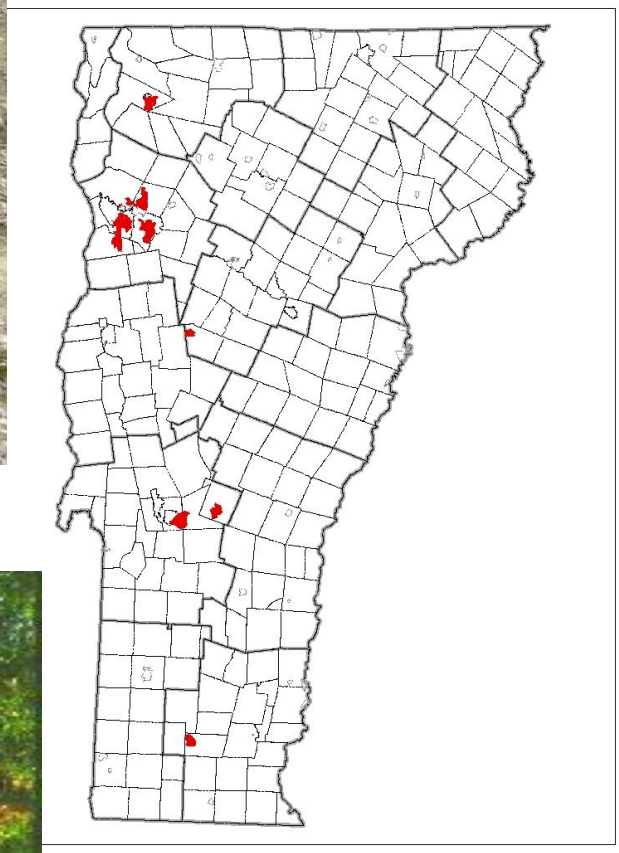
A Framework for Remediation of Vermont's Stormwater-Impaired Waters



VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

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Introduction

This report was originally prepared in December 2008 to describe the proceedings and outcome of a stakeholder process convened by the Vermont Department of Environmental Conservation to discuss issues relating to implementation of remediation plans for Vermont's seventeen stormwater impaired waters. The Executive Summary and Chapter 2 of this report have been updated to reflect substantive developments since December 2008. All other chapters and aspects of this report have not been significantly changed since the December 2008 draft, and continue to reflect issues discussed during the stakeholder process.

Executive Summary

Pursuant to 10 V.S.A. Section 1264(f)((3), the Vermont General Assembly directed the Vermont Department of Environmental Conservation to issue permits by January 15, 2010 to implement the Department's Total Maximum Daily Loads (TMDLs) and Water Quality Remediation Plans (WQRPs) for each of the seventeen stormwater-impaired waters on Vermont's 2004 Section 303(d) List of Waters required by the federal Clean Water Act (33 U.S.C.1313(d)). As discussed within this report, there are 12 "urban watersheds" – Allen, Bartlett, Centennial, Englesby, Indian, Moon, Morehouse, Munroe, Potash, Stevens, Rugg, and Sunderland Brooks; and 5 "mountain watersheds" - North Branch of the Deerfield River, Roaring Brook, East Branch of Roaring Brook, Rice Brook, and Clay Brook.

This report discusses the Department's creation of an overall framework for remediation of these seventeen stormwater-impaired waters and the permits that have been issued to require implementation activities.

It is crucial to recognize that there are no national models of implementation plans of the scale, nature and cost being requested of the Department. The number and scope of best management practices (BMPs) required to meet the TMDL flow reduction targets in these highly developed watersheds will be significant. Initial modeling of just one of these watersheds (Potash Brook) puts the cost of remediation at approximately $25.5 million dollars, and involves the construction of 236 retrofit BMPs (122 detention and 114 infiltration BMPs). Remediation activities across all seventeen watersheds will cost far greater.

Over the past several years, the Department's Stormwater Management Program has been actively engaged in developing EPA-approved TMDLs for Vermont's twelve urban stormwater-impaired watersheds and preparing water quality remediation plans (WQRPs) for five mountain stormwater-impaired watersheds. The Department has now completed EPA-approved hydrologic TMDLs for the twelve urban watersheds and is continuing to work with responsible parties developing watershed-specific WQRPs for the five impaired mountain watersheds.

In order to increase the chance of successful implementation and develop the most scientifically sound, cost-effective and administratively feasible implementation framework to serve as the foundation for issuing implementation permits, the Department:

- Researched existing TMDL implementation approaches across the country and federal and state permitting options available to the Department.

