and education delivery system; Improve urban water quality through education and technical assistance programs on the application of urban runoff BMPs; and, Minnesota stormwater runoff stakeholders work together to address and prioritize runoff needs and research the effectiveness of urban runoff BMPs. Each goal then has a list of action steps, a timeline, funding source and the lead agencies for each effort. Many of these action steps are in direct alignment with current local and national efforts in stormwater research.

There are also several projects relating to road salts occurring at the local level. The U of M St. Anthony Falls Laboratory (SAFL) has conducted previous research and continues their efforts to better understand the effects of road salts on the environment. While these projects did not show up through the LRRB website search there have been two completed projects at SAFL regarding road salt use in the twin cities (Project Report No. 503) and the impact on lakes (Project Report No. 505). There are also on-going efforts at SAFL related to road salt, more information can be found at http://www.safl.umn.edu/research/new_stefan_projects4.html. The MPCA has also funded a project with Fortin Consulting, Inc. titled: *Winter Maintenance Training for Reduced Impacts to Waters* which is aimed at reducing the input of chlorides into our surface and groundwater by training private contractors and local community staff in the use of Best Management Practices for winter parking lot and sidewalk maintenance. The MPCA has a website describing the education program which has been developed under this project (<http://www.pca.state.mn.us/programs/roadsalt.html>). WI DNR and Canada share our interest in better understanding the impact that road salt has on water resources as well as ways to reduce or mitigate that impact and have conducted their own road salt projects. Ecoplans Limited is a consulting firm in Canada that has worked on several of these projects and is on the Road Salts Working Group. Environment Canada has recently conducted a five-year comprehensive scientific assessment studying de-icers, and has since then developed a code of practice for the environmental management of road salts.

The search conducted for the purpose of this project is in no way exhaustive, but does highlight the major efforts currently underway by the major stormwater professionals, practitioners and researchers.

Stormwater Research Needs

A comprehensive list of the stormwater research needs both nationally and locally which were identified as part of this project can be found in Appendices D and E respectively. There were several overarching themes at both the national scale and the local scale. They can be grouped and described through seven groupings ranked in order of prevalence:

1. Infiltration Practices
2. BMPs
3. LID
4. Cold Climate Conditions
5. Road Salts
6. Precipitation Patterns/Climate Change
7. Education
8. Information Management

Infiltration Practices

While general knowledge regarding the efficiency of stormwater BMPs was also commonly considered to be lacking, infiltration practices were often stressed as most important and listed separately. There were several aspects of using infiltration practices to treat stormwater runoff which were thought to need additional research. One common concern is the impact that concentrating contaminants to one localized area has on the quality of groundwater. This is an issue which will be dependant on multiple factors and local efforts may be necessary to appropriately determine where and under what circumstances this may be an issue. The long-term function and the maintenance requirements of infiltration BMPs were expressed as common research needs both nationally and locally. While general determinations and guidance may be developed on a large scale site, specific considerations will always impact both long-term functionality and maintenance. The final common research need regarding infiltration practices was the need for cost comparisons to more traditional practices to determine economic feasibility.

Best Management Practices

It was clear that the long-term efficiency and maintenance requirements of all stormwater BMPs were an area which was in need of additional research. Additionally, there was a common need for information regarding the cost of installation and maintenance and the proper installation recommendations.

Low Impact Development

The responses and information gathered through this project indicated that LID practices were a top priority and in desperate need of additional research. Scientific support and evidence of LID effectiveness to reduce and manage stormwater runoff is of interest nationally as well as locally. The three main areas in need of immediate research are: effectiveness to reduce/treat stormwater runoff (especially in highly urbanized areas), the cost of installation and maintenance along with a comparison to traditional structural BMPs, and how these practices perform under cold climate conditions.

Cold Climate Conditions

There was overlap with this specific topic regarding the overall functionality of BMPs, but the specific conditions of their functionality and long-term performance under cold climate conditions was specifically mentioned as an area of concern several times. This theme gets to the need for understanding how various BMPs and LID practices perform under site specific conditions (specifically climate, but other considerations such as native soils, existing hydrologic considerations, etc.) and how those conditions may impact their longevity, maintenance requirements and treatment efficiencies.

Road Salts

This topic was especially noted on local scale as Minnesota is somewhat ahead of the nation on dealing with the impacts that road salts has on water resources. There were some very specific areas of concern, those not receiving much current research effort include: the impacts road salts have on emerging biota during spring runoff, the effects of road salts on plants and wildlife in lakes or wetlands, and the current chloride levels in ground water.

Precipitation Patterns/Climate Change

This specific topic is, of course, not only a concern nationally and locally but on a global level and its overall implications for the environment. In regards to the potential implications that climate change will have on stormwater management, the current research needs are the following: the adaptation of stormwater management and infrastructure to climate changes and to investigate the level of impact that it will have on water resources. With almost no previous or current research dealing with these specific issues, more research needs are predicted in the near future.

Education

This topic is again an overall theme for environmental issues, but specific to stormwater management and source reduction, there is a great need both locally and nationally for the successful education of the public. The two specific topics that were recognized as a priority were the development of sustainable education strategies to create social change and the effectiveness and benefit of child vs. adult focused educational activities. While there were a few research projects examining the social component to water resource management, there is perhaps only one study locally (Duluth) which is researching social indicators for measuring success. This particular topic may be the most complicated of all the topics and possess the most potential for significant impact.

Information Management

Through this effort there has been an exceptional response locally indicating a great need for this type of information. It has become apparent that there is a great need for the communication of the research being conducted on both the national and local scale. A system that can be utilized by locals to share this type of information would be greatly beneficial for not only stormwater management but also water resource management in general. There have also been several requests for this report to be shared in some type of venue or distributed.

To reinforce an earlier point, continued and expanded stormwater research is highly desired among the stormwater community. Although this report is certainly not exhaustive, it is a good starting point for attempting to determine where the gaps are in our stormwater research programs. One gap not mentioned, but very apparent is the need for a centralized database or system to keep track of past and new research results to be shared by the stormwater management community to make better decisions, spend money efficiently, and collaborates with each other to gain a broader and more comprehensive understanding of these complex issues. While working on this project, new research efforts have started, and others that were not easily obtainable came to light. This stresses the need to develop a central database and have it maintained to assist the staff and policy makers in the stormwater management community.

Conclusions and Recommendations

Conclusions

It is clear from the information provided above that:

- A significant amount of research has been completed and is in the process of completion.
- A substantial investment has been made in the field of stormwater management research.
- There are significant unmet research needs.
- The Ramsey-Washington Metro Watershed District as well as other Districts, local, regional and state agencies have an interest in and a documented need for continued research.

Given these understandings, the path to meeting and completing this needed research is not clear. Research is needed in a number of areas, but how do we move forward in an organized fashion that meets everyone's needs? The information provided above and in the appendices gives us a better understanding of the stormwater research landscape, but does not provide us with a clear path to reach our diverse agency research objectives. Several obvious and subtle issues arise from reading this paper and considering our future options. Addressing these issues will be necessary to decide how to proceed.

Objective

A reasonable research objective for the Ramsey-Washington Metro Watershed District would be to: (1) develop an approach that will lead to research on priority issues; (2) implement research with District funds for projects that serve a defined local need and where the information will allow the District Board to make informed decisions affecting selection of stormwater treatment methods, planning, design and funding; and , (3) to complete this research, where possible, through a collaborative decision making and funding approach.

If the Ramsey-Washington Metro Watershed District and others adopted objectives as proposed above, key questions still remain to be addressed:

- How do we establish research priorities given the different levels of interests between local, regional and state concerns?
- What is the mechanism or institutional structure for organizing research projects?
- How are researchers selected for various issues?
- What research methods are used and can these vary by issue?
- Where does the research funding come from?
- Are there different scales of issues, e.g., watershed level, county, regional, state? Should the scale of issues be funded differently or from a different source?
- Who decides what research to fund?

Research Issues Critical to RWMWD

One of the objectives of this paper was to identify research topics of high priority to the RWMWD that warrant District investment of taxpayer funds. This list is not as clear as it was originally hoped. There are several issues that are clearly in our interests, but almost all issues have a larger audience that can benefit from the results.

Although an extensive list of issues is included in Appendix E, the issues that appear to be the highest priority for the District in 2008 are listed below:

- Affects of Chlorides on lakes and wetlands and the relationship of Chloride levels to winter street snow and ice management.
- Long-term impact of using natural wetlands to receive stormwater and the impact various pollutants have on these wetlands and the mitigation effects of pre-treatment.
- Effectiveness of street sweeping as a BMP and the benefits of new vacuum sweepers as compared to brush sweepers.
- The long-term effectiveness of rigorous municipal infrastructure maintenance (catch basin cleaning, road repairs, pond maintenance, street sweeping, etc.) for drainage area nutrient load reduction.
- Compare the effectiveness and benefits to the “true” costs of educational activities. Consideration also needs to be given to analysis of educational program effectiveness and benefits for different adult target audience groups.
- BMP maintenance requirements and costs.
- Effectiveness/practicality of LID techniques in a cold-weather climate and special management considerations in cold-weather climates
- Long-term effectiveness and maintenance costs of infiltration BMPs.
- Analysis of the effectiveness of subsurface vs. surface infiltration systems.
- Testing performance of self-contained manhole systems for water quality and particle size removal efficiency.
- Infiltration systems - what % of annual rainfall can be infiltrated and what is the effect of these systems on groundwater.
- Benefits of a centralized vs. decentralized (LID techniques) approach to managing stormwater runoff and the implications for education strategies.
- Water quality impact of urban plant litter in stormwater runoff.
- The effects of Carp populations on re-suspension of lake sediments and internal phosphorus loads.
- Litter control in urban areas.

A District Research Strategy

This stormwater research strategy and framework was adapted from the Washington State Department of Transportation research process. Elements were deleted or modified to better fit the needs of the District. This is generally viewed to be overly elaborate for our needs, but provides a good starting framework.

1. The framework proposed here includes the following major elements:
2. Appointment of a staff research coordinator.
3. Appointment of a Research Review Committee (RRC).
4. Development of a communication and coordination process.
5. A research proposal development and evaluation process.

Stormwater management is a challenging task with a variety of regulatory drivers and constraints. It spans numerous technical disciplines including hydraulics, hydrology, geology, water quality urban planning and zoning, and public education. The Ramsey-Washington Metro Watershed District (RWMWD) is additionally challenged by the difficulty of managing stormwater impacts in a fully developed urban area. To help meet this challenge, the RWMWD

relies on research efforts to help identify state-of-the-art, cost-effective solutions for designing, constructing, and maintaining stormwater management systems.

This Stormwater Research Strategy is a tool for communicating RWMWD's stormwater-related research needs and priorities. The Strategy provides the framework to:

- Coordinate and build partnerships with other local agencies and at regional, state, and federal levels to leverage stormwater research resources
- Provide a clear process for soliciting, submitting, prioritizing, and implementing stormwater-related research proposals
- Find solutions that improve the design, constructability, maintainability, cost effectiveness, hydraulic performance, and treatment efficiency of stormwater facilities, as well as stormwater management operations and maintenance practices
- Improve the compilation, tracking, and dissemination of stormwater research findings

Coordination and Communication

Although this process has been informal in the past, this strategy proposes to designate an experienced District employee as the District Research Coordinator. The Research Coordinator, in collaboration with the District Administrator and the Board of Managers will coordinate the identification, selection, and management of research projects funded through the District Research Program, and participates as appropriate in regional and state research coordinating initiatives. This includes establishing an internal procedure for research project description, data collection, final reporting, and publication (web and/or hard copy).

Effective internal and external communication and coordination is essential to supporting, promoting, and executing stormwater research. Although the RWMWD is a small part of the universe of stormwater research, this strategy is designed to follow a planned communication process to share District sponsored research information and finding with others and participate in any system for broad statewide or national research sharing system. The RWMWD will organize, manage, and disseminate the results of research (stormwater-related and other) conducted by the District.

Research Review Committee

District sponsored stormwater research proposals would be reviewed by the Research Review Committee (RRC). The RRC is an ad hoc District technical team convened and chaired by the Research Coordinator. In addition to the chair, the RRC will consist of a member(s) of the Board of Managers, interested District staff, the District Engineer or another appropriate representative of the engineering firm, and additional disciplines or agency representatives as needed.

The RRC will meet at least once per year for the sole purpose of setting the direction and focus (priorities) for District stormwater research for the coming year. This list of research priorities will be used in the review and ranking of any submitted research proposals.

The RRC will review research proposals for applicability, potential overlap with other research proposals or completed research, and potential for partnering on a given proposal. The RRC also prioritizes the research proposals.

The RRC selects stormwater research projects to submit to the Board of Managers and other entities for possible funding. The ranking by the RRC sets a direction and focus that advances the District's stormwater research goals. However, funding sources ultimately control which RRC-recommended proposals get funded.

Local, State, and National Programs Coordination

To facilitate research partnerships and information sharing, the District will coordinate with local, regional and state efforts to promote or conduct stormwater research. Maintaining communication and coordination with these and other stormwater programs ensures that the District stays abreast of the latest stormwater developments and priorities, and that the District can leverage resources through shared stormwater research efforts and information sharing.

The District will work actively with the Metro MAWD organization and other WMO's to develop and fund a shared research program. The District will actively promote the concept of an Urban Stormwater Management Research Council to develop a collaborative research program and budget.

There appears to be a consensus among stormwater professionals that there needs to be some type of group with a strong interest and knowledge of stormwater needs, to act as decision makers on the issues of stormwater research priorities and allocation of funding. There are varying opinions on how this would be administered and governed. Should we work toward a single Research Council that raises funds and allocates resources based on the wishes of the Council members? Is this a statewide or regional Council? Should there be councils established for smaller geographic areas that can reflect local needs and interests? How is the Research Council operated, i.e., do they have established operating by-laws, do they have set obligations to the funders, do they oversee dedicated research funds that can respect the needs of various contributors?

Resolution to these issues will require more discussion among the interested agencies and organizations that can provide funding professional and technical information relevant to this issue.

The concept of a Research Council does not propose to replace or limit the ability of government agencies or organizations from initiating and funding their own research projects. The concept originated from the principal that significant progress on major stormwater issues is not likely without considerable funding and is also not likely without a more impartial governing and funding structure. For example, there is a practical need for study of the best inlet design for rain gardens that collect street drainage, but there is a larger need to understand what is on the streets that is leading to water quality. There is also a larger need to understand particle size distribution in runoff and test BMPs for the effective collection of small size particles. This type of research is highly technical and scientific. The design of the research is critical and often requires specially designed instruments. Testing inlet designs is more of a trial and error research project that could be conducted by any agency with the desire and means.

The concept of a Research Council has several benefits:

- Avoid duplication of research.
- Identify gaps in past studies that need additional research.
- Widely distribute research results and findings.
- Work to integrate research results into training programs.
- Develop research collaborations and interdisciplinary teams,
- Work to incorporate research needs into University graduate programs.
- Leverage local financial resources with national grant programs and federal agencies.
- Develop linkages with other research councils and programs like the Local Road Research Board (LRRB), Water Environment Research Foundation (WERF), St. Anthony Falls Laboratory, and others.
- Develop a stormwater research inventory, on-line library and interactive database.

Stormwater Research Program Web Site

The District will develop a Research Program section on the District web site that summarizes and communicates stormwater-related research activities and findings, and provides guidance for proposal submission and review. The intended audience includes District staff interested in proposing research or reviewing current research priorities, affiliated research partners (e.g., universities, municipalities, state and federal agencies, etc.), and any citizens or public interest groups interested in stormwater research. The Research Program web site will include the following elements:

- Overview of the research program including strategies and objectives
- List of current and past research efforts
- Reports and findings on stormwater-related research
- List of current research priorities
- Assistance with proposal development and submittal
- Links to research resources
- Contacts within the program

Research Areas and Needs

Stormwater management operates in a dynamic arena of rapidly evolving public policy and advancements in management and design methods. Although these changes and advancements tend to shift stormwater research priorities every few years, the District's core research areas will likely remain the same unless modified by the Board of Managers. Currently, District stormwater-related research needs fall into the four categories outlined below.

1. Characterization of the properties of runoff and sources of pollutants

The extensive data collected by other states and local governments have significantly reduced the need for additional data to characterize stormwater runoff. However, many of these studies were completed years ago and changes in urban land management and street management practices have altered runoff constituents and concentrations. Accurate characterization of runoff and sources is needed to evaluate BMP effectiveness.

2. Characterization of the environmental effects of runoff constituents on lake, wetland and stream water quality.
Although the character of stormwater runoff is generally known, the effects of runoff on the water quality, ecology, hydrology, and geomorphology of downstream systems is still a priority research area. Research on the effects of stormwater runoff will help further refine policy and management practices.
3. Methods to avoid, minimize, buffer, or mitigate runoff effects
The District currently sees long-term benefits in continuing to pursue and evaluate stormwater treatment methods, volume control and infiltration, watershed-based management approaches (including education programs), and other cost-effective treatment options. New techniques and technologies continue to be made available without good performance research. The emergence of new stormwater approaches and technologies developed to comply with regulations often spurs the need for research on design and maintenance questions associated with those new management options. The District also recognizes the need to ensure that surface water quality protection efforts do not come at the expense of soil or groundwater contamination.
4. Water quality impacts of new and emerging contaminants
The District has had considerable experience in nutrient management, but we are becoming aware of new contaminant concerns such as chlorides from winter snow and ice control and PAHs from asphalt sealants. We are also becoming aware of the increased role of dissolved phosphorus in our lake water quality management. Also included here is the emergence of biological issues such as Carp management as a water quality issue.
5. Characterization of lake and wetland ecology as it relates to water quality.
The District is fast becoming aware that much of the in-lake and wetland conditions we see is a by product of ecological conditions within the water body as well as a condition of the quantity and quality of the water discharging to the system. Factors that need to be considered are lake sediments, re-suspension issues, influence of aquatic plants and fisheries, water temperature, ice and snow cover, waterfowl impacts and more. Understanding this relationship and the factors influencing change warrants additional research.

Research Proposal Development and Evaluation Process

This section outlines the development and review process for research proposals. *Figure 7-1* (WSDOT, 11/2/05) depicts the process that a research idea goes through from conception to a fully developed and prioritized proposal. This is a collaborative effort between the proponent generating the idea and District staff, who will assist in shepherding the concept through the process.

Proponents may wish to consult with District staff for advice and assistance while preparing their proposal. To avoid expending energy in pursuing research ideas that have been adequately investigated, a literature search should be conducted very early in the process.

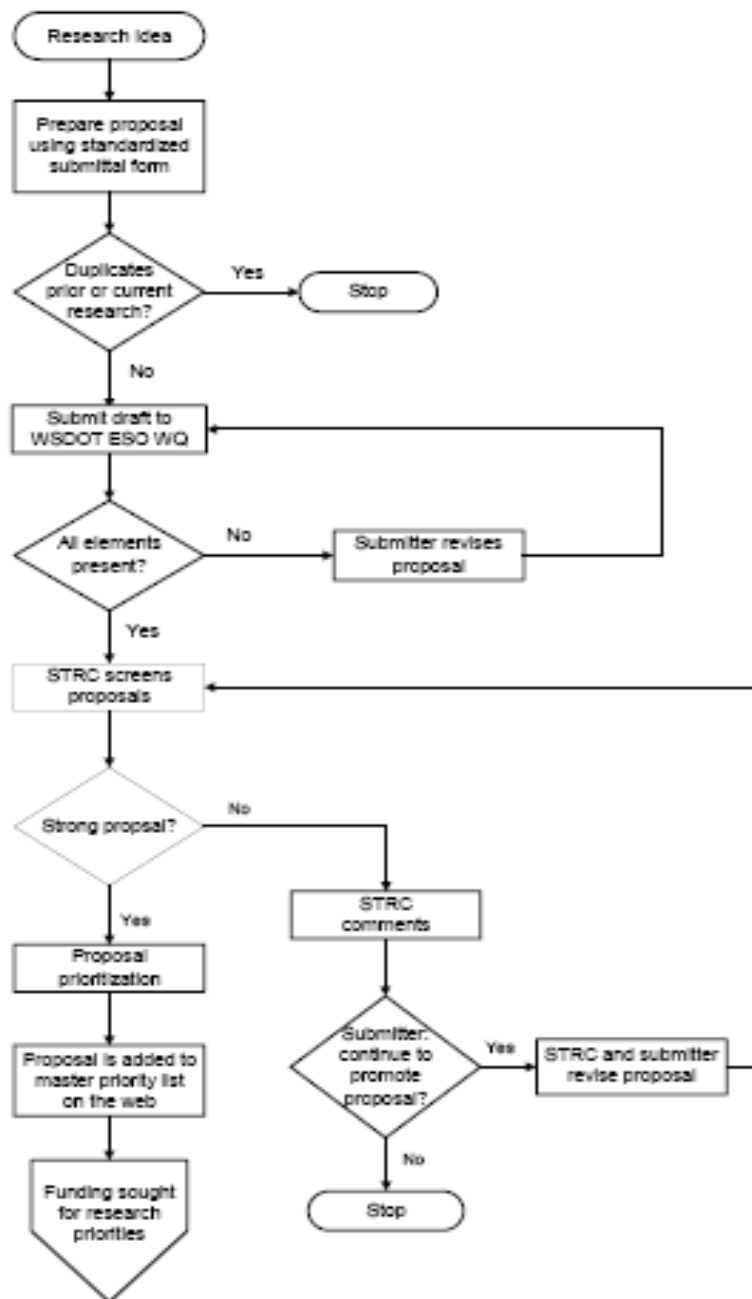


Figure 7-1 Research idea development process

Upon submittal, RWMWD's staff will check the proposal to ensure it contains all the required information prior to sending it to the Research Review Committee (RRC). The SRRC's initial screening evaluates whether:

- The proposal addresses key concern(s) for RWMWD.
- RWMWD or others have already adequately investigated the topic.
- It overlaps with other existing research proposals or can be combined with other proposals.
- Potential funding partners exist.
- The proposal clearly identifies target audiences for the new information and strategies for reaching these audiences.

The purpose of the preliminary screening is not to rank the research proposals, but to:

- Screen out proposals too far removed from RWMWD's interests and responsibilities, or that have already been covered in existing proposals or by previous research efforts
- Strengthen the proposal by suggesting refinements, re-directions, or additions to the proposed study
- Strengthen the proposal by integrating it with similar proposals or partnering with others interested in the same topic.
- Strengthen the proposal to meet short term needs whenever possible.

Screened proposals may be returned, with comments, to submitter; integrated with other proposals; or kept as-is. In the event that the RRC fails to embrace the proposal, a submitter may elect to either abandon the proposal or work collaboratively to refine the proposal in order to adequately respond to the RRC's feedback.

The RRC prioritizes promising proposals based on the following criteria:

- *Applicability and Practicality.* Research having practical application statewide or regionally will rank higher than those with limited applicability, or less practical applications.
- *Time-Sensitivity.* Research filling an immediate critical need will rank higher than proposals for more general or "pure" research.
- *Cost Considerations and Potential for Partnerships.* A qualitative cost-benefit evaluation will be performed for each proposal to determine whether the investment in the research effort will provide a valuable benefit to the District. Proposal reviewers will also consider the availability of funds and funding partners.
- *Study Design Feasibility and Quality.* Proposal reviewers will evaluate whether the research method could be successfully deployed to yield useful results.
- *Degree of Knowledge Gap.* Research proposals may address topics that have been investigated to some degree by others. A high rank for this criterion will be applied to proposals where insufficient information exists or prior investigation has yielded inadequate knowledge.

Selected prioritized proposals will be placed on a master list of key research proposals, which will be maintained by the District.

Final SRRC recommendations will be presented to the District Administrator for review by the Board of Managers. Final proposal approvals are at the discretion of the Board of Managers.

RWMWD Funding Recommendations

The RWMWD has funded a research budget for the past 3 years. The 2005 through 2008 budgets and amounts spent for research are listed below:

<u>Year</u>	<u>Budget</u>	<u>Expenses</u>
2005	\$135,000	\$83,000
2006	\$125,000	\$66,500
2007	\$65,000	\$37,000
2008	\$165,000	\$104,000 (est.)

These expenditures do not include staff time for each of the District Research projects, but do include all equipment, lab costs, shipping and equipment installation costs. These funds have been used for District sponsored research on projects initiated by the District through its program or capital improvements budget. These projects and the approximate total cost (projected through 2008) on each project is listed below:

Owasso Basin Enhancements Project (2006-2008)	\$172,000
Carver Porous Pavement Cul-de-sac Project (2006-2008)	\$20,000
Office BMPs (2006-2008)	\$60,000
Biomonitoring Metrics Data Analysis	\$23,500
Reed Canary Grass Research (1999-2001) (Total cost \$225,000)	\$25,000

The District Board has made a preliminary research commitment for three additional research projects and one ongoing project:

- Dr. Sorenson, University of Minnesota, for a carp research project studying the impact of carp on water quality in Kohlman Lake. This research project is estimated at approximately \$350,000 (2009-2011)
- Continued performance monitoring at the District office site (ongoing)
- Monitoring of the new White Bear Lake stormwater irrigation project (2008-2010)
- Performance monitoring of the Enhanced Sand Filter project at Kohlman Basin (2009-2010)

Based on this report, past research investments, future commitments and projected future needs, staff recommends that the Board of Managers continue to provide a budget for District sponsored research, but to also consider allocating a portion of the budget to a possible Research Council if this becomes a reality and meets the Districts interests. Based on the costs of research activities and University grad students (approximately \$30,000 per year), staff would recommend a District internal research budget of approximately \$200,000 per year. This general amount would fund 2-3 studies per year with several projects extending over multiple years.

If the collaborative Research Council concept were to become a reality and meet the interests of the District, an additional budget line item would be requested to allocate our contribution to this shared funding program. No estimate is available for this program at this time.

Another recommendation would be to become a member of the Water Environment Research Foundation as an individual member or as a group member through the Metropolitan Council with other communities and WMO's contributing to the Metro membership. This membership give us direct access to the latest research report published through the Stormwater research program and a voice in the research priorities of this national research program. This membership would likely cost from \$5,000 to \$8,000 per year under the individual membership and somewhat less under a metro membership option.

Proposed Next Steps

Staff proposes the following process for addressing the issues identified in this report:

1. Work with the RWMWD Board of Managers through the 2009 budget process to establish an appropriate annual research budget amount that addresses District needs.
2. Work with staff and Board of Managers to refine our internal research proposal process referred to in the *Research Strategy* section on pages 12 - 14.
3. Start discussions with the Metropolitan Council and at the Research Council meeting about a joint WERF membership. Follow-up discussions would be held with WERF staff about the metro membership rate and services or a special rate for watershed organizations.
4. Call a meeting of Watershed Districts, WMOs, and agencies interested in the idea of a metro or Minnesota Stormwater Research Council. This meeting would be for the purpose of identifying individual interest in supporting the concept and identifying concerns that would need to be addressed in the operating policies and structure of the organization. This group would also be asked to review this Research report and provide comments and suggested refinements.

Appendix A

APPENDIX A

Current WERF (2007) Stormwater Research

source: <http://www.werf.org/AM/Template.cfm?Section=Stormwater1>

Topic	Project #	Title	Description	Total Cost	Publication #	Status
Decentralized Approaches	04-DEC-8W	<i>Long Range Planning for Decentralized Wastewater and Stormwater Treatment Research: Workshop and Synthesis Report</i>	This report is a summary of a WERF/NOWRA workshop on Research Needs in Decentralized Wastewater, Stormwater, and Related Fields held on March 14-15, 2007 in Baltimore, MD. The purpose of the workshop was to build future visions, identify research gaps, gain guidance on promising avenues for investment, and begin collaboration discussions within the U.S. and the global community. Participants included U.S. and international professionals and policymakers in decentralized wastewater, stormwater, and related fields. The report includes a literature review which provides an overview of some of the research completed since 2002 related to decentralized wastewater ES&E priorities and to summarize current research in ES&E related to decentralized stormwater (Appendix G). Published by WERF. 166 pages. Online PDF. (2007)	\$100,000	04DEC8WPDF	Completed
CSOs	03-SW-2	<i>Development of a Protocol for Risk Assessment of Separate Stormwater System Microorganisms</i>	The primary objective of this investigation was to generate guidance to enable more accurate and defensible evaluations of stormwater microorganism data and the associated risks to human health from exposure to pathogenic microorganisms (i.e., pathogens) in stormwater. The project was designed to help public agencies begin to understand how to answer questions such as: which pathogens are present in stormwater; what are the potential health risks associated with exposure to these pathogens; what are the sources of pathogens in stormwater; and what can be done to manage the potential health risks? Published by WERF. 200 pages. Soft cover and online PDF. (2007)	\$300,731	03SW2PDF	Completed
Decentralized Approaches & CSOs	03-SW-3	<i>Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction</i>	This report synthesized the results of a research initiative commissioned by WERF. Its purpose is to help define the current state of decentralized source controls for capturing rainwater where it falls and to present a plan for implementation of decentralized controls in an urban environment specifically for the goal of CSO mitigation. The primary focus of the applied research was how decentralized controls can reduce the volume of rainwater runoff generated and, consequently, entering the combined sewer system in urban areas. Published by WERF. 182 pages. Online PDF. (2006)	\$175,000	03SW3PDF	Completed
Human Health	00-HHE-6	<i>Identifying Technologies and Communicating the Benefits and Risks of Disinfecting Wet Weather Flows</i>	The primary objective of this project was to identify and communicate the benefits and risks of disinfecting wet weather flows by evaluating the effectiveness of available disinfection technologies and identifying disinfection by-products and their potential risks to aquatic and human life. A decision-making framework was developed that could be used as a model to guide combined sewer overflow, sanitary sewer overflow, and stormwater disinfection control policies. The project also provided a summary of a disinfection demonstration test plan, which subscribers can use to design their own disinfection demonstrations, as it may be necessary for municipalities to perform site-specific disinfection demonstrations to fill data gaps and develop and implement a risk communication plan. Published by WERF. 174 pages. Soft cover and free online PDF.	\$310,552	00HHE6PDF	Completed
BMPs	02-SW-1	<i>Critical Assessment of Stormwater Treatment and Control Issues</i>	The International Best Management Practices Database is a searchable, online database that provides access to best management practice (BMP) performance data in a standardized format for roughly 200 BMP studies. Database listings include basic test site information, a list of analytical parameters for the BMP, and PDF files that include key characteristics of the study, detailed statistical analysis of BMP performance, and a summary of precipitation and flow data. The database is available at www.bmpdatabase.org .	\$300,000	02SW1PDF	Completed
Decentralized Approaches	03-SW-3a	<i>Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction</i>	NA	\$200,000	NA	Ongoing
	04-CTS-10S	<i>Integrated, GIS-Based Consequence Assessment Model for Sewer and Stormwater</i>	NA	\$281,905	NA	Ongoing
Monitoring	04-DEC-11SG	<i>Washington State University County Low Impact Development Pilot Project Monitoring</i>	Monitoring results will provide stormwater managers and researchers at the state and local level with quantifiable results required to develop and refine guidelines for incorporating LID strategies into residential and commercial development.	\$150,203	NA	Ongoing
	04-DEC-10SG	<i>Greenroofs: Measuring Water Loss and Neutralization of Acid Rain</i>	This project will provide information on the effectiveness of greenroofs for stormwater runoff reduction, in particular as relates to the rate of water loss (evapotranspiration) from a planted green roof as well as potential for greenroofs to neutralize acid runoff.	\$75,000	NA	Ongoing
	04-DEC-12SG	<i>Model Standards for Decentralized Stormwater Management</i>	This project will create a set of model standards that can be used to efficiently update local ordinances to affect sustainable development and decentralized stormwater management.	\$608,433	NA	Ongoing
	03-SW-1COa	<i>International Stormwater BMP Database (Phase II)</i>	NA	NA	NA	Ongoing
	03-WSM-3	<i>Protocols for Studying Wet Weather Impacts and Urbanization Patterns</i>	NA	\$300,000	NA	Ongoing
	03-CTS-12PP	<i>Characterizing the Quality of Effluent and Other Contributory Sources During Peak Wet Weather</i>	NA	\$400,000	NA	Ongoing

Current WERF (2005-2006) Stormwater Research

source: 2005-2006 Programs in Progress: Long-Range Plan & Annual Report (also looked projects up on website for the most up-to-date info.)

* gray lettering indicates information not available on website, used information from August-05 research project list

Topic	Project #	Title	Description	Total Cost	Publication #	Status	Last Updated
BMPs	92-NPS-1	<i>Use of Riparian Buffer Zones and Constructed Wetlands in Water Quality Management</i>	This publication examines the pollutant removal performance of an urban wetland constructed in a formerly dry detention pond and investigates seasonal trends in removal efficiencies. This research identifies the characteristics contributing to high performance of constructed wetlands in ecosystem reclamation. The report also demonstrates the results of examination of vegetation dynamics of both planted and non-planted constructed wetlands over time. Published by WERF. 60 pages. Soft cover.	\$454,144	D93004	Completed	NA
BMPs	95-WWR-1 and 95-WWR-1A	<i>Wet Weather Research Protocol</i>	This final report presents methods for characterizing nonpoint and point sources of wet weather flows (WWFs), assessing effects of WWF-induced pollution on receiving water systems, and evaluating WWF control practices and treatment technologies. This work was based on the fact that many water quality and ecosystem problems are best solved at the watershed level than at the individual waterbody or discharger level, and ideally a framework investigation should be completed for the entire watershed before details of individual pollution sources or waterbodies are addressed. Published by WERF. 122 pages. Soft cover.	\$50,000	D13003	Completed	NA
BMPs	97-IRM-2	<i>Innovative Metal Removal Technologies for Urban Stormwater</i>	Provides a concise, easy-to-understand summary of the full report which examines innovative methods for removing heavy metals from stormwater runoff. The project team focused on two removal methods: media filtration systems and swales. Published by WERF. 22 pages. Soft cover. WERF is offering a 10% discount for orders of more than 20.	\$536,445	97IRM2PDF	Completed	NA
BMPs	00-WSM-7UR	<i>Stormwater Thermal Enrichment in Urban Watersheds</i>	Mounting evidence suggests that stormwater mitigation and treatment approaches targeting only pollutant loading and flow moderation in urbanized, coldwater habitats are not sufficient to achieve overall desired water quality benefits. Temperature, as one of the key environmental variables controlling aquatic biota, must also be considered in stormwater management planning where urban runoff is introduced into aquatic systems. This project examines optimal management design considerations to mitigate the impact of stormwater that has warmed during runoff over urbanized areas and demonstrates the effect of stormwater best management practices on the thermal regime of runoff and the receiving stream. Published by WERF. 205 pages. Softcover and online PDF.	\$445,160	00WSM7URPDF (Cliff has hard copy)	Completed	1/9/04
BMPs	99-WSM-4	<i>Use of Riparian Buffer Zones in Water Quality Management Programs</i>	The objectives of this study were to provide information and begin to fill the data gaps for resource managers on the multiple functions of urban forest buffers. The information provided will assist resource managers in the formulation of regulatory programs to protect riparian forest buffers from future development impacts and for use in stream restoration prioritization. Published by WERF. 290 pages. Online PDF only.	\$342,110	99WSM4PDF	Completed	1/15/04
BMPs	01-CTS-21-T	<i>Performance and Whole Life Costs of Best Management Practices and Sustainable Urban Drainage Systems</i>	This report documents the performance and whole life costs of Best Management Practices (BMPs) and Sustainable Urban Drainage Systems (SUDS). In this the second phase of the project, the research team identified preferred designs for a wide range of settings, as well as improved design procedures for more effective maintenance. The report also documents maintenance costs from across the U.S. and UK, which allows planners to estimate future outlays and develop a funding system for sustaining ongoing maintenance requirements. Hydraulic modeling conducted through the project demonstrates the benefits of BMPs/SUDS in comparison to traditional drainage systems and may help promote their adoption and use in new developments. In addition to the report, the researchers created a series of spreadsheets that pull together all of the expenses required to construct and maintain a BMP/SUDS system. These spreadsheets consider factors such as design life, capitol costs, routine and corrective	\$690,000	01CTS21TAPDF	Completed	1/4/07
BMPs	02-SW-1	<i>Critical Assessment of Stormwater Control Selection Issues</i>	This guidance document attempts to offer assistance to stormwater managers in cities and other public agencies, and the consultants who serve them on choosing, sizing, and design of urban runoff controls as a function of mitigation goals, site-specific needs, and regional and local characteristics. It does not attempt to be a stand-alone design manual; rather it is intended to provide a thorough background on the theory and state-of-the-practice of stormwater management supported by methods, equations, and references useful for making sound stormwater management decisions. Published by WERF. 2005. 290-page online report, plus 452-page PDF of appendices. Online PDF only.	\$300,000	02SW1PDF	Completed	12/27/06
BMPs	03-SW-1CO	<i>International Stormwater Best Management Practices (BMP) Database</i>	The International Best Management Practices Database is a searchable, online database that provides access to best management practice (BMP) performance data in a standardized format for roughly 200 BMP studies. Database listings include basic test site information, a list of analytical parameters for the BMP, and PDF files that include key characteristics of the study, detailed statistical analysis of BMP performance, and a summary of precipitation and flow data. The database is available at www.bmpdatabase.org .	\$120,000	NA	Completed	3/21/06

BMPs	04-SW-1	<i>Successful Integration of Stormwater BMPs into the Urban Landscape</i>	Results of this project will help stormwater managers effectively balance aesthetics with urban runoff control in designing and implementing stormwater management and best management practices. Will develop a compendium of major community development and redevelopment projects and summarize key factors that have contributed to high public acceptance, effective pollution control and added value to the community.	\$175,000	NA	Ongoing	5/2/07
Receiving Water Effects	90-WPCF	<i>Nonpoint Source Impact Assessment</i>	Results of this project will help stormwater managers effectively balance aesthetics with urban runoff control in designing and implementing stormwater management and BMPs. Will develop a compendium of major community development and redevelopment projects and summarize key factors that have contributed to high public acceptance, effective pollution control and added value to the community.	\$100,000	D0009	Completed	NA
Receiving Water Effects	92-BAR-1	<i>Time-Scale Effects of Chemically Toxic Events in Freshwater and/or Marine Ecosystems</i>	This new WERF report presents conclusions that are critically important when addressing wet weather discharge impact assessment. It also provides a tiered protocol for assessing the effects of wet weather events on receiving water ecosystems, reviews literature and evaluates available tests for wet weather discharge impact assessment, modifies standard tests to produce complementary tests appropriate for time-scale toxicity assessment, provides a predictive tool for wet weather impact assessment, and addresses variability of exposure during wet weather events. Published by WERF. 285 pages. Soft cover.	\$777,000	D83003PDF	Completed	NA
Receiving Water Effects	94-IRM-2	<i>Urban and Highway Snowmelt</i>	Maintaining population mobility in snowbelt areas and highways, and providing air traffic safety during winter requires expensive snow and ice removal practices that may have serious adverse water quality and ecological consequences. This manual provides comprehensive guidelines for assessment of winter pollution loads from urban and highway drainage systems and their impact on receiving waters. Also outlines the sources and causes of winter snowmelt pollution, addresses the environmental impact of snowmelt, and describes the process that will lead to watershed management. Published by WERF. 1999. 400 pages. Soft cover.	\$194,000	D93001PDF	Completed	NA
Receiving Water Effects	96-IRM-2	<i>Effects of Multiple Stressors on Aquatic Ecosystems</i>	The existing framework for identifying risks to aquatic biota generally focuses on chemical water quality criteria, with less emphasis on physical habitat and biological community interactions. Though there are circumstances where a single chemical stressor focus may be appropriate, there are many more circumstances where aquatic biological system characteristics need to be considered. This project analyzed the effects of multiple stressors from discharges and nonpoint sources on stream invertebrates in three different ecological areas. The resulting research provides a tool for assessing the effects of multiple stressors on aquatic ecosystems, and a resource document and annotated bibliography on the application of multiple stressor concepts to the risk assessment process. Published by WERF. 150 pages. Online PDF.	\$354,454	96IRM2PDF	Completed	NA
Receiving Water Effects	98-HHE-3	<i>Chemical Frequency, Magnitude, and Duration vs. Ecological Impact</i>	This CD-ROM product contains two PDF reports and Dynamic Load Analysis Tool software that includes a decision framework and analytical tools. The software allows the user to implement methods recommended in the reports for assessing permits and limits for fluctuating loads. The reports are: Volume 1: Technical Guidance and Software Provides information on how to improve implementation of existing water quality criteria and is to be used in conjunction with the software. The software User s Guide is found in Chapter 9. Volume 2: Alternate Frameworks for Water Quality Criteria Presents a methodology that allows criteria and standards to reflect site specific conditions and biological response factors.	\$478,285.35	98HHE3PDF	Completed	NA
Receiving Water Effects	98-WSM-1	<i>Ability to Discriminate Chemical Versus Habitat Limitations</i>	Provides users with both a report (in PDF format) and electronic databases used to develop the method described. In response to increased emphasis on chemistry and habitat in regulatory decisions of water quality, this project developed a method to quantitatively incorporate the significance of habitat limitations on aquatic life. Researchers developed the Integrated Impact Analysis method, refined it with several sets of real-world data, and used it to analyze data from Fountain Creek in Colorado. The main product of this project is a user's guide for the method, which provides a detailed process for analyzing and understanding physical and chemical stressor and biological response data. Published by WERF. CD-ROM.	\$315,902	D13208PDF	Completed	8/8/02
Receiving Water Effects	99-WSM-5	<i>Assessment of Availability and Use of Hydrodynamic, Runoff and Fate and Transport Models</i>	Provides users with both a report (in PDF format) and a software tool that assists water quality managers in choosing the appropriate modeling tools for their needs. The project investigators identified, reviewed, and categorized more than 150 different models and modeling systems that might be of use to water quality professionals, including rural and urban runoff models, hydrodynamic models, receiving water models, and groundwater models. It also include links to government, academic, and private sector websites for the model developers and, often, downloadable versions of the model codes and documentation documents. Published by WERF. CD-ROM Only.	\$182,768	D13209PDF	Completed	8/8/02