- Reconvened and held numerous meetings with the Vermont Stormwater Advisory Group (SWAG) to discuss implementation issues, approaches, and strategies. Active SWAG participants included representatives of state agencies (including VTrans, and Act 250), the U.S. Environmental Protection Agency, Conservation Law Foundation, Vermont Natural Resources Council, affected municipalities (including, Burlington, Winooski, Essex, South Burlington, Colchester, Shelburne, Rutland, St. Albans), the business community, individual homeowners, consulting firms, UVM, Lake Champlain Committee and regional planning associations.

- Developed a computer-based best-management-practice (BMP) decision support system to identify different BMP options and associated costs. This system will guide the development of watershed-specific BMP plans that will identify the full suite of BMPs required to meet TMDL flow targets.

- Actively engaged responsible parties in developing WQRPs for the five stormwater-impaired watersheds.

- Crafted an implementation framework that incorporates the Vermont Environmental Court's August 28, 2008 Judgment Order in In re: Stormwater NPDES Petition (Conservation Law Foundation Appeal) Docket No.14-1-07 Vtec. The Court's Order granted CLF's 2003 "Petition for Determination that Existing Discharges in Potash, Englesby, Morehouse, Centennial and Bartlett Brooks Contribute to Water Quality Standards Violations and Require NPDES Permits." The Order directed ANR to begin notifying existing unregulated dischargers of their obligation to apply for NPDES permits pursuant to the Department's "residual designation authority" under federal law.

This report provides an overview of the Department's research into TMDL implementation and permitting strategies and describes outcomes from the Stormwater Advisory Group (SWAG) process that was held during the summer of 2008. This research, combined with the valuable input of SWAG members, helped to shape the Department's overall implementation framework.

The main components of the Department's implementation framework for remediation of Vermont's seventeen stormwater-impaired waters are:

- Remediation of the twelve urban stormwater-impaired waters will commence through a combination of permits issued pursuant to Vermont's federally delegated National Pollutant Discharge Elimination System (NPDES) permitting program. These permits include a reissued and enhanced NDPES permit for small municipal separate storm sewer systems (MS4s) and a NPDES permit to certain designated discharges pursuant to the Department's "residual designation authority" (RDA) under the federal Clean Water Act.

- On January 22, 2010, the Department issued a draft General Permit (3-9014) for Stormwater Discharges from Small Municipal Storm Sewer Systems (MS4s). This

permit requires coverage for the designated MS4s in the urban area municipalities of Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, and Winooski, the University of Vermont, the Burlington International Airport and the Vermont Agency of Transportation. This draft permit contains detailed stormwater TMDL implementation requirements, including:

- Within the first three years of the permit, each MS4 permittee, in consultation with the Agency, shall work cooperatively with other MS4 permittees that discharge into the same stormwater impaired watershed to develop and submit a single, comprehensive Flow Restoration Plan for the stormwater-impaired watershed. The FRP shall contain the following elements: 1) an identification of the suite of necessary stormwater BMPs that will be used to achieve the flow restoration targets; 2) a design and construction schedule for the stormwater BMPs that have been identified as necessary to achieve the flow restoration targets; 3) a financing plan that estimates the costs for implementing the FRP and describes a strategy for financing the FRP; 4) a regulatory analysis that identifies and describes what, if any, additional regulatory authorities, including but not limited to the authority to require low impact development BMPs, the permittee will need in order for the permittee to implement the FRP; and 5) an identification of regulatory assistance that the permittee will need from the Secretary in order to effectively implement the FRP.

- Within ten years of the effective date of the permit, the permittee shall implement the measures identified in the Flow Restoration Plan as necessary to meet the flow restoration target.

- The draft MS4 General Permit by design places the initial responsibility on the MS4 permittes for controlling discharges from the MS4 system to the impaired streams to meet the flow restoration targets. The permit recognizes that responsibility for site-specific BMP implementation may be shifted to either a local or regional utility or to individual dischargers into the MS4 system as necessary to ensure implementation. The Department may issue additional RDA permits as necessary to ensure that any private dischargers into the MS4 system that are identified as a necessary component of BMP implementation participate in implementation activities.