Receiving Water Effects	00-WSM-4	<i>Research Needs: Physical Effects of Wet Weather Flows on Aquatic Habitats</i>	Wet weather flows from urban areas can change the physical properties of aquatic habitats, particularly streams, and lead to loss of aquatic life. This report explores current state of knowledge about these effects and makes recommendations for further research. After conducting a wide-ranging literature review, the project team identified knowledge gaps, examined the quantity and quality of current data, and recommended future research studies. Published by WERF. 200 pages. Soft cover.	\$123,322	00WSM4PDF	Completed	NA
Receiving Water Effects	01-WSM-3	<i>Bioassessment: A Tool for Managing Urban Aquatic Life Uses</i>	Will use field validation to evaluate how biocriteria and biological assessment can be used to evaluate water quality on a watershed scale and to evaluate aquatic life use designations. Will evaluate the degree to which urban systems can be assessed using predictive relationships between relative gradients of urbanization and biological conditions.	\$600,000	NA	In Production	4/26/07
Receiving Water Effects	02-WSM-3	<i>Factoring Frequency, Magnitude, and Duration in NPDES Permit Limits</i>	This report outlines research that identifies more appropriate methods for developing chronic permit limits and better ways to assess regulatory compliance of discharges that exceed a chronic permit limit. This project generated toxicity data for several common wastewater contaminants and many types of pulsed scenarios to support the development of a kinetic model incorporating the interaction of magnitude, duration, and frequency parameters. Published by WERF. 148 pages. Soft cover.	\$250,000	02WSM3PDF	Completed	6/6/05
Receiving Water Effects	03-ECO-1	<i>Workshop on Partitioning Multiple Stressors: Approaches, Information Gaps, and Tools</i>	This report summarizes a workshop that WERF held in September, 2005 which included researchers and WERF subscribers. The purpose of the workshop was threefold: 1) To assess progress made toward developing tools that could be used to determine if the participant's facilities were contributing to aquatic life impairment. 2) To identify currently available tools for partitioning effects from multiple factors. 3) To summarize the applicability of these tools and to provide recommendations for research areas that would improve the use and acceptance of available tools. Published by WERF. 90 pages. Soft cover and online PDF. (2007)	\$109,051	03ECO1PDF	Completed	4/10/07
Receiving Water Effects	03-WSM-3	<i>Protocols for Studying Wet Weather Impacts and Urbanization Patterns</i>	Will develop protocols for studies at various scales for evaluation of cause-and-effect relationships of wet weather flows on aquatic habitats. Protocols will be used to compare the affects of different types of urbanization patterns on receiving waters, including, for example, low density and cluster development.	\$300,000	NA	Ongoing	4/18/07
Source Control	95-IRM-1	<i>Commercial and Residential Source Control Assessment</i>	This report provides a comprehensive review of existing residential and commercial source reduction programs that will serve as a valuable resource for use by municipalities and other water quality management professionals. The project team gathered information from around the country on wastewater and stormwater pollution prevention and public education programs that have been developed to address non-industrial sources. Also described are monitoring studies conducted to identify wastewater and stormwater pollutants and their sources. The report covers best management practices and program ideas for specific sources of pollutants. Public education programs and efforts to measure program effectiveness are also discussed. Published by WERF. 400 pages. Soft cover.	\$80,000	D72005PDF	Completed	NA
Source Control	98-WSM-2	<i>Residential and Commercial Source Control Program Effectiveness Measurement</i>	Provides information on effectiveness measurement for stormwater and wastewater pollution prevention and public education projects. Includes cost information to implement pollution prevention programs and to measure program effectiveness. Factors and participation rates can be used to identify control strategies and plan programs. A process/framework for developing an effective pollution prevention or source control program is described. Published by WERF. 150 pages. Soft cover.	\$300,000	D00302PDF	Completed	8/8/02
Source Control	98-WSM-2P	<i>Salt Creek Water Quality Demonstration Study</i>	This is a summary of part of a larger project which addressed proposed ammonia effluent limits for Lincoln's two wastewater treatment plants. The project focused on characterizing Salt Creek by quantifying the existing biological community, evaluating water quality, physical and hydrologic conditions, and evaluating the impact of ammonia discharges from the WWTPs to the biological community compared to other stressors. The portion of the project that is the focus of this report is the in situ toxicity study that modeled laboratory tests that introduce a species of fish to known levels of ammonia to determine a dose-response relationship. The in situ toxicity study results would be the basis for developing a site-specific chronic ammonia water quality criterion. WERF provided peer review for the project, which resulted in credible research results that were used to develop alternative ammonia discharge limits for the city's WWTPs.	\$55,893	98WSM2PPDF	Completed	12/27/06

Source Control	99-HHE-2	<i>Sources of Cryptosporidium in Watersheds</i>	Several recent waterborne Cryptosporidium outbreaks have been attributed to possible treatment deficiencies linked with source water (watershed) contamination. The purpose of this research was to define the relative magnitude and contributions of Cryptosporidium from major nonpoint and point sources, and to characterize contributions of each source by factors such as hydrograph timing, climatic effects, and seasonal variations. The project team examined two watersheds - one rural and one urban - over the course of two years. This report presents the results of their research, as well as statistical models that can be used to estimate the probability of high Cryptosporidium levels from a given combination of conditions. Published by WERF. 132 pages. Soft cover.	\$493,952	99HHE2PDF	Completed	NA
Source Control	03-HHE-3	<i>Workshop on Source Tracking of Pathogens</i>	This report summarizes the result of a workshop of 45 experts representing water and wastewater utilities, academia, state and federal government agencies, medical institutions, and private laboratories that convened in San Antonio, Texas in February 2005. The objective of the workshop was to identify the knowledge gaps and research needs for application of microbial source tracking techniques by the wastewater and drinking water industries. The general conclusion was that there is a role for MST as long as it is part of an overall strategy that includes: multiple congruent methods; traditional land use, sanitary, and wildlife surveys; the geographic scale is not too large; and defined criteria of standardization, quality assurance and quality control, and measures of data quality are met. Published by WERF. 114 pages. Soft cover.	\$100,000	03HHE3PDF	Completed	7/20/05
Monitoring	01-WSM-2A	<i>Sensor Technology for Water Quality Monitoring: Bioluminescent Microorganisms</i>	This report documents efforts to generate new biosensor microorganisms for screening influent wastewater for toxicity to biological treatment systems. Building on previous WERF-sponsored research, the project team set out to create an effective influent toxicity monitoring system based on an array of biosensor organisms. Although the research team was not able to successfully develop a new biosensor microorganisms for screening influent wastewater for toxicity to biological wastewater treatment systems, this report provides valuable information on their efforts. The report details methodologies appropriate for the creation of new bioluminescent biosensors from bacteria that are common constituents of activated sludge and discusses potential pitfalls for future investigations. It also identifies potential areas for future and long-term research to take this work to the next level. Published by WERF. 76 pages. Softcover.	\$211,700	01WSM2APDF	Completed	NA
Monitoring	01-WSM-2B	<i>Sensor Technology for Water Quality Monitoring: Fiber-Optic Biosensor</i>	Rapid detection of waterborne pathogens, such as bacteria and protozoa, is essential for the timely treatment of contaminated water. This project investigates two methods for detecting the pathogens <i>Cryptosporidium parvum</i> and <i>Helicobacter pylori</i> : the Analyte 2000 [®] biosensor (a fiber-optic biosensor developed to detect chemicals), and real-time polymerase chain reaction (PCR). Both technologies employ recognition of specific DNA sequences in the target organisms. Although the team successfully created protocols for detecting <i>H. pylori</i> via real-time PCR, they did encounter difficulty proving the feasibility of the Analyte 2000 [®] biosensor for pathogen detection. The report documents their attempts at using this biosensor to measure DNA:DNA interactions. Published by WERF. 70 pages. Soft cover.	\$198,234	01WSM2BPDF	Completed	NA
Monitoring	01-WSM-2C	<i>Sensor Technology for Water Quality Monitoring: XRF Spectroscopy</i>	This project demonstrates that online monitoring of waterborne metals by x-ray fluorescence (XRF) at trace levels, which has been successfully applied in the power industry for several years, can be applied successfully in water and wastewater treatment plants. A specially designed online XRF monitor was assembled, tested in the laboratory, and used at the City of Alliance, Ohio Wastewater and Water Treatment Plants from July 2002 until March 2004. At various times throughout this project, the metals monitored included iron, copper, chromium, nickel, zinc, manganese, arsenic, cadmium, mercury, and lead. Published by WERF. 68 pages. Soft cover.	\$135,441	01WSM2CPDF	Completed	4/3/04
Monitoring	03-SW-2	<i>Development of a Protocol for Risk Assessment of Separate Stormwater System Microorganisms</i>	The primary objective of this investigation was to generate guidance to enable more accurate and defensible evaluations of stormwater microorganism data and the associated risks to human health from exposure to pathogenic microorganisms (i.e., pathogens) in stormwater. The project was designed to help public agencies begin to understand how to answer questions such as: which pathogens are present in stormwater; what are the potential health risks associated with exposure to these pathogens; what are the sources of pathogens in stormwater; and what can be done to manage the potential health risks? Published by WERF. 200 pages. Soft cover and online PDF. (2007)	\$300,731	03SW2PDF	Completed	7/24/07
Monitoring	04-SW-4	<i>Improved Monitoring Methods for Stormwater-borne Solids</i>	This project will lead to improved and more standardized methods to characterize stormwater and receiving waters that contain floatable substances, suspended solids, settleable particles, and/or gross solids. Improved methods will lead to better stormwater quality control strategies, increased effectiveness of BMPs and other facilities, and better protection of receiving water quality.	\$83,699	NA	In Production	5/1/07

Decentralized Approaches	03-SW-3	<i>Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction</i>	This report synthesized the results of a research initiative commissioned by WERF. Its purpose is to help define the current state of decentralized source controls for capturing rainwater where it falls and to present a plan for implementation of decentralized controls in an urban environment specifically for the goal of CSO mitigation. The primary focus of the applied research was how decentralized controls can reduce the volume of rainwater runoff generated and, consequently, entering the combined sewer system in urban areas. Published by WERF. 182 pages. Online PDF. (2006)	\$175,000	03SW3PDF	Completed	7/20/05
Decentralized Approaches	03-SW-3A	<i>Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction (Phase 2)</i>	NA	\$200,000	NA	Ongoing	4/10/07
Program Management	93-IRM-4A	<i>Watershed Level Risk Assessment</i>	This new report surveys the current status of integrating the watershed approach and the ecological risk assessment framework, and evaluates the potential for improving this integration under current federal regulations governing aquatic ecosystem protection. The report also evaluates examples of state program experience in implementing watershed-scale risk-based management. Included in this document are an analysis of existing programs and tools, a summary of state experience, and a review of watershed-scale ecological risk assessment case studies. Published by WERF. 236 pages. Soft cover.	\$94,000	NA	Completed	NA
Program Management	96-IRM-1	<i>Wet Weather Research Assessment</i>	This WERF report identifies information gaps and defines further research projects to fill those gaps. Provides a detailed introduction into major topic areas and includes a literature review/statement of the problem, research needs in the area, and key references. Twenty-six research topics are organized into 10 categories such as: sources and monitoring; receiving water impacts; management; models and decision support systems; regulatory policies and financial aspects; and storage treatment systems. Published by WERF. 1998. 270 pages. Soft cover.	\$64,884	D83005PDF	Completed	NA
Program Management	96-IRM-3	<i>Stormwater Environmental Indicators Pilot Demonstration Project</i>	Selects and demonstrates proposed stormwater environmental indicators and measures of success.	\$560,000	Executive Summary - ES-96-IRM-3.pdf	Completed	NA
Program Management	97-CTS-6	<i>Assessment of Decision Criteria Used to Determine Benefits of CSO/SSO/SW Investments</i>	This report presents the most current federal combined sewer overflow, sanitary sewer overflow, and stormwater policies. Communities will benefit from essential criteria presented as guidance for wet weather pollution abatement and from cost-benefit analysis procedures. Reviews a history of wet weather pollution management control strategies. Published by WERF. 164 pages. Soft cover.	\$200,000	D93014	Completed	NA
Program Management	00-WSM-5	<i>Global Lessons for Watershed Management in the United States</i>	Although the number and diversity of watershed management initiatives underway in the United States is impressive, successful transition to an integrated watershed management approach remains a challenge. This report identifies the promising watershed planning and management approaches from around the world; evaluates how they operate, their benefits and limitations; and assesses the degree to which these approaches could be successfully adapted to facilities in the United States. In addition to providing a decision-making framework of watershed management efforts at all scales in the United States, this report offers 10 key lessons for sustainable water management. Published by WERF. 292 pages. Soft cover.	\$165,200	00WSM5PDF	Completed	1/15/04
Program Management	00-WSM-6	<i>Strategies for Sustainable Water Resource Management</i>	Sustainable Water Resources Management (SWRM) can appear to be overwhelming, but really should not be considered as such. The key to SWRM is to start: pick an issue, form a team, and start the process. Nearly all the information you need is available within these reports. This Synthesis Report presents a framework and a set of guidelines for developing an implementation plan for SWRM. The framework accounts for the reality that the issue of sustainable water resources may not receive attention until a crisis occurs. But, it also encourages proactive planning to avert a crisis. These paths are summarized in a two-part process flow chart. The first part of the flow chart (Crisis Chart) deals with SWRM initiated in a crisis situation. The second part of the flow chart (Proactive Chart) deals with initiating SWRM as a proactive effort to avert crisis. Questions and selected examples are provided to help users understand the rationale and information needs for the implementation plan.	\$326,660	00WSM6A and 00WSM6B	Completed	7/8/03
Program Management	03-SW-4	<i>Infiltration vs. Surface Water Discharge: Development of Guidance for Stormwater Managers</i>	As stormwater managers seek to protect surface and ground waters from the impacts of polluted urban runoff, it is imperative to select the correct options for the desired goals and to understand the appropriate applications and restrictions of the different methods available for use. The older models often rely upon hand calculations and have many restrictions. Computer methods allow for the use of continuous simulation, but again, limitations exist, and in the case of a computer model, these restrictions are often not as obvious. This report focuses on the development of an overall strategy for selecting appropriate BMPs, and once selected, for selecting appropriate tools to design those BMPs. The report has a specific focus on the appropriateness of, sizing of, and prediction of the performance of infiltration devices. Published by WERF. 260 pages. Online PDF only.	\$75,000	03SW4PDF	Completed	6/20/05

Program Management	04-SW-3	<i>Infiltration vs. Surface-Water Discharge: Development of Guidelines - Phase II</i>	Planners and engineers who are responsible for managing municipal stormwater commonly make decisions that have the effect of infiltrating some stormwater and routing other stormwater to surface waters. These decisions are generally made on the basis of local conditions, policies, opportunities, constraints and regulatory requirements. In areas where the requirements of federal, state, and regional regulations impose inconsistent requirements, it is difficult for municipal agencies to decide upon a stormwater management strategy that complies with the obligations and also meets multi-objective environmental planning goals. Municipal stormwater planners and engineers would benefit from having a rational decision-making framework that would prompt them to consider the many local factors that should influence their decisions. Benefits: The guidance document would educate users about the spectrum of technical factors that should be considered during planning and would explain how these factors relate to the benefits and potential problems associated with infiltration and with discharges to surface waters. The document would provide a structured framework for keeping track of the num	\$200,000	NA	Ongoing	8/22/07
CSOs	92-TCR-2	<i>Optimization of Vortex Separator Removal Efficiencies for CSO Treatment</i>	This study covers preliminary findings and investigates the degree of contaminant removal achievable through the modification of vortex combined sewer overflow (CSO) control devices. This research specifically uses dissolved air flotation, UV disinfection and/or chemical addition. Published by WERF. 208 pages. Soft cover.	\$121,000	D41002PDF	Completed	NA
CSOs	00-CTS-4	<i>Assessment of Technologies for Screening, Floatable Control, and Screenings Handling</i>	This report provides guidance for utilities in choosing screening, floatable control, and screenings handling technologies that are appropriate for combined sewer overflows and wastewater under a variety of conditions. Utilities, consulting firms, and others involved in the design and operation of screening, floatable controls, and screenings handling systems will benefit from this thorough, unbiased assessment of current and emerging technologies. Choosing an appropriate technology can result in cost savings and increased operations efficiency. Published by WERF. 124 pages. Soft cover.	\$109,900	00CTS4PDF	Completed	NA
CSOs	00-CTS-6	<i>Best Practices for Treatment of Wet Weather Flows</i>	This report reviews available technologies to improve performance and efficiency of wet weather wastewater treatment and identifies potentially beneficial technologies and methodologies that are emerging. It assesses vortex separation, enhanced clarification, operational enhancements, flushing system, and disinfection technologies. It includes operation and maintenance requirements and cost for each. The information presented will help stormwater owners and operators choose the most appropriate, cost-effective technologies for their treatment plants. Published by WERF. 140 pages. Soft cover.	\$85,980	00CTS6PDF	Completed	7/20/05
CSOs	03-CTS-12	<i>Characterizing the Quality of Effluent and Other Contributory Sources during Peak Wet Weather Events</i>	Close the gap in the amount of useful wet weather water quality data and information needed to properly assess contributory impacts and verifying and comparing the cost effectiveness on in-plant wet weather flow management strategies with other options. The project will entail extensive field sampling and laboratory analysis before, during and after significant wet weather events.	\$400,000	NA	Ongoing	4/26/07
Infrastructure	97-CTS-3	<i>Innovative Materials and Techniques for New and Replacement Sewers</i>	This report identifies and evaluates new and alternative materials and techniques used in sewer systems and considers design developments and implications that have arisen from these new materials and methods. Published by WERF. 220 pages. Soft cover.	\$95,200	D00308PDF	Completed	NA
TMDLs	99-ECO-8UR	<i>Development of a Water Quality Model to Support Newport Bay, CA TMDL</i>	Newport Bay, Calif., served as a case study in this project to develop and implement a total maximum daily load (TMDL) for fecal coliform bacteria. This report provides an overview of the health risk assessment methodology used, a summary of the major findings from the risk assessment investigation, and a discussion of how the health risk methodology may be applied to other watersheds where impairment of beneficial use is in question. Researchers determined that evaluating the impairment of the REC-1 beneficial use requires a more rigorous and comprehensive health-based approach than that prescribed by the current regulations for recreational waters. Published by WERF. 120 pages. Soft cover.	\$256,000	99ECO8URPDF	Completed	NA
TMDLs	00-WSM-1	<i>Navigating the TMDL Process: Evaluation and Design</i>	This report discusses and evaluates technical tools used to develop TMDLs. Through a survey of state TMDL programs and a review of approved TMDLs, the project team addressed issues and problems with the current TMDL process. These issues include: estimating background pollutant loads, quantifying nonpoint source loads, incorporating urban wet weather sources, determining critical conditions, modeling in the TMDL process, estimating the TMDL margin of safety, approaches to allocating loads, linking best management practices to load reductions, implementing planning, tracking and adaptation, and adaptive watershed management in the TMDL process. The report suggests a range of improvements, alternative approaches, or available resources to address each issue. Published by WERF. 360 pages. Soft cover.	\$635,113	00WSM1PDF	Completed	NA

TMDLs	00-WSM-2	<i>Navigating the TMDL Process: Listing and Delisting</i>	This report provides a guide to assist states as they navigate the TMDL listing and delisting processes based on a review of several states and published literature. The report details a minimum set of activities states should undertake when making listing and delisting decisions, an investigation of their alternatives and options, and a comprehensive approach to the listing and delisting processes. Published by WERF. 112 pages. Soft cover.	\$226,323	00WSM2PDF	Completed	NA
TMDLs	01-WSM-1	<i>Navigating the TMDL Process: Narrative Criteria</i>	Qualitative narrative water quality criteria are difficult to incorporate into the quantitative TMDL process. In order to address this issue, this project team reviewed and evaluated 120 narrative TMDLs. The resulting report defines the range of problems associated with all types of narrative criteria, and provides guiding principles to help address those problems. Adhering to these guiding principles should significantly improve the evaluation of waterbodies for impairment due to nonattainment of narrative water quality criteria, resulting in more accurate 303(d) lists with a greater focus on truly impaired waterbodies. Published by WERF. 100 pages. Soft cover.	\$150,000	01WSM1PDF	Completed	NA
TMDLs	03-WSM-6CO	<i>Comparing Economics of Nitrogen Farming With Traditional Removal</i>	Nutrient control via large-scale treatment wetlands holds great potential for wastewater treatment plants. To better gauge that potential, this project conducted an economic analysis of conventional treatment in comparison with treatment wetlands based on the U.S. Environmental Protection Agency's recommended nutrient criteria. As a result, the project was able to derive cost equations for nutrient removal using conventional wastewater technology and treatment wetlands. Additionally, the project also created a nutrient removal model and associated parameters for treatment wetlands and demonstrated the savings in capital and operating costs that treatment wetlands can provide. Published by WERF. 58 pages. Soft cover and free online PDF.	\$50,000	03WSM6COPDF	Completed	11/1/04
TMDLs	02-WSM-2	<i>Navigating the TMDL Process: Sediment Toxicity</i>	This report focuses on application of Toxicity Identification Evaluations (TIEs). The U.S. EPA and others have developed sediment TIE procedures which are conducted using both the aqueous matrix (sediment interstitial water) and the solid-phase matrix (whole sediment). While literature has demonstrated that efficacy of TIE procedures for identifying causes of toxicity in effluents and receiving waters, their application to sediments is less well developed. WERF initiated this project to evaluate the current state of the science for accomplishing TMDLs in waterways listed as impaired for sediment toxicity, including the ability to identify the sediment-associated pollutants in need of management to restore water quality. Published by WERF. 192 pages. Soft cover and online and PDF. (2007)	\$500,000	02WSM2PDF	In Production	4/17/07
TMDLs	03-WSM-4CO	<i>Workshop on Adaptive Implementation in the TMDL Process</i>	Will develop guidance for adaptive watershed management with a focus on TMDL development and implementation. This will help states to meet and refine water quality standards and provide management strategies to address uncertainties in the TMDL process.	\$25,000	NA	In Production	4/26/07
TMDLs	03-WSM-5CO	<i>Identify Knowledge Gaps with Total Maximum Daily Loads (TMDL) and Drinking Water Utilities</i>	The Total Maximum Daily Load (TMDL) program focuses on restoring and protecting water quality primarily for recreational, aquatic life, and public health uses, but protecting drinking water quality is often neglected. This project explores the benefits of drinking water utilities' involvement in the TMDL process.	\$167,000	NA	Completed	NA
TMDLs	99-WSM-3	<i>Technical Approaches for Setting Site Specific Nutrient Criteria</i>	This project developed a methodology for deriving site-specific nutrient criteria (SSNC) for surface waters, including streams and rivers, lakes and reservoirs, and coastal estuaries. The methodology was developed to extend the specification of U.S. EPA regional nutrient criteria for more localized conditions characterized by particular desired water quality requirements or designated uses. The proposed SSNC methodology provides local stakeholders with a recipe for estimating nutrient criteria consistent with site-specific water quality management goals and objectives. SSNC can serve as effective alternatives to regional criteria and an efficient and economical approach for achieving site-specific water quality objectives. Published by WERF. 136 pages. Soft cover.	\$429,902	99WSM3PDF	Completed	1/15/04
Watershed Based Trading	97-IRM-5A	<i>Watershed-Based Trading Demonstration Project-Cherry Creek Reservoir, CO</i>	Comprehensively documents the development and implementation of the Cherry Creek Basin Water Quality Authority's trading program in Denver, Colorado, while highlighting several other trading programs. By identifying the similarities and differences in program design and linking those key elements to scientific, economic, and institutional conditions in the watershed community, this report examines some lessons, guidelines, and patterns emerging from the growing field of trading. Published by WERF. 130 pages. Soft cover.	\$201,320	D00310PDF	Completed	NA

Watershed Based Trading	97-IRM-5B	<i>Nitrogen Credit Trading for Long Island Sound Watershed</i>	This study tracked a watershed-based trading program in the Long Island Sound in Connecticut to help other municipalities develop and implement trading programs of their own. Nitrogen effluent credit trading offers an equitable and cost-saving approach for major point sources to meet nitrogen reduction requirements and total maximum daily load (TMDL) limits. Published by WERF. 132 pages. Soft cover.	\$160,824	D00300	Completed	NA
Watershed Based Trading	97-IRM-5C	<i>Water Quality Trading Demonstration-Kalamazoo River Watershed</i>	This report describes a program of watershed-based trading intended to reduce phosphorus and sediment loading in ed reaches of the Kalamazoo River in Michigan. Examines the environmental and economic benefits of trading between point and nonpoint sources. Identifies policy issues and technical design elements vital to the design of a statewide water quality trading program. Published by WERF. 282 pages. Soft cover.	\$100,000	D00311PDF	Completed	NA
Watershed Based Trading	97-IRM-5D	<i>Initiating Watershed-Based Phosphorus Trading in the Fox-Wolf Basin of Northeast Wisconsin</i>	This study tracked a watershed-based trading program in the Long Island Sound in Connecticut to help other municipalities develop and implement trading programs of their own. Nitrogen effluent credit trading offers an equitable and cost-saving approach for major point sources to meet nitrogen reduction requirements and total maximum daily load (TMDL) limits. Published by WERF. 132 pages. Soft cover.	\$100,000	D00300PDF and D00312PDF	Completed	NA
Watershed Based Trading	97-IRM-5E	<i>Establishing a Statewide Framework for Nutrient Trading in Maryland</i>	This report explores whether a market for nitrogen credits could help wastewater treatment plants in Maryland achieve cost-effective water quality objectives. The results of this study indicate that, compared with approaches that require all plants to attain equal nitrogen concentrations, trading options could achieve the same environmental objectives while saving millions of dollars. Published by WERF. 90 pages. Soft cover.	\$298,692	97IRM5EPDF	Completed	NA
Watershed Based Trading	01-WSM-6CO	<i>Watershed-Based Trading: A Guide for the Wastewater Community</i>	NA	NA	NA	Completed	4/17/07
Watershed Based Trading	02-WSM-1	<i>Water Quality Trading: Tools for Assessment and Implementation</i>	The objective of this 32-page user guide and workbook is to help stakeholders interested in water quality credit trading fill gaps in their understanding of trading, augment their capabilities to undertake a trading program, and facilitate trading deliberations at the watershed-level to help more programs meet watershed goals and objectives. The Powerpoint workbook includes a combination of information, analyses, guidance, examples, templates, checklists, model elements, and references that offer an organized, systematic process in the form of ready-made presentations. It assumes some prior general knowledge of watershed management programs and trading concepts. Published by WERF. CD ROM, online PDF, and Powerpoint workbook files. (2007)	\$100,000	02WSM1PDF	Completed	7/23/07

Current American Society of Civil Engineers Stormwater Research

Topic	Title	Abstract	Publication Type	Reference
BMP Model	<i>ANSWAPPS: Model for the Analysis of Grass Swale-Perforated Pipe Systems</i>	A computer model for the analysis and design of grass swale perforated pipe systems is presented. The model, which was calibrated and validated using experimental as well as field data, performs detailed computations for flow through the system on a lot by lot basis (i.e., from one catchbasin to another). Several parameters affecting the system performance are considered in the modeling approach. These especially included lot size and imperviousness, grass swale dimensions and its infiltration capacity, pipe length, number of orifices and their configuration, trench dimensions, and native soil infiltration capacity. The model was used to simulate the minimum trench depth required to capture runoff from a 25 mm storm for different native soils and different lot imperviousness ratios. Trench depths varied from 0.3 to 1.4 mm depending on native soil infiltration capacity and lot imperviousness.	Journal Paper	Journal of Irrigation and Drainage Engineering, Vol. 133, No. 3, May/June 2007, pp. 211-221 . (doi 10.1061/(ASCE)0733-9437(2007)133:3(211))
BMPs	<i>Field Survey of Permeable Pavement Surface Infiltration Rates</i>	The surface infiltration rates of 40 permeable pavement sites were tested in North Carolina, Maryland, Virginia, and Delaware. Two surface infiltration tests (pre- and postmaintenance) were performed on 15 concrete grid paver lots filled with sand. Maintenance was simulated by removing the top layer of residual material (13 — 19 mm). Simulated maintenance significantly (p<0.007) improved the surface infiltration rate. The median site surface infiltration rate increased from 4.9 cm/h for existing conditions to 8.6 cm/h after simulated maintenance. Fourteen permeable interlocking concrete pavers (PICP) and eleven porous concrete (PC) sites were also tested. PICP and PC sites built in close proximity to disturbed soil areas had surface infiltration rates significantly (p<0.0014 and p<0.0074, respectively) less than stable landscape sites. Median PICP surface infiltration rates of each condition were 80 cm/h and 2,000 cm/h, respectively. Median PC surface infiltration rates with and without fines were 13 cm/h and 4,000 cm/h, respectively. This study showed that: (1) the location of permeable pavements; and (2) maintenance of permeable pavements	Journal Paper	Journal of Irrigation and Drainage Engineering, Vol. 133, No. 3, May/June 2007, pp. 249-255 . (doi 10.1061/(ASCE)0733-9437(2007)133:3(249))
Highway Runoff	<i>Particle Destabilization in Highway Runoff to Optimize Pollutant Removal</i>	Sedimentation column studies and simulations using particle size distribution suggest that low removal efficiencies of smaller particles in highway runoff would be obtained using sedimentation if coagulation-flocculation is not performed. Coagulation-flocculation studies, using metal salts (alum and ferric chloride) and one organic polymer in three molecular weights, were evaluated over the 2004-2005 storm seasons. Only the first flush or approximately the first hour of runoff was coagulated. Efficiencies were quantified with particle size distribution measurements and turbidity. Results with low dosages of metal salts were ineffective and did not improve water quality. High dosages of metal salts using a sweep floc mechanism were effective in dramatically lowering runoff turbidity, but resulted in large quantities of sludge production and required pH control. A cationic organic polymer at low dosages (<10 mg/L) was effective in coagulating highway runoff and reducing particle charge. Extended mixing time was required to achieve low turbidities (~5 NTU). A combination of organic polymer, followed by small doses of alum (<10 mg/L)	Journal Paper	Journal of Environmental Engineering, Vol. 133, No. 4, April 2007, pp. 426-434 . (doi 10.1061/(ASCE)0733-9372(2007)133:4(426))
Highway Runoff	<i>Pollutant Mass Flushing Characterization of Highway Stormwater Runoff from an Ultra-Urban Area</i>	Water quality of highway stormwater runoff from an ultra-urban area was characterized by determining the event mean concentration (EMC) for several pollutants and by evaluating pollutant flushing. Thirty-two storm events were monitored between June 2002 and October 2003. Mean EMCs in mg/L were 0.035, 0.11, 0.22, 1.18, 420, 3.4, 0.14, 1.0, and 0.56 for Cd, Cu, Pb, Zn, total suspended solids (TSS), total Kjeldahl nitrogen (TKN), NO ₂ — N, NO ₃ — N, and TP. First flush as defined by flushing of 50% of the total pollutant mass load in the first 25% of the event runoff volume occurred in 33% of the storm events for NO ₂ , 27% for TP, 22% for NO ₃ and TKN, 21% for Cu, 17% for TSS, 14% for Zn, and 13% for Pb. Median values for the mass flushed in the first 25% of runoff volume were greater than the mass flushed in any 25% portion beyond the first for all pollutants. The mass in later 25% volume portions were greater than in the first 25% volume in at least 17% of the events for all pollutants, indicating that a significant amount of the pollutant load can be contained in later portions of the runoff volume. Nonetheless, management of the first 1.3 mm (1/2 in.) of runoff was able to capture 81 — 86% of the total pollutant mass.	Journal Paper	Journal of Environmental Engineering, Vol. 133, No. 6, June 2007, pp. 616-626 . (doi 10.1061/(ASCE)0733-9372(2007)133:6(616))

Rainwater Capture	<i>Sizing of Rainwater Storage Units for Green Building Applications</i>	<p>Green building design principles advocate the use of rainwater storage units to collect roof runoff during nonwinter seasons for landscaping, hardscape cleaning, and/or maintenance purposes, either in the form of rain barrels for smaller scale applications or cisterns for larger scale applications. This not only saves water which would otherwise be supplied from municipal water distribution systems but also reduces storm-water runoff which would otherwise be handled through urban storm-water management systems. The size of the storage units needs to be commensurate with the area of the roof and the desired water use rate. The local climate has an influence on the required size and achievable use rate as well. In this paper, analytical formulas are derived to estimate the required rainwater storage volume as a function of desired water use rate, reliability and local climate. In deriving these formulas, local climate characteristics are represented by probabilistic models and incorporated into the stochastic description of storage unit operating procedures and requirements. The resulting formulas may be</p>	Journal Paper	<p>Journal of Hydrologic Engineering, Vol. 12, No. 2, March/April 2007, pp. 197-205 , (doi 10.1061/(ASCE)1084-0699(2007)12:2(197))</p>
Land Use Modeling	<i>Utility of LANDSAT-Derived Land Use Data for Estimating Storm-Water Pollutant Loads in an Urbanizing Area</i>	<p>In many watersheds located in southern California, efforts are being focused on urban runoff because of its adverse impact on receiving water quality. The Sweetwater River watershed is a good example, where the drainage area is rapidly urbanizing and deteriorating reservoir water quality. Contaminated storm water is captured and diverted but as urbanization increases, additional runoff will be generated which will overload the existing infrastructure. To better manage the diversion systems and minimize future construction, storm-water volumes and pollutant loadings need to be estimated. Due to the lack of real-time storm-water runoff monitoring data, pollutant loadings must be estimated from land use information. We used satellite imagery to estimate selected storm-water pollutant loads and compared the results to predictions using land use information from public records. Satellite imagery was useful in estimating storm-water pollutant loads and identifying high loading areas. Satellite imagery with appropriate classification is a promising tool for watershed management and for</p>	Journal Paper	<p>Journal of Environmental Engineering, Vol. 133, No. 2, February 2007, pp. 203-210 , (doi 10.1061/(ASCE)0733-9372(2007)133:2(203))</p>
Water Quality Modeling	<i>Analytical Urban Storm Water Quality Models Based on Pollutant Buildup and Washoff Processes</i>	<p>This paper presents methodology and major procedures for the development of analytical urban storm water quality models following derived probability distribution theory, which involves conceptualization of the three major components, i.e., the rainfall—runoff transformation, pollutant buildup, and washoff processes. In this study, two different types of the rainfall runoff transformations are employed in an attempt to improve model performance by considering spatial variations of parameters associated with runoff generation mechanisms. By integrating different types of the rainfall—runoff transformations and pollutant buildup function with washoff function, two different types of pollutant washoff load models are formulated. Thereby, the probability distributions of the rainfall characteristics are mathematically transformed to create system storm water quality control measures, such as the average pollutant event mean concentration and long-term pollutant loads to receiving waters. These storm water quality control measures are closed-form analytical models and can be employed as</p>	Journal Paper	<p>Journal of Environmental Engineering, Vol. 132, No. 10, October 2006, pp. 1314-1330 , (doi 10.1061/(ASCE)0733-9372(2006)132:10(1314))</p>
Deicing Agents	<i>Calibrated Models of Deicing Agent Solids, Pavement Texture, and Specific Conductivity of Highway Runoff</i>	<p>Field data and existing theory suggest that pavement texture governs the seasonal persistence of deicing agent solids and the storm scale variability of the specific conductivity of highway runoff. We measured precipitation, runoff, and specific conductivity for 50 storms over four deicing seasons at a highway drainage system in southeastern Massachusetts. An average pavement texture of 2.44 mm was measured and 5.17_105 kg of calcium magnesium acetate, salt, and premix applications was reported as well. Catchments and a depression storage layer model the highway drainage system, which routes hyetographs and slowly dissolving deicing agent solids to storm scale hydrographs and specific conductivity pollutographs. We equate the average pavement texture to the depression storage layer depth, which receives applied deicing agent solids, controls their dissolution during a storm, and governs their seasonal scale persistence. The observed average pavement texture, precipitation, and deicing agent applications yield first flush (storm scale) specific conductivity values in the depression storage layer that range from a v</p>	Journal Paper	<p>Journal of Environmental Engineering, Vol. 132, No. 12, December 2006, pp. 1562-1571 , (doi 10.1061/(ASCE)0733-9372(2006)132:12(1562))</p>

		<p>to summer values two orders of magnitude lower. The winter maximum, or seasonal scale first flush of specific conductivity, would be lower for rougher pavement due to slower dissolution. The rougher pavement would also induce stronger persistence of deicing agent solids throughout the year, so that appreciable storm scale first flushes would occur in the summer.</p>		
BMPs	<p><i>Case Study: Design and Operation of Sustainable Urban Infiltration Ponds Treating Storm Runoff</i></p>	<p>Combined wetlands and infiltration ponds are cost-effective 'end of pipe' drainage solutions that can be applied for local source control as part of urban development and regeneration. The aims of this case study were to assess constraints associated with the planning, design, and operation of these ponds, the influence of aquatic plants on infiltration rates, and the water treatment potential. Storm runoff was first stored and treated in a constructed wetland before it overflowed into parallel infiltration ponds of which one was planted and the other one was unplanted. Three international best management practice design guidelines failed in practice. The presence of macrophytes in one infiltration pond had no significant influence on the drainage properties. The water quality of both ponds was not acceptable for water reuse directly after the system setup. Filamentous green algae within the unplanted pond were blooming in spring and summer creating an aesthetically unpleasing pond surface area. After 1 year of operation, barley straw and 'Carassius auratus (common goldfish) were introduced</p>	Journal Paper	<p>Journal of Urban Planning and Development, Vol. 132, No. 1, March 2006, pp. 36-41 , (doi 10.1061/(ASCE)0733 9488(2006)132:1(36))</p>
Economic Impacts	<p><i>Downstream Economic Benefits of Conservation Development</i></p>	<p>successfully to control the growth of algae.</p> <p>This paper evaluates the downstream hydrologic and economic impacts of development strategies that promote greater on-site storage of storm water. This paper applies a methodology to a specific case study that emphasizes flood risk reduction and drainage infrastructure. The estimates are at a first level of approximation. We use widely accepted simulation models and available data to compare alternative development scenarios for the 0.01 annual probability storm event. For a watershed in a rapidly developing area near Chicago, IL, reduced downstream flooding with the employment of conservation design practices generates from \$0 to 19,400/ha (\$0–7,800/acre) in downstream property value benefits over all affected areas. For comparison purposes, flood-damage estimation methods generate an average of \$16,800–\$24,200/ha (\$6,700–\$9,700/acres present value reduction in damages for the 0.01 probability flood event alone. The two methods yield conservative, but mutually reinforcing estimates. For infrastructure benefits, considering only downstream road culverts, the use of conservation design techniques upstream avoids \$3.3 million in</p>	Journal Paper	<p>Journal of Water Resources Planning and Management, Vol. 132, No. 1, January/February 2006, pp. 35-43 , (doi 10.1061/(ASCE)0733 9496(2006)132:1(35))</p>
Integrated Management	<p><i>Integrated Management of Irrigation and Urban Storm-Water Infiltration</i></p>	<p>costs of culvert replacement or upgrades. The sum of the downstream flood mitigation and infrastructure benefits amounts to \$920–1,440/developed hectares (\$380–590/developed acres) following conservation design practices.</p> <p>New microscale techniques have become available to assist urban designers in better water management. Urban water management has focused on two different areas: storm water and water supply. The focus of storm-water management is shifting toward low-impact development, which emphasizes better management of urban storm water through reductions in postdevelopment runoff by increasing on-site infiltration, while water supply planning has been enhanced by the emergence of end-use demand management, especially outdoor irrigation. Implementation of these two objectives requires examination of processes at smaller scales in order to evaluate changes being contemplated at a parcel level. A modeling approach is presented that incorporates decentralized options for management of both storm water and urban water supply. Management options that can be evaluated with this approach include restrictive irrigation policies and rainwater harvesting. A simpler model based upon Soil Conservation Service hydrology is then calibrated to the more complex model using a commercially available nonlinear</p>	Journal Paper	<p>Journal of Water Resources Planning and Management, Vol. 132, No. 5, September/October 2006, pp. 362-373 , (doi 10.1061/(ASCE)0733 9496(2006)132:5(362))</p>
		<p>optimizer. A method for comparison of costs and benefits from a consumer perspective is presented.</p>		

Highway Runoff	<i>Oil and Grease Measurement in Highway Runoff — Sampling Time and Event Mean Concentrations</i>	<p>An event mean concentration (EMC), usually collected with an automatic, flow-weighted composite sampler, is often used to characterize stormwater pollutants. Automatic samplers are not recommended for collecting oil and grease (O&G) samples due to possible biases associated with interactions with tubing and pumps. To measure the EMC without sampler interferences, a series of grab samples (often over ten samples) must be collected along with the flow measurement to compute the EMC. This paper examines 22 O&G pollutographs from small, impervious highway sites, to determine when a single O&G grab sample most closely approximates a flow-weighted composite sample. Samples collected within the first hour of a storm event overestimated the O&G EMC by 20 mg/L or more, while samples collected toward the end of the event underestimated the EMC. The best time to collect a single grab sample ranged from 1 to 6 h after the beginning of runoff, and was related to site or storm-specific factors. Results obtained from this study also showed that strong correlations ($R_{=0.9}$) exist between O&G and other organic constituents, such as</p> <p>chemical oxygen demand (COD) and dissolved organic carbon (DOC). Correlations also exist between O&G EMC, antecedent dry days, and total rainfall. Depending upon site and regulatory specific factors, using COD or DOC EMCs in lieu O&G samples may be a better strategy.</p>	Journal Paper	<p>Journal of Environmental Engineering, Vol. 132, No. 3, March 2006, pp. 415-422, (doi 10.1061/(ASCE)0733-9372(2006)132:3(415))</p>
Economic Incentives	<i>Opportunity Costs of Residential Best Management Practices for Stormwater Runoff Control</i>	<p>Excess stormwater runoff is a serious problem in a large number of urban areas, causing flooding, water pollution, groundwater recharge deficits, and ecological damage to urban streams. Solutions currently proposed to deal with this problem often involve large centralized infrastructure and high expense. Phase II of the Environmental Protection Agency's stormwater regulation is now requiring smaller communities nationwide to make important decisions about the potentially expensive management of excess stormwater runoff. This paper builds on research investigating the use of economic incentives to promote dispersed placement of smaller-scale best management practices (BMPs) for water detention to control excess runoff. We estimate a hedonic price function for houses in the area of a pilot project, and include the estimated part worth of yard area as our lower bound for opportunity cost in the cost function of the residential BMPs. We then show the effects of the inclusion of opportunity cost on two potentially useful incentive-based policy instruments available to communities.</p>	Journal Paper	<p>Journal of Water Resources Planning and Management, Vol. 132, No. 2, March/April 2006, pp. 89-96, (doi 10.1061/(ASCE)0733-9496(2006)132:2(89))</p>
BMPs	<i>Storm Water Detention Ponds: Modeling Heavy Metal Removal by Plant Species and Sediments</i>	<p>Laboratory and field studies were conducted to elucidate heavy metal removal by three wetland grasses and sediments in storm water detention pond. The removal of heavy metals including Cd, Cu, Pb, and Zn was mediated by fluid-flow intensity in the reactors. The growth of plants and the removal rates of contaminants were plant species dependent. All three wetland grasses removed contaminants from the spiked nutrient solutions. A first-order kinetic model adequately represented the removal of contaminants by plants. The analyses of undisturbed sediment cores in detention pond revealed strong stratification of heavy metal concentrations at the sediment-water interface. A simple model that integrates heavy metal removal by aquatic plants and sediments in storm water detention ponds is proposed. The model provides an estimate of contaminant residence time which can be related to hydraulic residence time in storm water detention ponds.</p>	Journal Paper	<p>Journal of Environmental Engineering, Vol. 132, No. 9, September 2006, pp. 1034-1042, (doi 10.1061/(ASCE)0733-9372(2006)132:9(1034))</p>
WQ Trading	<i>Implementation of the EPA's Water Quality Trading Policy for Storm Water Management and Smart Growth</i>	<p>A strategy has been presented to address conflicts that may arise in implementing smart growth initiatives in the face of the growing importance given to controlling nonpoint source pollutants. These pollutants are the result of urban development and subsequent storm water runoff and are regulated under the U.S. Environmental Protection Agency's (EPA's) Phase I and Phase II storm water requirements. The strategy is based on utilizing EPA's newly promulgated Water Quality Trading (WQT) Policy that seeks tradeoffs between development in different portions of a watershed. The strategy is consistent with regulatory requirements in providing a means to maintain compliance with water quality criteria in all portions of a stream, while providing a community with the flexibility to allow continued development in economically important areas. The strategy can be applied on a community-wide basis or in individual locations to support individual smart growth projects. Issues that must be addressed before WQT can be implemented are identified, along with potential solution strategies. Although additional effort is necessary to implement WQ</p> <p>growth, a framework has been established upon which subsequent work can be built.</p>	Journal Paper	<p>Journal of Urban Planning and Development, Vol. 131, No. 4, December 2005, pp. 258-269, (doi 10.1061/(ASCE)0733-9488(2005)131:4(258))</p>