- The Department has also issued a NPDES RDA permit with TMDL implementation requirements to over 450 individual dischargers to five of the 12 urban stormwater-impaired waters pursuant to the Vermont Environmental Court's August 28, 2008 Judgment Order which granted CLF's 2003 "Petition for Determination that Existing Discharges in Potash, Englesby, Morehouse, Centennial and Bartlett Brooks Contribute to Water Quality Standards Violations and Require NPDES Permits." The Department notified these dischargers of their obligation to apply for permit coverage by December 16, 2009. These identified stormwater discharges go directly to these impaired streams and do not enter or commingle with the stormwater discharges regulated under the MS4 permit. The TMDL implementation requirements in the RDA permit are geared for three categories of discharges, including:

- Designated Discharges from Property with Existing Impervious Surfaces that are Subject to a Previously Issued State Stormwater Permit. These dischargers must by June 30, 2011, conduct and submit to the Department an Engineering Feasibility Analysis (EFA) to determine the best opportunities for upgrading stormwater treatment on their site. No later than eighteen (18) months after the Secretary's approval of the analysis and associated BMP design plans, the permittee shall implement the stormwater BMPs for the designated discharge in accordance with the approved plans.

- Designated Discharges from Property with Existing Impervious Surfaces Greater than One Acre that do not have a Previously Issued State Stormwater Permit. These dischargers must by December 31, 2010 conduct and submit a Site Assessment (SA) performed in accordance with the Department's VTDEC Procedure for Site Assessments. If the Department determines after review of the SA and other available information that stormwater BMPs or other measures must be implemented or undertaken for the subject property in order to implement the applicable TMDL, the Secretary shall reopen the permit to specify and require implementation of these stormwater BMPs or other measures by the permittee. The Secretary shall require that these BMPs or measures be completed within 18 months of the effective date of the amended permit. Any amendment of the permit shall be subject to a formal notice and comment period. Also, by no later than October 15, 2010, the permittee shall maximize infiltration of stormwater runoff, prevent soil and eliminate soil erosion, and prevent and eliminate delivery of pollutants to stormwater conveyances. The Department has created a "Small Sites Guide for Stormwater Management" to assist property owners in meeting these requirements.

- Designated Discharges from Property with Existing Impervious Surfaces Less than One Acre that do not have a Previously Issued State Stormwater Permit. By no later than October 15, 2010, the permittee shall maximize infiltration of stormwater runoff, prevent and eliminate soil erosion, and prevent and eliminate delivery of pollutants to stormwater conveyances. The "Small Sites Guide for Stormwater Management" may be used to assist property owners in meeting these requirements.

- The implementation framework discussed in this report acknowledges that the Department will use staged adaptive implementation and management in TMDL implementation. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of practices and programs that are underway. In the adaptive management approach, first round stormwater controls are identified and implemented through permits (e.g. individual or general) or other strategies (e.g. municipal ordinances controlling discretionary runoff) in order to implement the TMDL. After an implementation period, monitoring is conducted and, based on an evaluation of the monitoring data, additional actions are required. This

process may involve successive iterations of permitting, implementation, monitoring and evaluation.

- The Department will continue to pursue federal funding for implementation activities and monies for studying the feasibility of a regional stormwater utility to foster remediation efforts.

- The Department will continue to work with responsible parties in developing Water Quality Remediation Plans (WQRPs) for Vermont's five stormwater-impaired mountain watersheds and will issue permits as appropriate to foster implementation. .

In sum, the Department believes that without careful and thoughtful planning, implementation will fail. Moreover, without a strong and reliable funding mechanism, implementation will be very difficult. The Department's implementation framework discussed in this report is supported by EPA guidance and by case studies of TMDL implementation efforts around the country.

Finally, it should not be overlooked that substantial progress has been made in recent years by MS4 permittees implementing stormwater clean-up projects in stormwater-impaired waters. The majority of these restoration projects have taken place as part of the MS4 General Permit program. Substantial additional work has also been done in St. Albans City, St. Albans Town, and Rutland City. Since 2001 over $14.8 million dollars have been invested in stormwater maintenance equipment and stormwater retrofits for treatment and control. Under the MS4 General Permit program, and through independent municipal actions, most of the MS4 municipalities have created new municipal stormwater management programs resulting in increased maintenance of their stormwater infrastructure, education and involvement of the public, the elimination of municipal wastewater or industrial wastewater connections from stormwater drainage systems, and greater oversight of new development during both the design, construction, and post-construction phases.