<p>BMPs</p> <p><i>Optimal Location of Infiltration-Based Best Management Practices for Storm Water Management</i></p>	<p>A distributed hydrologic model of an urban watershed in the northeast United States was developed and combined with a genetic algorithm to determine the optimal location of infiltration-based best management practices (BMPs) for storm water management. The distributed, event-based hydrologic model integrates the curve number method with a distributed hydrologic network model of the catchment using a system of 4,533 hydrologic response units (HRUs). The infiltration-based BMP was conceptualized as an element that alters the infiltration/runoff partitioning of the HRUs in which it was applied. The results indicate that the optimal location and number of BMPs is a complex function of watershed network connectivity, flow travel time, land use, distance to channel, and contributing area, requiring an optimization approach of the type introduced here. A Pareto frontier describing the trade-off between the number of BMPs, representing project cost, and watershed flooding was developed.</p>	<p>Journal Paper</p>	<p>Journal of Water Resources Planning and Management, Vol. 131, No. 6, November/December 2005, pp. 441-448 . (doi 10.1061/(ASCE)0733-9496(2005)131:6(441))</p>
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Current The Center for Watershed Protection (CWP) Stormwater Research

source: http://www.cwp.org/stormwater_mgt.htm

Topic	Project Sponsor	Title	Project Profile	Publication	Status	Staff Contact
Watershed	CWP	<i>Watershed Restoration Manual</i>	The Center will produce a practical and useful manual on how to restore urban watersheds geared towards practitioners. The 300 to 400-page manual will present an integrated framework for urban watershed restoration, outline effective techniques for assessing urban watersheds, and provide a comprehensive review of watershed restoration techniques. The manual will be profusely illustrated, contain extensive case studies and applications, and include easy-to-use templates that agencies or organizations can directly use.	NA	Completed by: May 2004	T. Schueler
Maintenance	CWP	<i>Stormwater Maintenance Manual</i>	In this project, the Center is developing a set of web-based tools to help communities develop a state-of the art maintenance program. Stormwater practitioners will be able to download readily usable maintenance forms, updated maintenance cost data, ordinances, and other key elements of a good program.	NA	Completed by: TBD	T. Schueler
Land Value	CWP	<i>Benefits of Stormwater Management on Land Value, VA</i>	The Center conducted surveys in Virginia to document the positive impact of stormwater management on adjacent land values.	NA	Completed: December 2000	T. Brown
Pollutant Removal	CWP	<i>National Pollutant Removal Performance Database</i>	The National Pollutant Removal Performance Database, version 2 (Winer, 2000) consisted of 139 individual best management practice (BMP) performance studies published through 2000. The National Pollutant Removal Performance Database v. 3 was recently updated to include an additional 27 studies published through 2006. The updated database was statistically analyzed to derive the median and quartile removal values for each major group of stormwater BMPs. The data are presented as box and whisker plots for the various pollutants found in stormwater runoff. A brief technical paper (10 pp.) presenting this data is now available for direct free download.	http://www.cwp.org/Downloads/bmpwriteup_092007_v3.pdf	Completed: Sept. 2007	
Monitoring	CWP	<i>Evaluation of NPDES Phase 1 Municipal Stormwater Monitoring Data</i>	The University of Alabama and the Center for Watershed Protection were awarded an EPA Office of Water 104(b)3 grant in 2001 to collect and evaluate stormwater data from a representative number of NPDES (National Pollutant Discharge Elimination System) MS4 (municipal separate storm sewer system) municipal stormwater permit holders. The data are being collected and reviewed to both statistically describe the characteristics of this data and to provide guidance to permit writers for future sampling needs.		Completed by: TBD	T. Brown

Current Low Impact Development (LID) Center Available Research

source: <http://www.lowimpactdevelopment.org/research.htm>

Topic	Project Sponsor	Title	Project Profile	Publication	Completion Date
LID for Retailers	US EPA, Assistance Agreement	<i>Low Impact Development for Big Box Retailers</i>	This effort was funded by an EPA Assistance Agreement funded by the Office of Water. The recommendations or outcomes of this effort may or may not reflect the views or policies of EPA. The purpose of this project is to provide large building and site footprint high volume retailers with strategies that integrate innovative and highly effective Low Impact Development (LID) stormwater management techniques into their site designs for regulatory compliance and natural resource protection at the local levels. LID is an innovative approach to stormwater management that uses decentralized, or source, controls to replicate pre-development hydrology (stormwater) conditions. This approach can be used as an alternative or enhancement for conventional end-of-pipe stormwater pond technology. This alternative tool is important because of the potential to lessen the energy impacts of large concentrated volumes of runoff from conventional end-of-pipe approaches on receiving waters as well as reducing the development footprint and long-term maintenance considerations for end-of-pipe facilities.	http://lowimpactdevelopment.org/bigbox/lid%20articles/bigbox_final_doc.pdf	2005
Integrating LID into Building Programs	US EPA	<i>Municipal Guide to Low Impact Development</i>	The LID Center worked as a subcontractor to the National Association of Home Builders Research Center to develop two (2) LID brochures as part of a comprehensive outreach program. The brochures are used together to give municipal officials and builders basic information and guidance on how to initiate acceptance of LID and integrate it into local building programs.	http://www.lowimpactdevelopment.org/municipalguide.htm	2002
Incorporating LID into Community Design	National Fish and Wildlife Foundation Grant	<i>Arthur Capper Hope VI Housing Study</i>	The goal of this grant has two (2) purposes. First, demonstrate to the developer the feasibility of incorporating sustainable development strategies into the planning and engineering of the community. For this project, sustainable development techniques are defined as site and building design features that will be extremely effective at reducing pollutant loads to the Anacostia River while at the same time being capable reducing construction costs, public and private maintenance costs, and can enhance the appearance and economic value of the properties. The second goal is to provide the Department of Planning with a "framework" of strategies and techniques that can be negotiated and incorporated into the zoning and site design approval process for the community and determine the feasibility of having a largescale water feature that can be incorporated into a central community park for the development.	http://www.lowimpactdevelopment.org/lid%20articles/COG_lid%20report_4_12.pdf	2002
LID and CSO Retrofit	National Fish and Wildlife Foundation Grant	<i>Outfall 006 Retrofit Study</i>	The LID Center, in association with the Anacostia Watershed Society, is developing an LID retrofit plan for the District of Columbia Office of Planning. When completed, it will serve as a model process for the District and other jurisdictions in the Chesapeake Bay watershed. This is one of three (3) Legacy grants awarded annually by the National Fish and Wildlife Foundation (NFWF) as signature projects and is the first Legacy grant awarded to the District.	http://www.lowimpactdevelopment.org/anacostia/	2003
Policy	Natural Resources Defense Council (NRDC)	<i>Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows</i>	A policy guide for decision makers on how to use Green Infrastructure to address water quality and volume reduction for communities with Combined Sewer Overflow issues.	http://www.nrdc.org/water/pollution/rooftops/contents.asp	May 2006
BMPs	(National Cooperative Highway Research Program, NCHRP)	<i>Evaluation of Best Management Practices for Highway Runoff Control</i>	A policy guide for decision makers on how to use Green Infrastructure to address water quality and volume reduction for communities with Combined Sewer Overflow issues.	http://www.trb.org/news/blurbs_detail.asp?id=7184	5/31/2006

Current UNH Stormwater Center Research
source: UNH Stormwater Center 2005 Data Report
<http://www.unh.edu/erg/cstev/>

Topic	Project Sponsor	Title	Description	Publication #	Status	Last Updated
BMPs	CICEET and NOAA	<i>UNH Stormwater Center BMP Research Project</i>	Between September 2004 and August 2005, researchers evaluated 12 stormwater treatments for water quality performance and storm volume reduction during 11 rainfall runoff events with a range of characteristics. This analysis assessed water quality parameters such as pH, temperature, dissolved oxygen, specific conductivity, and turbidity, as well as pollutant removal, peak flow reduction, maintenance, cost of installation, and materials.	http://www.unh.edu/erg/cstev/pubs_specs_info/annual_data_report_06.pdf	Ongoing	NA
Porous Pavement & Salt Application	CICEET and NOAA	<i>Salt Reduction for Pervious Pavements</i>	Salting strategies are currently being studied to determine if reduced amounts of salt are adequate for use on a porous asphalt parking lot. Test-plot analyses, which include percentage of snow and ice cover, undissolved crystal mass, pavement temperature, dynamic friction factors, and required salt loads compared to standard application rates, demonstrate that porous asphalt requires as little as 0-25% less salt for winter maintenance than standard pavement. Higher frictional properties were recorded on porous asphalt with no salt addition than were observed for standard asphalt with a full application. The lack of standing water on porous asphalt greatly reduces the number of required applications during freeze-thaw periods and largely eliminates the formation of black ice. Report should be available by Fall 2007.	NA	In Progress	NA
Gravel Wetlands	CICEET and NOAA	<i>NH Department of Transportation I-93 Exit 2 Gravel Wetland</i>	The UNHSC has been collaborating with the NH Department of Transportation and the project's engineering consultant design teams (Vanasse Hangen Brustlin, and Louis Berger Group) involving the use of gravel wetlands as part of I-93 Corridor Expansion. The use of gravel wetlands for this project was instrumental to meeting permit requirements to prevent impacts to impaired waters within the watershed. Pilot gravel wetlands are planned for install in 2007. If the pilot projects are successful, it is conceivable that the gravel wetlands will be an integral component in future highway expansion.	NA	In Progress	NA

Current Villanova Urban Stormwater Partnership (VUSP) Research

source: <http://www3.villanova.edu/vusp/bmp.html>

Topic	Project Sponsor	Title	Description	Total Cost	Publication #	Status	Last Updated
BMPs	PADEP (319) and Villanova	Villanova Stormwater Wetlands	<p>An existing stormwater detention basin on Villanova University property has been converted into an extended detention wetland BMP (Center for Watershed Protection 1996) using the design concepts presented in the Pennsylvania Handbook of Best Management Practices for Developing Areas (PACD 1998). The stormwater wetland treats runoff from a 41 acre site that includes approximately 16 acres of impervious surface, that forms the headwaters of a watershed listed as medium priority on the degraded watershed list, and treats flows that impact a high priority stream segment on the 303(d) list. In the design and construction of the extended detention wetland, multiple meanders and gravel berms were placed to maximize water storage. A sediment forebay was installed off-center to allow for sedimentation of small to medium size storms, but to be bypassed by larger storms, so that resedimentation does not occur. Multiple wetlands plants were planted throughout the site to allow for competitive selection and maximum nutrient uptake. The site has been instrumented to collect flow and level data, as well as conductivity, dissolved oxygen, pH, and temperature</p> <p>measurements. Numerous presentations and tours have been conducted at the sight. An educational sign has been installed to enhance the learning experience. In November 2001, a statewide symposium was held at Villanova University, further showcasing the project. Research focusing on the pollutant removal and hydraulic performance of the stormwater wetlands is currently underway.</p>	52,070	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VUSP_Web_Folder/SW_web_folder/SW_main.html	Ongoing	NA
BMPs	PADEP (319) and Villanova	VILLANOVA STORMWATER BEST MANAGEMENT PRACTICE DEMONSTRATION PARK - Phase I – Planning	The purpose of the planning phase has been to develop the concept plan for a Stormwater Best Management Practice (BMP) Demonstration and Research Park on the campus of Villanova University (Fig.1). Originally intended for a three month period, this project far exceeded the original project deliverables. Already a substantial portion of the Stormwater BMP Park is in place, funded by Villanova and through other Growing Greener and Act 319 Non Point Source Pollution Grants.	32,694	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VUSP_Web_Folder/BMP-Park_web_folder/BMP_Park-Final_Report.pdf	Complete	01 June 2000 – 31 July 2002
BMPs	PADEP (319) and Villanova	VILLANOVA STORMWATER BIOINFILTRATION TRAFFIC ISLAND (Originally Bioretention)	<p>An existing traffic island was retrofitted to become a bio-infiltration BMP. The facility intercepts flows that would normally be captured by inlets and delivered through culverts to a dry detention basin without a chance to cleanse or infiltrate the stormwater runoff. Designed for the smaller storms (0 – 1.5 inches), the runoff infiltrates thereby reducing downstream stormwater volumes, stream bank erosion, and non-point source pollution to the headwaters of the Darby Creek. The advantage of this type of facility is the capture and infiltration of over 90% of the yearly rainfall. This will significantly reduce stream bank erosion and protect low baseflows during times of drought. As all the stormwater for these rainfalls is infiltrated, there is NO pollutant input to the headwaters for smaller storms. During larger storm events (2 – 100 year storms) a significant portion of the rainfall, as well as the first flush of pollutants is infiltrated. Flows over the capacity of the BMP go through the original culvert system to a dry detention pond.</p> <p>The bio-infiltration pond is incorporated within the "Best Management Practice Demonstration Park" on Villanova's campus, and joins the retrofitted stormwater wetlands, infiltration trench, porous asphalt and porous concrete site. To validate the performance of the device, rainfall and groundwater depth are monitored. In addition to those displayed on this website, results are included in the final report to the PaDEP.</p>	109,665	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VUSP_Web_Folder/TI_web_folder/GG-TI-Final_Report.pdf	Ongoing	31 May 2001 – 30 November 2002
BMPs	PADEP (319) and Villanova	Villanova Pervious Concrete Site	<p>The site is designed to capture and infiltrate storms of up to two inches of rainfall. From these events there is virtually no runoff from the site. Before the retrofit this rainwater would have runoff to the nearby first-order streams contributing to flooding problems which cause excessive stream bank erosion and sedimentation. Instead the rainwater now recharges the local groundwater and helps maintain baseflow in the same first-order streams. This recharge is especially crucial since Villanova University is located in the extreme headwaters of the watershed.</p> <p>The pervious concrete itself only drains the grass areas and some impervious areas of the entire 1.3 acre drainage area. The roof drains from the adjacent dormitories and some impervious areas are piped directly to the infiltration beds. The three infiltration beds are arranged in a cascade formation. The beds are approximately three feet deep and filled with AASHTO #2 stones which create approximately 40% void space in the beds. Here the rainwater is temporarily stored while it infiltrates back into the undisturbed soil below the beds. In extreme events when the capacity of the storage beds is exceeded, flows are The Pervious Concrete site is part of the Villanova University Stormwater</p>	186,500	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VUSP_Web_Folder/PC_web_folder/PC_main.html	Ongoing	NA

			BMP Park. It has been fully equipped with monitoring instrumentation. The site is instrumented to record rainfall using a standard tipping bucket rain gage. Movement of the rainwater through the undisturbed soil is measured using a series of twelve Water Content Reflectometers placed at various depths. A key component to measuring the effectiveness of the site is monitoring the amount of water leaving the site. For this task a V-notch weir was machined and installed. The weir, in conjunction with a pressure transducer provides accurate outflow measurements for the site.				
BMPs	PADEP (319) and Villanova	Villanova Infiltration Trench	<p>A network of PVC pipes collect runoff from approximately half of the parking garage (~1/2acre). The flow is routed into a bench where debris and sediment are removed. The flow is also measured and water samples can be taken inside the bench. The flow then enters a perforated distribution pipe where it is released into the stone bed. The stone bed provides temporary storage as the water slowly soaks into the surrounding soil. At the top of the storage bed there is an overflow pipe that allows flows in excess of the capacity of the trench to flow into an existing stormwater inlet. During extremely intense periods of rainfall the porous paver patio acts as a secondary overflow and the water flows over a grass strip and into the same stormwater inlet. One of the questions being answered through the ongoing research at the Infiltration Trench is the question of longevity. In order to maintain the infiltration capacity of the soil it is necessary to remove as much sediment and debris as possible. The inflow at the Infiltration Trench carries some small debris and sediment. Inside the pretreatment / monitoring bench a system of innovative Stormwater BMPs like the Infiltration Trench are still relatively</p> <p>new to the engineering profession. However in an effort to better manage our water resources, recent stormwater regulations are placing more emphasis on these types of practices. Therefore long-term performance data on these BMPs is essential. The monitoring and research being conducted at the Infiltration Trench focuses on both water quantity and water quality. The site has been instrumented to record rainfall, inflow, temperature, and depth within the stone storage bed. These parameters are being used to document how effective the BMP is at reducing the volume of runoff from the parking garage. Groundwater samplers (lysimeters) were installed at two and four feet beneath the bottom of the trench. These water samples along with samples taken from the inflow and from within the storage bed enable the site's water quality characteristics to be studied.</p>	27,900	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VJSP_Web_Folder/TI_web_folder/GG-TI-Final_Report.pdf	Ongoing	31 May 2001 – 30 November 2002
BMPs	PADEP (319) and Villanova	Villanova Green Roof	<p>Construction of Villanova's Green Roof took place in 3 days in the summer of 2006. The design was a retrofit of a small portion of Villanova's Center for Engineering Education Research (CEER) roof. The green roof is located on a second storey terrace above the "Holy Grounds" coffee shop. It is highly visible because it is located outside of the main stairwell and serves multiple purposes. By eliminating the first half inch of rain falling on that portion of the roof for any storm event.</p> <p>By providing research opportunities for students and possible quantification of the environmental advantages of a green roof.</p> <p>By providing a much more aesthetically appealing roof than its predecessor. Underlying the green roof is a traditional roof which was refinished in order to ensure maximum life of the green roof. The next layer is an additional waterproofing layer which is also resistant to root penetration. On top of this layer is an insulation layer which is a thick mat designed to keep the potential for a large temperature gradient between the surface of the green roof and the original roof layer. The insulation is overlain with a geosynthetic layer.</p> <p>serves several purposes including drainage pathways, water storage areas, and aeration. This layer which looks much like an egg crate has holes at the high points to allow excessive amounts of water to drain. A filter fabric lies on top of it and allows water to pass through but keeps the fine sediments from the growth media from occupying the voids in the drainage layer. The media is a mixture of baked minerals which look like gravel and make it hard for weeds or anything aside from the highly specialized Sedum species to grow.</p>	?	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VJSP_Web_Folder/GR_web_folder/GR_paper.html	Ongoing	planted 2006
BMPs	PADEP (319) and Villanova	Villanova Porous Asphalt BMP	The porous asphalt parking site was developed in June 2006 as part of the reconstruction of the University's athletic building, the Pavilion. The site previously consisted of a temporary gravel parking lot and a grass drainage swale. This best management practice (BMP), in conjunction with an underground retention basin, satisfies the runoff reduction required by state and local regulations for the development of the site. Monitoring and testing this site could help determine the effectiveness of such BMPs which are becoming more and more popular in construction as runoff reduction elements.	?	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VJSP_Web_Folder/PA_web_folder/PA_main.html	Ongoing	installed 2006

BMPs	PADEP	<i>Villanova Seepage Pit Site</i>	<p>Although the infiltration of stormwater is currently garnering much attention, it is not a new idea. Several seepage pits located on the southern side of Tolentine Hall, located at Villanova University in Villanova, Pennsylvania were discovered in July 2005. These seepage pits presented a unique opportunity to study the long-term impacts of infiltration. The history of these pits is still somewhat uncertain because of their age and a fire in Tolentine Hall in 1923. It is understood that the structures were built at the turn of the 20th century around the time Tolentine Hall, at the time called College Hall, was built. Originally, four pits existed in the area to collect and infiltrate stormwater off of Tolentine Hall, St. Thomas Monastery, and St. Thomas of Villanova Church which are located on the southwestern corner of the main campus. At the time of this research, two of the pits have been replaced by large box culverts and are no longer functioning as seepage pits. The pits are brick cylinders with sand bottoms. The pits were given names based on their location to certain buildings (i.e. "Monastery" and "Tolentine").</p>	?	http://egrfaculty.villanova.edu/public/Civil_Environmental/WREE/VUSP_Web_Folder/SP_web_folder/SP_main.html	Ongoing	discovered 2005
fecal	PADEP and USGS	<i>Fatty Acid methyl ester (FAME) Composition of Indicator Organisms for Microbial Source Tracking</i>	<p>In this research project, the host specific differences in the FAME profiles of total coliform (TC), fecal coliform (FC), Escherichia coli, and Enterococci isolated from the selected possible sources of fecal pollution are being investigated. The host categories include human (sewage samples), livestock (bovine, poultry, and swine), and wildlife (waterfowl and deer). Whole-cell fatty acids are identified and quantified by a gas chromatograph with flame ionization detector (GC/FID). The differences between the FAME profiles of different hosts are analyzed using multivariate statistical tools, mainly discriminant analysis (DA) and Principle Component Analysis (PCA).</p>		http://www3.villanova.edu/VUSP/to/MD/mst.html	Ongoing	September 2003 - present
hydrocarbons	?	<i>Determination of Hydrocarbons in Stormwater Runoff at the Villanova Stormwater Wetland</i>	<p>To evaluate the total hydrocarbon content in a stormwater runoff and baseflow at the Villanova Stormwater Wetland</p>	?	NA	NA	NA

Current The Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) Stormwater Research

source: <http://ciceet.unh.edu/>

(website has a great database system containing all this research information)

Topic	Project Sponsor	Title	Project Profile	Total Cost	Abstracts, Reports & Publications	Status	Project Start & End Date
Bioretention	CICEET	<i>Use of Sulfur Oxidizing Denitrifying Bioretention Systems for Control of Non-point Sources of Nitrogen</i>	Whether it comes from fertilizer, sewer overflows, animal waste, or atmospheric deposition, nitrogen is a common pollutant found in stormwater runoff. And when it hits coastal waters, nitrogen pollution can be an agent of dramatic and damaging change--fueling algal blooms, depleting oxygen, and ultimately disrupting ecosystems. One approach to treating polluted stormwater involves bioretention ponds that collect runoff and allow it to slowly infiltrate through plants, mulch, and sand. While this method successfully removes excess phosphorous, it's less effective on nitrogen. Building on a previous CICEET project, these researchers are adapting a system that employs sulfur and recycled oyster shells to remove nitrates from septic systems for use in bioretention ponds. If successful, it will provide a cost-effective, low maintenance method to reduce nitrogen in runoff.	\$189,098	http://ciceet.unh.edu/progressreports/2007/3_2007/sengupta06/	Ongoing	03/01/2006 - 03/01/2008
Monitoring Equipment	CICEET	<i>Development of highly affordable, environmentally friendly, sensor-like nutrient systems for high resolution remote monitoring.</i>	The biggest threat to coastal water quality comes from polluted stormwater runoff, which delivers, among other things, nutrient contamination directly into coastal waters. Nutrients like nitrogen and phosphorous can lead to harmful algal blooms that impact coastal environments and the economies. While nutrient analyzers for coastal ecosystems do exist, they tend to be cumbersome, costly, and complicated to use. This project's researchers are developing the NanoLAB: a small, field-ready nutrient monitoring system that incorporates time-tested wet chemistry nutrient assays. Researchers aim to develop a system that can be deployed in the field for as long as a month at a time, and have a programmable sampling frequency of a few minutes to several hours. This prototype will sample ammonium, nitrate, and orthophosphate. Researchers will also explore the incorporation of other standard tests to provide a versatile and cost-effective coastal monitoring tool.	\$240,345	http://rfp.ciceet.unh.edu/projects/abstract.php?chosen=206	Ongoing	07/15/2006 - 07/15/2008
Wood Filters	CICEET	<i>Field Demonstration of Wood Filter Technology for Stormwater Treatment</i>	Non-point source pollution, a byproduct of modern life, finds its way into coastal and estuarine environments via stormwater runoff. Once there, it impairs water quality, threatens fisheries and the local economy, and causes health problems. For many years, stormwater Best Management Practices were more adept at addressing water quantity than quality. However, methods that collect and trap water are often less successful in reducing dissolved contaminants. This project's investigators will explore the effectiveness of wood filters to bind organic and inorganic contaminants in stormwater. In field and lab studies, they will evaluate the use of different wood species and sizes, determine the filters' maintenance needs and life span, and create standard operating procedures for installation, maintenance, and disposal.	\$191,619	http://ciceet.unh.edu/briefs/boving_brief/index.html	Ongoing	09/01/2005 - 06/01/2008
Monitoring Equipment	CICEET	<i>Improved Performance Capabilities for the Acrobat Towed Instrument Platform: Data Collection, Calibration, and Interpolation/Graphic Visualization</i>	Excessive amounts of nutrients such as nitrogen and phosphorus from farm and stormwater runoff, and wastewater can fuel algal blooms in coastal waters. To respond effectively, coastal managers need to understand the scope and severity of coastal and estuarine oxygen depletion. The Acrobat, a small, undulating towed instrument, has successfully mapped the depth and distance of oxygen-poor zones. Increasing Acrobat's capability to collect other types of data, however, would give coastal managers a better understanding of the scope of low oxygen areas. This project's investigators plan to enhance Acrobat with the ability to collect multiple water samples and additional data such as dissolved oxygen while underway. An added GIS component will give managers a 3D graphical representation of dissolved oxygen distribution.	\$193,856	http://ciceet.unh.edu/progressreports/2007/3_2007/haas05/	Ongoing	09/01/2005 - 04/01/2008
Bioretention	CICEET	<i>Using Bioretention to Transport and Capture Pathogens from Urban Stormwater Runoff</i>	Polluted stormwater runoff is one of the greatest threats to water quality nationwide, and a critical management issue for small communities and large urban centers alike. As stormwater travels over parking lots, lawns, and fields, it picks up a variety of pollutants including heavy metals, nitrogen, oil, and grease. It also collects animal and human fecal matter containing pathogenic bacteria and viruses that threaten human health and fisheries. Many communities use bioretention facilities to trap and treat stormwater before it reaches the shore. These facilities combine physical, chemical, and biological processes to capture and transform pollutants. Building on a previous CICEET project that used soils and mulches to remove heavy metals, suspended solids, and nutrients, investigators will test a nature-based method of capturing and destroying pathogens. Keeping operational and maintenance costs of the low technology will be a project priority.	\$205,536	http://ciceet.unh.edu/briefs/davis_brief/index.html	Ongoing	09/01/2005 - 09/01/2008

Translation of NPS Pollution to Public	CICEET	<i>Science Translation for Non-point Source Pollution Control - A Cultural Models Approach with Municipal Officials</i>	Across the country municipal government officials, resource management agencies and the public are making land use decisions, including those that effect coastal watersheds. Environmental research that identifies and documents the scope, causes and consequences of degradation of coastal and estuarine resources can and should inform those decisions. For research to be useful in the decision making process it must be presented in a way that takes the audience perspective into account. This project will use cognitive and cultural models to gather information about the knowledge, attitudes, and information needs of the primary target audience for the Wells NERR Coastal Training Program. This information will be used to design and evaluate the effective translation of non-point source pollution information.	\$22,000	http://ciceet.unh.edu/progressreports/2005/8_2005/feurt03/	Completed	09/01/2003 - 09/01/2005
BMP Removal Efficiencies	CICEET	<i>Sorptive Clarification as an Environmental Technology to Passively Treat Stormwater from Elevated Transportation Infrastructure</i>	As watersheds continue to be developed, stormwater runoff delivers increasing amounts of contaminants, such as heavy metals, nutrients and particulate-bound microbial pathogens. To aid in the creation of effective best management practices (BMPs), scientific questions regarding the behavior and removal of particulate and associated contaminants from runoff must be answered. The goal of this project is to use new methods and technologies to better quantify the processes that form the basis of potential stormwater runoff treatment technologies.	\$144,302	http://ciceet.unh.edu/progressreports/2006/3_2006/sansal_0ne02/	Ongoing	09/01/2002 - 09/01/2005
Urban Growth and Predictions of Water Quality Impacts	CICEET	<i>Integrating Technologies to Monitor and Predict Patterns of Urban Growth</i>	Many estuaries in the US are impaired due to elevated levels of contaminant inputs. Estimates suggest that the leading sources of pollution to many estuaries are municipal/industrial point source and urban runoff/stormwater. To better manage watershed and estuarine resources, managers need an understanding of the spatial patterns of past and current development trends as well as the resulting impact on water quality. This project will develop a suite of GIS data layers representing a time series of urbanization for the area surrounding the Great Bay Estuary, NH. These data will then be added to economic, demographic, biophysical and transportation data to create a model that will gauge future development pressures and water quality impacts.	\$279,252	http://ciceet.unh.edu/progressreports/2005/8_2005/rubin02/	Completed	09/01/2002 - 09/01/2004
Monitoring and Pathogens	CICEET	<i>Real-Time Detection of Specific Pathogens with a Fiber Optic Biosensor and Determination of the Source of Bacterial Contamination Using Antibiotic Resistance Analysis and Ribotyping of E. coli in the GTM NERR</i>	As coastal areas are increasingly impacted by development and pollution from stormwater runoff and sewer discharges, there is an increasing need to rapidly and specifically identify microbial pathogens that can affect human health. This project will develop a fiber-optic biosensor assay for real-time detection of pathogens in natural waters. This research could result in considerable refinement of best management practices for coastal and estuarine systems.	\$198,433	http://ciceet.unh.edu/progressreports/2004/9_2004/harwood01/	Completed	09/01/2001 - 09/01/2004
Bioretention	CICEET	<i>Engineering Bioretention for Treatment of Stormwater Runoff</i>	A significant component of estuarine pollution arrives in the form of storm water. Bioretention—the use of soils and plants to filter pollutants from water—is a promising approach, but few studies have sought to optimize the technology. Specifically, it is vital to understand which soils and mulches are best for filtering different pollutants. The first year of this project will be dedicated to generating performance data for different soil mixes with regard to a suite of target pollutants. Experimental pollutants will include suspended solids, lead, nitrate, ammonium, phosphate, oil and grease. In the second year, different filtering materials will be tested at existing bioretention facilities. Pending results, data from this project can be used to create or improve storm water bioretention systems across the US.	\$186,187	http://ciceet.unh.edu/briefs/boving_brief/davis_report.pdf	Completed	09/01/2000 - 09/01/2002
NPDES Decision Support System	CICEET	<i>Development of a Decision Support Model for Compliance with the Clean Water Act National Pollutant Discharge Elimination System (NPDES) Stormwater Program</i>	In 1999, the EPA introduced the Phase II Storm Water Program in order to control pollution originating from small municipalities and construction sites. Complying with the new regulations will pose a significant challenge to local planners. The goal of this project is to create a computer-based decision support system (DSS)—both a database and a decision-making tool—to facilitate the compliance process. The result of this project will be a higher percentage of compliance with Phase II regulations, translating into less storm water pollution inputs into coastal and estuarine waters.	\$116,456	http://ciceet.unh.edu/briefs/boving_brief/ballester_report.pdf	Completed	09/01/2000 - 09/01/2002
Sediment Transport	CICEET	<i>Erosion Transport of Fine Sediments from Watersheds Tributary to NERR estuaries</i>	Protection and restoration of estuaries requires understanding the source, transport and fate of sediment-bound pollutants eroded from land and carried by rivers and streams into estuaries and the coastal zone. This study uses naturally occurring radioactive particles to trace the transport and fate of pollutants in estuaries. (Work is also being conducted at Weeks Bay NERR, in Alabama, and Old Woman Creek NERR, in Ohio.)	\$193,168	http://www.dnr.state.oh.us/Portals/3/publications/owc/images/owc.pdf	Completed	09/01/1998 - 09/01/2001
Water Quality Impacts	CICEET	<i>Water Quality Assessment of Stormwater Control Systems</i>	There are a number of different designs for stormwater control systems. However, it is not known how these different designs affect estuarine water quality. This project will measure the water quality differences between stormwater control systems that feed into the Great Bay NERR that have different geometry and flow characteristics.	\$200,001	http://ciceet.unh.edu/bulletins/ballester_0.html	Completed	09/01/1997 - 09/01/2000
Nitrate NPS Pollution from Septic Systems	CICEET	<i>Use of Permeable Reactive Barriers to Reduce the Release of Nitrate from Existing Septic Systems to Groundwater and Estuaries</i>	In U.S. coastal areas, nutrient enrichment is a very serious problem. Areas with a high density of residential septic systems can have significant nitrogen loading issues. New nitrate-removing septic systems are being developed, however, they are very expensive and don't address the problem of how to retrofit existing systems. The goal of this project is to develop low-cost, low-maintenance permeable reactive barriers that 1) stimulate microbial conversion of nitrate to nitrogen gas (denitrification), and 2) can be retrofitted with existing septic systems.	\$207,882	http://ciceet.unh.edu/progressreports/2005/8_2005/kinner02/	Ongoing	09/01/2002 - 09/01/2005

Current Misc. National Stormwater Research

Topic	Project Sponsor	Title	Project Profile	Source
BMPs	ASCE, US EPA, WERF, EWRI, FHWA, APWA	<i>International Stormwater Best Management Practices (BMP) Database</i>	The International Stormwater Best Management Practices (BMP) Database project web site, which features technical documents, software and database developed over the past decade. The overall purpose of the project is to provide scientifically sound information to improve the design, selection and performance of BMPs. To accomplish this goal, the Project Team has developed tools to promote scientifically-based collection and management of the data needed to evaluate the effectiveness of stormwater runoff BMPs. These tools include standardized BMP monitoring and reporting protocols, a stormwater BMP database, BMP performance evaluation protocols, and BMP monitoring guidance. Continued population of the database and assessment of its data will ultimately lead to a better understanding of factors influencing BMP performance and help to promote improvements in BMP design, selection and implementation.	http://www.bmpdatabase.org/Backup/index2.htm

University of Texas - Center for Research in Water Resources (Michael Barrett)

2002-2005 Post-Project Monitoring of BMPs/SUDS to Determine Performance and Whole-Life Costs: Research leader on project to develop data on performance and cost of stormwater management strategies. Joint US/UK study funded by WERF, AWWARF, UKWIR.
2001-2002 California Storm Water Program BMP Handbook Update: Providing guidance on the performance, design, and operation of structural BMPs for the update of the California handbooks. Project sponsored by the Statewide Stormwater Quality Task Force.
2002 Strategy for Assessing the Need for Treatment of Bridge Runoff: Project funded by TxDOT to evaluate relative impact of bridge stormwater runoff on water quality of rivers.
2001-2003 Characteristics of Compost: Moisture Holding and Water Quality Improvements: This project is assessing the potential impacts and improvements to stormwater quality from the use of compost amended soils in TxDOT construction projects. Evaluation will include investigation commercially available compost derived from feedlots, dairy wastes, biosolids, and poultry production. Co-PI with Joseph Malina, Jr.
2001-2003 Impact of Vegetated Hydraulic Conveyance Structures on Runoff Quality: Project funded by Caltrans to assess the effectiveness of existing vegetated medians, shoulders, roadside channels on removing pollutants in highway runoff. Providing technical guidance and oversight of the design, monitoring and evaluation of the collected data.
2001-2003 Review of Statewide Filtration Treatment Technology and Data: Providing oversight and technical review of a Caltrans funded program to establish the benefits of various media filtration systems for reducing the concentrations of the constituents of concern in highway runoff.
2001-2003 Prioritizing Water Quality Improvements for Meeting TMDLs in Texas: Principle Investigator in project funded by TxDOT to assess their liability under the TMDL program and to prioritize implementation of BMPs on state highways.
2001-2002 Urban Storm Water Quality Management: Instructor for 2-day continuing education course sponsored by ASCE. Course focuses on design, maintenance, operation and performance of structural BMPs.

University of Alabama (Robert Pitt)

Inappropriate Discharges				
1. Identify and describe the most common potential sources of non-stormwater pollutant entries into storm drainage systems.				
2. Describe an investigative procedure that will allow a user to determine whether significant non-stormwater entries are present in a storm drain, and then to identify the particular source, as an aid to the ultimate location of the source.				
http://unix.eng.ua.edu/~rpitt/Research/ID/CWP%20XCON%202001%20report.pdf				
Evaluation of NPDES Phase I Municipal Stormwater Monitoring Data				
This project will create a national database of Phase 1 stormwater monitoring data, provide a scientific analysis of the data, and provide recommendations for improving the quality and management value of future NPDES monitoring efforts.				
http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/Mainms4paper.html				
The National Stormwater Quality Database, Version 1.1, A Compilation and Analysis of NPDES Stormwater Monitoring Information (U.S. EPA Final report) (Alex Maestre and Robert Pitt, September 2005) (9061Kb)				
http://unix.eng.ua.edu/~rpitt/Publications/Stormwater%20Characteristics/NSQD%20EPA.pdf				

UCLA (Michael K. Stenstrom)

110. Khan, S., S-L Lau, M. Kavhanian and M.K. Stenstrom, "Oil and Grease Measurement in Highway Runoff-Sampling Time and Event Mean Concentrations," <i>Journal of Environmental Engineering</i> , ASCE, Vol. 132, pp. 415-422, 2006.
111. Park, M.H. and M.K. Stenstrom, "Spatial Estimates of Stormwater Pollutant Loadings Using Bayesian Networks and Geographic Information Systems," <i>Water Environment Research</i> , Vol. 78, pp. 421-429, 2006.
115. Kim, L-H., K-D. Zoh, S-M Jeong, M. Kavhanian and M.K. Stenstrom, "Estimating Pollutant Mass Accumulation on Highways during Dry Periods," <i>Journal of Environmental Engineering</i> , ASCE, Vol.132, pp. 985-993, 2006.
118. Li, Y., S-L Lau, M. Kavhanian and M.K. Stenstrom, "First Flush and Natural Aggregation of Particles in Highway Runoff," <i>Water Science and Technology</i> , Vol. 54, No 11-12, pp. 21-27, 2006.
119. Park, M-H and M.K. Stenstrom, "Using Satellite Imagery for Stormwater Pollution Management with Bayesian Networks," <i>Water Research</i> , Vol. 40, pp. 3429-3438, 2006.
121. Han, Y., S-L Lau, M. Kavhanian and M.K. Stenstrom, "Characteristics of Highway Stormwater Runoff," <i>Water Environment Research</i> , Vol. 54, No. 12, pp 2377-2388, 2006.
122. Park, M-H, I.H. Suflet, and M.K. Stenstrom, "Utility of LANDSAT-Derived Land Use Data for Estimating Storm-Water Pollutant Loads in an Urbanizing Area," <i>Journal of Environmental Engineering</i> , ASCE, Vol.133, pp. 203-210, 2007.
125. Kang, J.H., Y. Li, S-L Lau, M. Kavhanian, and M. K. Stenstrom, "Particle Destabilization in Highway Runoff to Optimize Pollutant Removal," <i>Journal of Environmental Engineering</i> , ASCE, Vol. 133, pp. 426-434, 2007.
126. Lee, H. X. Swamikannu, D. Radulescu, S-J Kim and M.K. Stenstrom, "Design of Storm Water Monitoring Programs," <i>Water Research</i> , Vol. 41, pp. 4186-4196, 2007.

Dissertations			
Kim, L-H., Monitoring and Modeling of Pollutant Mass in Urban Runoff: Washoff, Buildup and Litter, December 2002.			
Khan, Sabbir, Statistical Characterization of Stormwater Runoff and Environmental Implications: Oil and Grease, Heavy Metals			
	http://www.seas.ucla.edu/stenstro/d/d34		
Li, Sunny Particle Size Distribution in Highway Runoff: Measurement, Characteristics, and Management Implications, December, 2004.			
Ha, Simon Predictive Modeling of Stormwater Runoff Quantity and Quality for a Large Urban Watershed, 2006			
	http://www.seas.ucla.edu/stenstro/d/d42.pdf		

Appendix B

APPENDIX B

Current U of M Stormwater Research

source: personal communication

Topic	LID
Project Sponsor	MPCA & U of M
Title	<i>Performance of Low Impact Development Practices on Stormwater Pollutant Load Abatement</i>
Description	<p>In the proposed project, we will focus on the performance of low impact development (LID) practices and their impact on watershed pollutant load computations required for a TMDL study. The infiltration capacity testing methodology that we developed for rain gardens will be refined and expanded for other types of LID practices including infiltration basins and trenches, porous pavements, vegetative swales and filter strips. Several study sites adapting different types of LID practices will be selected and the long-term performance will be assessed using the infiltration capacity testing methodology. The recovery rate of infiltration capacity by maintenance and restoration will be also investigated. Based on the results from infiltration capacity testing, a TMDL demonstration study will be performed using different BMP scenarios. These include with and without BMPs, different BMP types and spatial allocation, and temporal performance deterioration of those BMPs. Pollutant load reduction will be estimated.</p> <p>This project will provide a methodology for planning, designing, and maintaining LID practices to meet TMDL regulatory requirements in urban watersheds. A computer model combined with the BMP assessment methodology will provide a better watershed TMDL analysis tool for planning, retrofitting and maintaining BMPs to comply with TMDL regulatory requirements on the watershed scale.</p>
Total Cost	\$935,000
Publication #	NA
Status	J. Gulliver
Contact	J. Gulliver
Topic	BMPs & Particle-size dist.
Project Sponsor	MPCA & U of M
Title	<i>Assessment and Maintenance of Stormwater Best Management Practices</i>
Description	<p>The work should be performed in two phases. Phase I, which is partially funded by the Minnesota Local Road Research Board at \$55,000, will improve the sampling technology to collect representative samples of the suspended sediment in stormwater runoff and to conduct the preparations necessary to develop a methodology to determine the suspended sediment size distribution in stormwater runoff across the state of Minnesota. Phase II of this work will be the development of the methodology to determine the suspended sediment size distribution in stormwater runoff, which involve the measurement of size distribution at a number of selected locations in the state of Minnesota which may be funded by other local or state agencies, e.g. the MWMO.</p>
Total Cost	NA
Publication #	NA
Status	final work plan - Sept. 2007
Contact	J. Gulliver

	<p>Proprietary underground devices are often used for stormwater treatment in urban areas to meet tight space constraints. Hydrodynamic separators are designed to remove suspended solids from stormwater runoff by sedimentation prior to discharge into lakes, rivers, and streams. Few data on the suspended solids removal performance of installed devices are available, and existing data are questionable because of the problems associated with assessment by monitoring. The objectives of our research are to: (1) investigate the feasibility and practicality of field testing to assess the performance of hydrodynamic separators as underground stormwater treatment devices, (2) evaluate the effects of sediment size and stormwater discharge on the performance of six devices from different manufacturers, and (3) develop a universal approach for predicting the performance of a device for any given application. In the field tests, a controlled and reproducible synthetic storm event containing sediment of a well defined size distribution and concentration was fed to a pre-cleaned device. The captured sediment was then removed, dried, sieved, and weighed.</p> <p>To assess the performance of the devices, suspended solids removal efficiency was related to a Peclet number, which accounts for two major processes that control performance: (1) settling of particles and (2) turbulent diffusion or mixing of particles. After analyzing the data, all devices showed similar behavior, therefore, a three-parameter performance function was proposed for all devices. Performance functions were developed from the result of the field tests and parallel testing of two other full-scale devices in the laboratory. The performance functions can be used to improve the selection and sizing of hydrodynamic separators and the assessment of their overall performance after installation.</p>
<p>Topic</p> <p>Project Sponsor</p> <p>Title</p> <p>Description</p>	<p>MnDOT</p> <p><i>Water Quality Performance of Dry Detention Ponds with Under-Drains</i></p> <p>This research is a field evaluation of the water quality performance of dry water quality ponds with under-drains. The evaluation is performed in terms of pollutant retention by measuring concentrations in the inflow and outflow from the pond. Three dry detention ponds, Mn/DOT pond 4012-03, Mn/DOT pond 4012-04 and a pond operated by Carver County, were investigated for their ability to remove total phosphorus, dissolved phosphorus, total suspended solids and volatile suspended solids. The measured influent concentrations of most parameters in storm water runoff at the Carver County dry detention pond with under-drains were substantially lower than concentrations typically mentioned in other studies throughout the nation and influenced the pollutant retention efficiency of the pond. This study confirmed that dry detention ponds with under-drains are an option for water quality control. The results of this study indicate that various storm water pollutants can be removed by dry detention ponds with under-drains. A comprehensive comparison of pollutant retention efficiencies of various dry detention ponds throughout the nation is also carried out in this study.</p> <p>Comparison of these values with the retention efficiencies of this study indicated that the pollutant retention performance of the Carver County pond was below the average expected performance of dry detention ponds but well within the expected variation, even with the low influent concentrations at the Carver County pond. This is an indication that the under-drains do provide improved pollutant retention when used with a dry detention pond.</p>
<p>Total Cost</p> <p>Publication #</p> <p>Status</p> <p>Contact</p>	<p>\$114,000</p> <p>NA</p> <p>Completed</p> <p>J.Gulliver</p>

<p>Topic</p> <p>Project Sponsor</p> <p>Title</p> <p>Description</p> <p>Total Cost</p> <p>Publication #</p> <p>Status</p> <p>Contact</p>	<p>BMPs</p> <p>LRRB</p> <p><i>Enhanced Sand Filtration for Storm Water Phosphorus Removal</i></p> <p>Batch studies with an initial phosphorus concentration typical of storm water were conducted at the University of Minnesota on C 33 sand, calcareous sand, limestone, three blast oxygen furnace BOF by-products, aluminum oxide, and chopped granular steel wool for the removal of dissolved phosphorus from synthetic storm water runoff. Based on the findings of these batch studies, sand filtration enhanced with steel wool, calcareous sand, or limestone has the potential to be a practical and cost-effective method of removing dissolved phosphorus from storm water runoff. Column studies are then performed on four enhancements with C 33 sand filtration: calcareous sand, limestone, chopped granular steel wool, and steel wool fabric. Synthetic storm water runoff with a variable dissolved phosphorus concentration passed through the columns while the flow rate was measured and effluent samples were taken and analyzed for total and dissolved phosphorus concentration and pH. As found in the batch studies, C 33 sand retained dissolved phosphorus but the capacity was quickly exhausted. Combinations of C 33 sand with limestone or calcareous sand clogged the columns and prevented them from draining completely. Steel wool, however, significantly increased the duration and level of phosphorus retention as compared to C 33 sand alone and did not clog the columns. Between 34 and 81% of the dissolved phosphorus was retained by the six steel-enhanced columns. Fine oxidized iron particles observed in the effluent are too small to be completely captured by typical geotextile fabric and may compromise phosphorus removal performance, but phosphorus adsorbed to iron oxide will be of limited bioavailability. Steel-enhanced sand filtration is modeled with contact time, total mass of phosphorus retained, and influent concentration as variables. Enhancing sand filtration systems with steel wool fabric would minimally increase installation costs and would increase the material cost by 3–5%. Based on these findings, steel-enhanced sand filtration is a potentially cost-effective treatment for removing dissolved phosphorus from storm water runoff.</p> <p>\$98,000</p> <p>Journal of Environmental Engineering, Vol. 133, No. 5, May 2007, pp. 485-497 , (doi 10.1061/(ASCE)0733-9372(2007)133:5(485))</p> <p>Completed</p> <p>J.Gulliver</p>
<p>Topic</p> <p>Project Sponsor</p> <p>Title</p> <p>Description</p> <p>Total Cost</p> <p>Publication #</p> <p>Status</p> <p>Contact</p>	<p>Source reduction</p> <p>MPCA</p> <p><i>Source Reduction</i></p> <p>Structural BMPs alone cannot provide sufficient pollution reduction to meet many urban water quality goals. Various forms of source reduction will always be needed to achieve major reductions of pollutant loadings. The ideal time to consider source reduction is during initial development, when improved construction and landscaping techniques can be used to reduce stormwater volumes, and when ESC programs can reduce the huge potential sediment load from construction. Source reduction also has considerable potential for previously developed sites. Much could be learned from prior efforts to change environmental behavior that could be applied to household lawn management as MS4 programs mature, especially where TMDL loading reductions are required.</p> <p>\$40,000</p> <p>http://wrc.umn.edu/outreach/stormwater/bmpassessment/assessmentmanual/</p> <p>Completed</p> <p>J.Gulliver</p>

Topic	Settling of solids in underground devices
Project Sponsor	LRRB
Title	<i>Settling of solids in underground devices</i>
Description	<p>Proprietary underground devices are often used for stormwater treatment in urban areas to meet tight space constraints. Hydrodynamic separators are designed to remove suspended solids from stormwater runoff by sedimentation prior to discharge into lakes, rivers, and streams. Few data on the suspended solids removal performance of installed devices are available, and existing data are questionable because of the problems associated with assessment by monitoring. The objectives of our research are to: (1) investigate the feasibility and practicality of field testing to assess the performance of hydrodynamic separators as underground stormwater treatment devices, (2) evaluate the effects of sediment size and stormwater discharge on the performance of six devices from different manufacturers, and (3) develop a universal approach for predicting the performance of a device for any given application. In the field tests, a controlled and reproducible synthetic storm event containing sediment of a well defined size distribution and concentration was fed to a pre-cleaned device. The captured sediment was then removed, dried, sieved, and weighed. To assess the performance of the devices,</p> <p>suspended solids removal efficiency was related to a Peclet number, which accounts for two major processes that control performance: (1) settling of particles and (2) turbulent diffusion or mixing of particles. After analyzing the data, all devices showed similar behavior, therefore, a three-parameter performance function was proposed for all devices. Performance functions were developed from the result of the field tests and parallel testing of two other full-scale devices in the laboratory. The performance functions can be used to improve the selection and sizing of hydrodynamic separators and the assessment of their overall performance after installation.</p>
Total Cost	\$160,000
Publication #	http://wrc.umn.edu/outreach/stormwater/bmpassessment/presentationsandpubs/index.html
Status	Completed
Contact	J.Gulliver

Topic	Road Salts
Project Sponsor	LRRB
Title	<i>Road Salt Effects on the Water Quality of Lakes in the Twin Cities Metropolitan Area</i>
Description	the results clearly show a continued degradation of the water quality of urban lakes due to application of NaCl in the watersheds. No acute damage has been observed, but the trend of increasing lake salinity is disturbing. Violation of existing water quality standards appears to occur in a few lakes occasionally. Road salt seems to be required for driving safety, but road salt application practices need to be implemented that also take into account the water quality trends in lakes, and in the groundwater.
Total Cost	NA
Publication #	Project Report No. 505
Status	Completed 2007
Contact	H. Stefan
Topic	Road Salts
Project Sponsor	MnDOT
Title	<i>Road Salt Budget for the Minneapolis/St. Paul Metropolitan Area</i>
Description	Application of salt (NaCl) by public agencies (state, county, municipal) is just one portion of the total salt use for winter road maintenance. Commercial contractors are responsible for areas such as commercial, school and private parking lots and driveways, and in some cases, township road maintenance. The number of commercial contractors and their road salt use in the TCMA could not be easily identified. To estimate the commercial salt use in the TCMA, market share amounts were used. The market share is 4 the percentage of road salt production and sale to the commercial sector. Since the TCMA matches national trends with regard to population growth and salt purchases, the average market share values of 13% and 20% were assessed using values by the U.S. Geological Survey and the Salt Institute, respectively. The U.S. Geological Survey (USGS) publishes a yearly minerals report, which contains this information. The Salt Institute (SI), an organization comprised of salt distributors, also publishes a national market share estimate annually. The Salt Institute value of 20% was used to determine the commercial use of road salt in the TCMA. The resulting an
Total Cost	NA
Publication #	NA
Status	Completed 2007
Contact	H. Stefan

Topic Project Sponsor Title Description Total Cost Publication # Status Description	Highway Runoff MnDOT <i>Design Tool for Controlling Runoff and Sediment from Highways</i> NA \$89,000 NA 12/1/2005-4/30/2008 This research is a field evaluation of the water quality performance of dry water quality ponds with under-drains. The evaluation is performed in terms of pollutant retention by measuring concentrations in the inflow and outflow from the pond. Three dry detention ponds, Mn/DOT pond 4012-03, Mn/DOT pond 4012-04 and a pond operated by Carver County, were investigated for their ability to remove total phosphorus, dissolved phosphorus, total suspended solids and volatile suspended solids. The measured influent concentrations of most parameters in storm water runoff at the Carver County dry detention pond with under-drains were substantially lower than concentrations typically mentioned in other studies throughout the nation and influenced the pollutant retention efficiency of the pond. This study confirmed that dry detention ponds with under-drains are an option for water quality control. The results of this study indicate that various storm water pollutants can be removed by dry detention ponds with under-drains. A comprehensive comparison of pollutant retention efficiencies of various dry detention ponds throughout the nation is also carried out in this study. Comparison of these values with the retention efficiencies of this study indicated that the pollutant retention performance of the Carver County pond was below the average expected performance of dry detention ponds but well within the expected variation, even with the low influent concentrations at the Carver County pond. This is an indication that the under-drains do provide improved pollutant retention when used with a dry detention pond.
Topic Project Sponsor Title Contact Total Cost Publication # Status Description	Stormwater Management USGS <i>An Evaluation of Storm Management in a Watershed of Minnesota Valley National Wildlife Refuge</i> NA \$72,823 NA 5/1/2004-9/30/2007 This research is a field evaluation of the water quality performance of dry water quality ponds with under-drains. The evaluation is performed in terms of pollutant retention by measuring concentrations in the inflow and outflow from the pond. Three dry detention ponds, Mn/DOT pond 4012-03, Mn/DOT pond 4012-04 and a pond operated by Carver County, were investigated for their ability to remove total phosphorus, dissolved phosphorus, total suspended solids and volatile suspended solids. The measured influent concentrations of most parameters in storm water runoff at the Carver County dry detention pond with under-drains were substantially lower than concentrations typically mentioned in other studies throughout the nation and influenced the pollutant retention efficiency of the pond. This study confirmed that dry detention ponds with under-drains are an option for water quality control. The results of this study indicate that various storm water pollutants can be removed by dry detention ponds with under-drains. A comprehensive comparison of pollutant retention efficiencies of various dry detention ponds throughout the nation is also carried out in this study. Com
	study indicated that the pollutant retention performance of the Carver County pond was below the average expected performance of dry detention ponds but well within the expected variation, even with the low influent concentrations at the Carver County pond. This is an indication that the under-drains do provide improved pollutant retention when used with a dry detention pond.

Topic	Highway Infrastructure
Project Sponsor	MnDOT
Title	<i>Impact of Alternative Storm Water Management Approaches on Highway Infrastructure</i>
Description	NA
Total Cost	\$121,896
Publication #	NA
Status	5/30/2003 -2/28/2006
Contact	John Nieber
Topic	Highway Construction
Project Sponsor	EPA
Title	<i>Design Tool for Controlling Runoff and Sediment from Highway Construction</i>
Description	Numerous experimental studies have been or are being supported by Mn/DOT and LRRB to understand erosion processes and to implement best erosion/sediment control practices. Nonetheless, extrapolating results from these studies to the myriad of construction conditions in Minnesota is difficult. It is best accomplished by using a theoretical framework that links together the many factors influencing erosion and sediment transport. An important first step in linking key processes was the development of the WATER (Watershed Assessment Tool for Environmental Risk) simulation tool. This model simulates the runoff and erosion for a single roadside construction unit and is limited to on-site erosion control practices. The proposed project expands the WATER model by including algorithms for off-site sediment control practices (such as detention ponds), by linking together multiple construction units and other land uses to simulate the response of watersheds, and by improving user friendliness with the use of spatial data sets. These additions are critically important in developing a model that is useful to erosion/sediment control practitioners.
Total Cost	NA
Publication #	NA
Status	NA
Contact	Bruce Wilson, John Nieber, Bruce Vondracek, James Perry

Current LRRB Stormwater Research

source: <http://www.research.dot.state.mn.us/browseresearch.asp?br=517>

stormwater search

No.	Title	Report No.	Report Date
1	Performance Assessment of Underground Stormwater Treatment Devices	2007-46	Jan-07

INV 834: This research 1) investigated the use of field-testing to access the performance of underwater devices designed to remove suspended solids from stormwater runoff, 2) evaluated the effects of sediment size and stormwater flow rate on the performance of four devices, and 3) developed a universal approach for predicting the performance of a device for any application. The results show that controlled field tests are an accurate and practical means to determine an underground device's performance.

2	The Cost and Effectiveness of Stormwater Management Practices	2005-23	Jun-05
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The results of this research can be used by planners and designers to estimate both the total cost of installing a stormwater management practice at a given site, and the corresponding total suspended solids and phosphorus removal.

3	Laboratory Measurements of Stormwater Quality Improvement in Detention Ponds	2004-21	Mar-04
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Pollution in detention ponds and constructed wetlands is a growing problem and this report takes a look at removal processes that are effective.

4	Improving the Design of Roadside Ditches to Decrease Transportation Related Surface Water Pollution	2004-11	Jun-03
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Properly designed strips of vegetation and swales that include peat and rock check dams can reduce the level of pollutants in stormwater runoff from road surfaces.

water quality search

No.	Title	Report No.	Report Date
1	Water Quality Performance of Dry Detention Ponds with Under-Drains	2006-43	Dec-06

This field research project evaluates water quality performance of three dry water quality ponds with under-drains and confirms these systems remove various storm water pollutants, and thus are an option for water quality control.

2	Impact of Alternative Storm Water Management Approaches on Highway Infrastructure: Project Task Reports - Volume 2	2005-49B	Feb-06
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In order to assist those highway professionals responsible for assessing appropriate applications of storm water management strategies, the authors review the strategies most commonly used in Minnesota and provide a framework for conducting assessments based on design, maintenance cost and impact on highway infrastructure.

3	Impact of Alternative Storm Water Management Approaches on Highway Infrastructure: Guide for Selection of Best Management Practices - Volume 1	2005-49A	Feb-06
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In order to assist those highway professionals responsible for assessing appropriate applications of storm water management strategies, the authors review the strategies most commonly used in Minnesota and provide a framework for conducting assessments based on design, maintenance cost and impact on highway infrastructure.

4	An Investigation of Water Quality in Runoff from Stockpiles of Salvaged Concrete and Bituminous Paving	96-31	Sep-96
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The objectives of this study were to determine the presence, quantity, and characteristics of leachates occurring in water runoff from salvaged pavement stockpiles and the possible impacts of these leachates on surface and ground water resources. The results of this study provide state, county and city engineers guidance on the selection of storage sites and best management practices for using recycled pavements.

5 [Quantity and Quality of Runoff from Selected Guttered and Unguttered Roadways in Northeastern Ramsey County, Minnesota](#)

964284

Jan-96

The specific objective of this study is to determine the loading of major ions, selected minor elements, and selected man-made organic compounds from guttered-section and unguttered-section roadways in Minnesota.

6 [Investigation of Water Quality in Runoff from Stockpiles of Salvaged Concrete and Bituminous Paving. An](#)

1996-311

Aug-95

The objectives of this study were to determine the presence, quantity and characteristics of leachates occurring in water runoff from salvaged pavement stockpile, and the possible impacts of those leachates on surface and ground water resources. The results of this study provide state, county and city engineers guidance on the selection of storage sites and best management practices for using recycled pavements.

Current and Recent WI DNR Research

source: A Summary of Cooperative Water-Resources Investigations in Wisconsin, 2006. (USGS)

Topic	BMPs
Project Sponsor	USGS, EPA, WI DNR
Title	<i>Effectiveness of a Pressurized Stormwater Filtration System in Green Bay, Wisconsin: A Study for the Environmental Technology Verification Program of the U.S. Environmental Protection Agency</i>
Report ID	Scientific Investigations Report 2004-5222
Period of Project	NA
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin</i>
Report ID	Scientific Investigations Report 2007-5156
Period of Project	May 2001 to September 2006
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Impacts of Urbanization on Infiltration</i>
Report ID	NA
Period of Project	July 2003 to September 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Bioretention Test</i>
Report ID	NA
Period of Project	July 2001 to October 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Impact of Phosphorus and Nitrogen Concentrations on the Biological Integrity of WI Streams</i>
Report ID	NA
Period of Project	March 2001 to October 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Lawn Fertilizer and Runoff</i>
Report ID	USGS Water-Resources Investigations Report 02-4130
Period of Project	March 1994 to Continuing
Topic	LID
Project Sponsor	USGS, WI DNR
Title	<i>Evaluation of the Effectiveness of Low-Impact Development Practices</i>
Report ID	NA
Period of Project	July 1998 to September 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Testing of High-Efficiency Street Sweeping on Highways</i>
Report ID	NA
Period of Project	October 2004 to September 2006
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Verification of Downstream Defender</i>
Report ID	NA

Period of Project	July 2005 to December 2007
Topic	Particle-size dist.
Project Sponsor	USGS, WI DNR
Title	<i>Particle-Size Distribution from Urban Land Uses and Source Areas</i>
Report ID	NA
Period of Project	July 2005 to September 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Characterization of Total Suspended Solids</i>
Report ID	NA
Period of Project	July 2005 to September 2007
Topic	BMPs
Project Sponsor	USGS, WI DNR
Title	<i>Soils Selection for Rain Gardens</i>
Report ID	NA
Period of Project	July 2005 to September 2007
Topic	Pollutant loads
Project Sponsor	USGS, WI DNR
Title	<i>Critical Periods of Pollutant Loading</i>
Report ID	NA
Period of Project	October 2005 to September 2007

Current and Past USGS Research

source: <http://pubs.er.usgs.gov/usgspubs/index.jsp?jboEventVo=PubResultView&jboEvent=Resort&pxorderby=1&ignoreme=Sort+Now>

Topic	Title	Report ID	Project Sponsor
BMPs	<i>Effectiveness of a Pressurized Stormwater Filtration System in Green Bay, Wisconsin: A Study for the Environmental Technology Verification Program of the U.S. Environmental Protection Agency</i>	Scientific Investigation Report 2004-5222	USGS, EPA, WI DNR
BMPs	<i>Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin</i>	Scientific Investigation Report 2007-5156	USGS, WI DNR
<p>MN183—Effects of Rain gardens on water quality: (USGS, Metropolitan Council) — Rain gardens are increasingly being used across the Nation and around the world as a storm-water management tool to temporarily store, filter, and encourage infiltration of runoff water while providing attractive landscaping. This project is designed to determine the potential benefits of selected rain gardens to remove contaminants from the runoff and thereby mitigate adverse effects on downstream waters. The effects of recharge on shallow ground-water quality also are being investigated. The first part of this study has been completed resulting in the scientific investigations report 2005-5189 'Effects of rain gardens on the quality of water in the Minneapolis-St. Paul metropolitan area of Minnesota, 2002-04' (SIR 2005-5189). The major findings of that report is that rain gardens reduce the concentrations of many components of runoff and enhance infiltration of water, and generally improve the quality of ground water beneath them. It is important to site rain gardens in locations where the soils are well drained to encourage infiltration. Additional sampling will be conducted during 2005-2007 at three of the sites to determine longer-term effects of rain gardens on water quality.</p>			
<p>MN222—Effects of Highway 169 expansion on the water-quality of tributaries to Mille Lacs Lake (USGS, MNDOT)—Water-quality and bed-sediments are being sampled in Seguchie Creek and wetland tributaries to Mille Lacs Lake. Sampling is planned to continue during the expansion of Highway 169 adjacent to Mille Lacs Lake. Analyses include nutrients, suspended and bed sediment, major ions and trace metals, (and semi-volatile organic compounds in wetland sediments). Real-time data include streamflow, water temperature and specific conductance at Seguchie Creek (05284305 and 05284310) here. Project may include ground water at later date.</p>			

Miscellaneous Local Stormwater Research

source: emails from practitioners

Three Rivers Park District

Measurement of volume reduction in soil areas amended with compost (on-going)
Long-term assessment of phosphorus-free fertilizers (completed, see MN Stormwater Steering Committee website for report)
Administration center rain garden (completed, see MN Stormwater Steering Committee website for report)
Bass Creek Business Park (completed, see MN Stormwater Steering Committee website for report)
Grass clippings (completed, see MN Stormwater Steering Committee website for report)
Eagle Lake Golf Course (completed, see MN Stormwater Steering Committee website for report)

Fortin Consulting, Inc.

Winter Maintenance Training for Reduced Impacts to Waters

EOR

Evaluation of the function of infiltration and biofiltration practices installed in RCWD (based on B. Asleson's research)
The infiltration impacts of bioretention - ground water impacts (partnering with U of M, RWMWD, Dept. of Health)

UMD

Paired neighborhood study looking at residential stormwater BMPs (I believe this a partner project with MPCA's social indicators project)

Met Council

Monitoring ground water beneath rain gardens for various pollutants (partnering with USGS)
Build up and wash off with particle-size distribution in Shingle Creek
Wetland buffer study looking at distance and water quality

Mississippi WMO/Minnehaha Creek Watershed District Joint Research Grant Program

Program Description

2008 Grants:

Project Name	Evaluation & Monitoring BMPs with wireless sensors
Contact	University of MN, Dept. of Civil Engineering
Cost	\$183,000
Summary	An innovative wireless sensor network will be used to obtain accurate, continuous, and instantaneous water quality and flow data. This data will be used to quantitatively evaluate stormwater best management practices and to improve the determination of sediment and nutrient total maximum daily loads. A wireless sensor network will be deployed along stretches of urban streams in the Twin Cities area.
Project Name	Plants and Media for Twin Cities Green Roofs
Contact	University of MN, Dept. of Horticultural Services
Cost	\$78,000
Summary	Many green roofs in the Twin Cities area do not survive because plants and media used are not based on local testing. This proposal identifies 1) what species survive locally, 2) the impact of media type and depth on survival, and 3) the impact of species on different environmental parameters.
Project Name	Burnsville Raingarden efficacy monitoring and cost evaluation
Contact	City of Burnsville
Cost	\$63,000

Summary This project will determine the long-term efficacy and cost-effectiveness of rainwater gardens with three years of monitoring to supplement the Burnsville Stormwater Retrofit Study paired watershed data. The overall monitoring results, cost-benefit analysis and BMP comparison, and recommendations for design and maintenance in retrofit and new developments will be published.

Project Name Estimating Size distribution of suspended solids in Minnesota Stormwater

Contact U of M, St. Anthony Falls Laboratory

Cost \$60,000

Summary A new sampling technology will be used in collecting representative samples of the suspended solids in stormwater runoff across the Twin Cities area, and a methodology will be developed to determine the size distribution of suspended solids in stormwater runoff. The study results will be incorporated into the Stormwater BMP Assessment Protocol.

Ramsey-Washington Metro Watershed District

Evaluation of 4 different proprietary stormwater treatment devices for partical size removal and water quality benefits (to be completed early 2009)

Impacts of Carp on resuspension of lake sediments and degradation of lake alum treatment (three year study beginning 2009)

Long-term infiltration results and performance of rain gardens, porous asphalt parking lot and green roof (ongoing)

Riley Purgatory-Bluff Creek Watershed District

Impacts of Carp on lake water quality

Appendix C

APPENDIX C

DRAFT 2008 – 2012 Nonpoint Source Management Program Plan (MPCA)

source: <http://www.pca.state.mn.us/water/nonpoint/mplan.html>

Goal 1: Jurisdictions Responsible for Unregulated Small Municipal Separate Storm Sewer System (MS4) Develop Comprehensive Runoff Management Programs (see EPA's National Management Measure to Control Source Pollution from Urban Areas).

Goal 2: Additional Best Management Practices (BMPs) and Better Site Design (BSD) Techniques are Advanced in Minnesota (see the Stormwater Steering Committee's Minnesota Stormwater Manual).

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Overcome barriers to Better Site Design •Research local codes and ordinances •Identify stakeholders •Conduct roundtable discussions to reach consensus •Implement code and ordinance changes			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
2. Evaluate and implement BSD through education/behavior change, incentive programs, or ordinances.				X	X	State, Local, 320	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
3. Evaluate and implement alternative BMPs such as rain gardens, porous pavement, green roofs, etc. that are located closer to the source of runoff.	X	X	X	X	X	State, Local, 321	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
4. Evaluate and implement infiltration to provide for ground water recharge.	X	X	X	X	X	State, Local, 322	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
5. Evaluate and incorporate into codes or ordinances unified sizing criteria (see Minnesota Stormwater Manual).				X	X	State, Local, 323	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
6. Model and evaluate potential impacts of proposed BMPs for site specific watersheds, neighborhoods, and water bodies.					X	State, Local, 324	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
7. Evaluate proper utilization and combinations of urban BMPs as appropriate with varying sets of circumstances within watersheds, such as: •pond design; •outlet flow controls; •wetland pretreatment and use; •wetland construction; •housekeeping; •erosion controls	X	X	X	X	X	State, Local, 325	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
8. Develop a program of stormwater credits which may include: •Natural Area Conservation •Site Reforestation/Prairie Restoration •Drainage to Buffers (stream, wetland or shoreline) •Surface Impervious Cover Disconnection •Rooftop Disconnection •Use of Grass Channels			X	X	X	State, Local, 326	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT

Goal 3: Address Load Allocation Reductions for Total Maximum Daily Loads Established due to Stormwater Runoff Impacting Impaired Water or Maintain Water Quality of a Water Body Threatened by Urban Runoff.

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Coordinate LGUs and stakeholders to assess and address threats to a water body within a watershed		X	X	X	X	State, Local, 319	MPCA, Met. Council
2. Implement structural or non-structural BMPs					X	State, Local, 320	MPCA, Met. Council
3. Monitor or evaluate effectiveness of BMPs					X	State, Local, 321	MPCA, Met. Council
4. Track BMP use within a watershed					X	State, Local, 322	MPCA, Met. Council
5. Develop guidance options to allocate urban runoff inputs to water quality for Total Maximum Daily Loads (TMDLs).	X	X	X	X	X	State, Local, 323	MPCA, Met. Council

Goal 4: Establish an Effective Technical Assistance and Education Delivery System.

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Delivery systems are focused with clear goals			X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
2. Benefits and barriers to achieving the desired goal are identified prior to implementation •Benefits are reinforced, created, or recommended to be enacted, •Barriers to meeting the goals of the education or technical assistance are addressed			X	X	X	State, Local, 320	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
3. Educational materials take into account age, cultural, ethnic, language and other audience differences as needed.				X	X	State, Local, 321	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
4. Outcomes of the education or technical assistance delivery system are measured to determine effectiveness of meeting the desired goals.			X	X	X	State, Local, 322	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Goal 5: Improve Urban Water Quality through Education and Technical Assistance Programs on the Application of Urban Runoff Best Management Practices Consistent with Goal 4 and Chapter 6 of this Plan.

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Education of children through such methods as school curriculum or water festivals	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
2. Expand and develop certification/training programs to address contractors, administrators and installers/inspectors. (319 funds would not be used for actual inspections, but for training).	X	X	X	X	X	State, Local, 320	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

3. Pool resources within a watershed or region for more effective outreach efforts.	X	X	X	X	X	State, Local, 321	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
4. Expand and develop both informational materials and educational workshops related to pollution prevention plans for education about compliance with the NPDES storm water program. Workshops would be targeted toward providing technical assistance to NPDES industrial, construction and MS4 permittees.	X	X	X	X	X	State, Local, 322	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT
5. Improve public education efforts related to urban impacts through such delivery channels as neighborhood networks, demonstrations, media coverage, advertisement, public service announcements, publications, and videotapes. Initial areas of emphasis would include: •Storm sewers (where they discharge to); •Lawn and garden chemical use, composting and debris disposal; •Construction (BMPs and erosion control); •Material handling (tanks, spills, hazardous materials solid waste, etc.); •Animal waste; •Public participation; •Litter (source controls, collection and prevention); •Imperviousness and the; need to mitigate runoff by running water over pervious surfaces or other measures; •Water collection and treatment system especially swales, sewers, & ponds. •Evaluating educational tools	X	X	X	X	X	State, Local, 323	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, MDA
6. Provide education to elected officials, their staff and consultants on impacts of land use on water resources and Better Site Design Principles	X	X	X	X	X	State, Local, 324	MPCA, MDNR, Met. Council, BWSR, UM

Goal 6: Minnesota Stormwater Runoff Stakeholders Work Together to Address and Prioritize Runoff Needs for the State.

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Stakeholders address and prioritize runoff needs including: •Education •Research •Coordination	X	X	X	X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

2. Continue to revise state manuals to reflect the findings of studies and experience gained locally and throughout the nation and publicize and document the work of the group.	X	X	X	X	X	State, Local, 320	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
3. Encourage the involvement of associations and non-governmental units in utilizing grant opportunities	X	X	X	X	X	State, Local, 321	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Goal 7: Research the Effectiveness of Urban Runoff Best Management Practices (see Appendix K of the Minnesota Stormwater Manual).

Milestones (Action Steps)	8	9	10	11	12	Funding Sources	Lead Agencies
1. Evaluate BMP life cycles •long-term effectiveness •costs including maintenance •acceptance of urban BMPs.				X	X	State, Local, 319	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
2. Research the performance of emerging and nontraditional BMPs including but not limited to: •Bioretention •Pervious pavement •Green roofs •Infiltration •Proprietary sediment removal devices •Long term performance data.		X	X	X	X	State, Local, 320	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
3. Assess the impacts of freezing, snow and snowmelt on the operation and effectiveness of existing and potential BMPs (BMP assessment).				X	X	State, Local, 321	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
4. Develop cold climate simulation tools					X	State, Local, 322	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
5. Research BMP effectiveness in contaminate removal for pathogens, toxins, and other emerging issue contaminants.					X	State, Local, 323	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
6. Research infiltration techniques including: •Soil amendments and deep ripping to increase infiltration •Effectiveness in cold conditions •Monitor, evaluate, identify or develop BMPs that protect ground water where it may be detrimentally impacted.		X	X	X	X	State, Local, 324	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
7. Develop stormwater runoff demonstration sites for research, monitoring and educational purposes. Publicizing of the sites can be done through being open to the public, published in sources such as the Minnesota Stormwater Manual, and/or cited in training materials.	X	X	X	X	X	State, Local, 325	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

8. Research low impact development and better site design techniques			X	X	X	State, Local, 326	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
9. Research on salt contamination: •Salt management including storage and application •BMPs •Alternative methods and products.	X	X	X	X	X	State, Local, 327	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
10. Research into updating TP-40 (Technical Publication 40, Hershfield, 1961) for precipitation analysis in Minnesota.				X	X	State, Local, 328	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM
11. Evaluate, identify or develop BMPs on ways to mitigate artificially extended "bankfull" flow in developed areas.		X				State, Local, 329	MPCA, MDNR, Met. Council, BWSR, MDH, MnDOT, UM

Appendix D

APPENDIX D

National Stormwater Research Needs

Great Bay, NH Research Needs (Workshop held October 2003)

1. Integrate and maintain long-term water quality data sets to improve accessibility and utility for multiple user groups.
2. Improve utility of existing information for land use planning by examining barriers to its use and developing an adaptable user-friendly clearinghouse to support the planning process, identify data gaps, and indicate future research needs (first determine need for such a product by
3. Identify and characterize species and communities at risk and better understand stressors responsible. Assess non-point nutrient sources such as septic systems, storm-water events, groundwater discharge, and agricultural contributions as part of an overall nutrient budget.
4. Define the extent and distribution of impervious surface at sufficient spatial scale to support research into its effects on adjacent habitats.
5. Investigate climate change level impacts on indicators in context of examining at risk communities.
6. Define a suite of indicator species (~10 to 20 potentially stratified by trophic level) that reflect the whole ecosystem condition and establish quantitative methods to monitor their abundance and condition.
7. Identify appropriate metrics for evaluating the effect of changing land use on natural resources.
8. Demonstrate and evaluate new approaches to minimize impervious surface and better manage stormwater in a variety of NH sites and conditions (i.e., evaluate the application of low-impact development approaches in NH conditions).
9. Evaluate factors that influence the effect of impervious cover on water quality (e.g., examine the role of different types, sizes and locations of buffers, the effect of different stormwater management and age of management facilities, the effect of different types of developed land use

Villanova Conference, October 2005

Research Needs (from Randy Neprash email)

1. Hydrologic/Hydraulic analysis tools that cover new design concepts in stormwater management
2. Examining and comparing commonly used methods and models
3. Maintenance and lifetime performance of BMPs (specifically bioretention)
4. Cost and Installation of BMPs
5. Temperature impacts
6. construction means and methods
7. Failures: are there commonalities among BMP failures
8. Overloading infiltration practices to see how they perform
9. Where to use structural or preventative measures
10. Getting upstream communities more aware of downstream impacts
11. More soil scientist involvement
12. After BMPs are inventoried follow up to see how they perform during flood events
13. Need to stress retrofitting - new regulations never improve what is already in the ground

14. Retrofit before stream restoration - understand ties between stormwater management and BMPs and stream restoration
15. How to keep standards more consistent
16. Support the installation of BMPs using cost analysis comparison to traditional practices

USEPA 2002, The 20 Needs Report: How research can improve TMDL program

1. Improve watershed and water quality modeling
2. Improve the science base concerning all stressors (pollution and pollutants) and their impacts
3. Improve information on BMP restoration or other management practice effectiveness, and the related processes of system recovery
4. Make monitoring more program-relevant and results-relevant
5. Develop and improve biocriteria, address other criteria gaps, and evaluate the potential for ecological water quality standards

Appendix E

APPENDIX E

Local Stormwater Research Needs

Local Needs (Brooke)–2007

1. Salt impacts on emerging biota during spring runoff events
2. Aesthetics standards required for public acceptance of native plantings
3. Sustainable education strategies for social change
4. Pond maintenance
5. Adaptation to climate change
6. Assessment of underground features such as perforated pipes and underground trenches
7. Depth that stormwater pollutants travel in the ground water
8. Cold weather functionality of BMPs
9. Long-term effectiveness of infiltration BMPs
10. Clay soils BMP research

UMN/MPCA/Met Council Stormwater Practice Assessment Program

Input sessions (June 2-9, 2005)

Top twelve stormwater practices needing further assessment

1. Rain gardens
2. Grass channels & swales
3. Constructed bioretention systems
4. Porous pavement and permeable pavers
5. Stream & shoreline buffers
6. Infiltration basins
7. Proprietary sediment removal devices
8. Erosion repair (shore land stabilization)
9. Street sweeping
10. Multi-cell ponds
11. Surface flow filters
12. Wet ponds

Specific performance information needs

1. Practice effectiveness, cost effectiveness, and longevity
2. Practice performance under cold weather conditions
3. Practice performance under specific soil, slope, and geological conditions
4. Groundwater impacts from stormwater infiltration practices
5. Potential negative impacts of practices including impact in urban infrastructure (e.g., roadbeds)
6. Maintenance procedures and costs
7. Need for a standard stormwater practice assessment protocol so data can be shared and trusted

Lessons learned

1. Good rainfall data is needed for monitoring sites in terms of both intensity and volume
2. Since stormwater monitoring only measures suspended solids, heavier bed load material is often not
3. Monitoring needs to be included in the practice design phase to avoid the need to retrofit
4. Two years of monitoring is required to "settle into" a site before reliable data can be taken and five years of

5. The level of effort required for reliable stormwater practice monitoring is high
6. It takes two seasons in northern MN to adequately establish vegetation on practices
7. Operation and maintenance considerations need to be included in practice design to assure equipment access,
8. Public works budgets need to be increased as stormwater practices are installed to assure their regular

Brooke's Thesis (August 2007)

1. Long term function of BMPs
2. Optimal performance requirements of rain gardens/infiltration practices
3. Maintenance requirements of rain gardens/infiltration practices
4. Optimal vegetation selection for improved infiltration, nutrient/pollutant removal and sustainability
5. Long-term concentration of nutrients and pollutants remaining in soil
6. Possible impacts of concentrating all pollutants to one area on ground water
7. Cation Exchange Capacity (CEC) of different soil mixtures and timeline for reaching its capacity to adsorb
8. Expected time length rain gardens can successfully treat stormwater with and without maintenance

MN Stormwater Steering Committee Needs - 2005

1. Performance of Emerging and Non-Traditional Best Management Practice (BMPs)

Data on the water quantity and quality performance of new BMPs or those not commonly used is desperately needed for the Minnesota climate. Such practices as bioretention, pervious pavement, green roofs, infiltration, and proprietary sediment removal devices are included in this need. Of particular need are the

2. Cold Climate Adaptations

Many of the suggested adaptations for cold climate BMP installation have not been adequately tested with installed system research. Building modified BMPs and collection of performance behavior is essential as we

3. Cold Climate Simulation Tools

MPCA is in the process of developing a new predictive tool for runoff and sediment from construction sites with funds provided by Mn/DOT, LRRB, and MPCA. It is expanding the model to include watershed scale (with more support by Mn/DOT and LRRB). It already provides an upgrade to the TP-40 approach. More work

4. Pathogen and Toxin Treatment

Few data exist on the effectiveness of BMPs on the removal of pathogens and many toxins of concern. Data collection on in-place effectiveness of various BMPs relative to these pollutants is needed.

5. Outdoor Labs Dedicated to Stormwater Study

MPCA staff has been promoting an outdoor laboratory at UMore Park. Long-term progress in understanding the performance of different stormwater systems require that inflow (rainfall and runoff) be controlled in

6. LID/BSD Construction and Maintenance

Low Impact Development (LID) and Better Site Design (NSD) techniques outlined in this Manual are common sense approaches to minimizing the impact of development, yet little research based guidance is available on the design features and follow-up maintenance needed to keep them functional. Maintenance

7. The Impact of Infiltration Practices

One of the themes of this Manual and of the changing field of stormwater management is soaking precipitation into the ground before it gets a chance to concentrate and mobilize surface pollutants. It has gone further and promoted infiltration as one of the major BMP processes that can effectively address stormwater. Unfortunately, many of the conclusions drawn on the water quality benefits of infiltration are anecdotal or based on research done in climates much different than Minnesota's. Comprehensive data collection on what happens in the ground water as a result of increased urban area infiltration is essential, especially in those many

8. The Impact of Salt

The application of NaCl to our roads and parking areas has had a negative impact on water quality. The public's need for safety, which absolutely must come first, directly conflicts with the judicious use of salt to keep road and parking surfaces ice-free. Recent data have shown increases in both shallow ground water and lake chloride (Cl) levels – a condition that has been detected in other cold climate portions of the world. Minnesota (Mn/DOT) has been a national leader on anti- and de-icing research, but we need continued research

9. Precipitation Patterns

TP 40 has been criticized for being out of date because of the changes that have occurred over the past 20 years in Minnesota's climate. Some effort has been started to update precipitation frequency tables for the state,

Local Needs (Cliff)-2001

1. Affects of NaCl concentrations on plants and wildlife in lakes and wetlands
2. Cost/benefit of various stormwater regulatory programs
3. Cost effectiveness of carp removal as a water quality initiative
4. Buffer effectiveness (how wide given a range of variables)
5. Effects of riprap on lake eco-systems
6. Impact of internal phosphorus load from built wetlands and other stormwater facilities in urban areas on
7. Impact of chip and deal programs that are widespread in MN
8. Cost effectiveness and effects of impervious surface limitations
9. Long-term impact of using natural wetlands to receive stormwater and the impact various pollutants have on these wetlands and the mitigation effects of pre-treatment
10. Effectiveness of street sweeping as a BMP and the benefits of new vacuum sweepers as compared to brush sweepers, is there a benefit to setting schedules & priorities
11. Testing the effectiveness (and cost-effectiveness) of alternative treatments methods for difficult situations
12. The effectiveness and benefit of child vs. adult focused educational activities
13. Maintenance requirements and cost of BMPs and the development of a manual
14. Effectiveness of bioretention in a cold-weather climate
15. Effectiveness/practicality of LID techniques in a cold-weather climate
16. Modification to practices and special management considerations in cold-weather climates
17. Impacts of snow plowing on various practices
18. Long-term effectiveness and maintenance costs of infiltration
19. Best technique to protect infiltration during construction
20. Evaluation of the most appropriate snowmelt event for spring snowmelt criteria storm event modeling
21. Testing performance of self-contained manhole systems for treatment and what does this mean
22. Infiltration systems - what % of annual rainfall can be infiltrated, threshold of impervious % above which loose effectiveness, influence of these systems on groundwater
23. Is their good data on the effectiveness of NURP ponds based on different sizes used for standard designs
24. How stormwater, both treated and untreated, affects the water quality, vegetative diversity/invasive species
25. Evaluation of alternative stormwater management methods focused on maintaining existing drainage
26. Aging of combined detention/wetland treatment systems and possible methods for mitigation
27. Watershed capacity and the threshold in development before adverse impacts are seen
28. Is the policy/approach to runoff management (flood control) controlling peak flows at the expense of
29. Centralized vs. decentralized approach to managing stormwater runoff and LID techniques, comparison of
30. % soluble phosphorus in runoff
31. Affects of various BMPs on groundwater
32. Water quality impact of urban plant litter in stormwater runoff
33. Impacts of lawn fertilizers on water quality

34. Relating dry-fall accumulation on impervious surfaces to stormwater quality
35. The effects of Carp populations on resuspension of lake sediments and internal phosphorus loads.