Since 2001, the MS4 municipalities have initiated twenty nine stormwater treatment and control projects in the stormwater-impaired waters with a total expenditure upon completion of over $10.6 million dollars; an additional seventeen projects have been initiated that directly benefit Lake Champlain or the Winooski River. Finally twelve additional projects have been initiated by private developers or non-MS4 municipalities in the stormwater impaired watersheds. These projects will remove tons of sediment and will contribute towards meeting the goals of the stormwater flow TMDLs. A rough estimate is that 15-20% of the target stormwater volume for six of the twelve watersheds has already been achieved thru these projects. In fact, 100% of the high flow target has been achieved in the Sunderland Brook watershed. The types of projects range from improved runoff management of municipal properties, to high efficiency street sweepers, to state of the art stormwater treatment retrofits. A list of the projects can be found in Appendix J.

Chapter One - Complexities of Implementation and Necessary Components for Successful Implementation

The Department was often pressured during the TMDL development phase to simply "issue the permits" to accomplish implementation. The Department has consistently resisted this approach, knowing that implementation will be complex and costly and that without careful planning and reliable funding implementation will fail, permits will be ignored, extensive enforcement efforts will be required and litigation will abound. In order to increase the chance of successful implementation, the Department has taken a more measured approach by exploring the issues and complexities of implementation, identifying the scientific uncertainties, developing a Stormwater BMP Modeling Tool to identify different BMP options and associated costs, researching the necessary components and benefits of different implementation plans, and actively engaging stakeholders.

The number and scope of stormwater best management practices (BMPs) required to meet the TMDL flow reduction targets in these highly developed watersheds is significant. Initial modeling of just one of these watersheds (Potash Brook) puts the cost of remediation at approximately $25.5 million dollars, involving the construction of 236 retrofit BMPs (122 detention and 114 infiltration BMPs). Examples of typical structural BMPs that might be required include: bioretention systems, stormwater ponds, stormwater wetlands, swales, and various infiltration practices.

To best ensure successful and cost-effective implementation, the Department, in collaboration with EPA and their principal contractor, Tetratech, Inc, has developed a BMP decision support system that considers type, sizing, and placement of BMPs and produces different combinations of BMPs that can be compared to TMDL targets. The BMP Tool can also be used to estimate the cost associated with each identified implementation scenario. Initial modeling results of different BMP implementation scenarios estimate that there will be an extremely high aggregate cost involved in the remediation work across all of the stormwater impaired streams.

It is important to understand that preliminary cost estimates are rough and costs are expected to rise significantly as implementation proceeds. Numerous implementation issues that may drive costs upward include:

- The inherent spatial limitations of the twelve urban stormwater-impaired watersheds will make them particularly difficult and time-consuming to evaluate when planning which BMPs to implement. Limited space also makes many BMPs impractical – e.g. construction of new stormwater systems.

- In some watersheds with significant TMDL flow reduction targets, remediation activities may require implementing a large number of small-scale BMPs, even down to the household level. This may require the creation of new permitting programs or ordinances (e.g. to require downspout disconnections) and the inherent enforcement issues associated with such an effort.

- There is limited environmental data and scientific uncertainty as to how and when remediation targets will be met – if at all - and differing opinions on the efficacy of proposed BMPs to achieve water quality standards. This may lead to disputes.

- Implementation is complicated by the need to include multiple parties in any proposed solution. Since the TMDL flow reduction targets may be met through a number of BMP combinations, decisions will need to be made as to who will have to implement BMPs. Issues of "fairness" will arise.

- Landowners will face difficult implementation issues such as physical site constraints, and difficulties in managing stormwater runoff to and run-on from properties over which they have limited control or access.

- The high cost of stormwater system retrofits is well documented. These costs will only increase over time due to increases in consultant and construction costs.

- BMP implementation may require the purchase of land for placement of stormwater treatment and control systems. Land costs are high and the need for any particular parcel of land under an implementation plan may drive its value upward.

- There is a limited pool of consulting firms in Vermont to perform the planning and implementation work necessary to implement seventeen TMDLs. The scarcity of firms may drive up consulting costs.

Taken together, these "on the ground" technical and administrative complexities and associated costs have increased the Department's determination to develop a fundable and step-wise approach to implementation. This approach is supported by EPA-sponsored research which has identified the following six critical components of successful TMDL implementation efforts:

1. **Adequate Funding** Successful TMDL implementation depends on the availability of resources to fund program development and operation. TMDL program coordinators from across the country report that the identification of funding sources and a commitment to funding projects throughout TMDL implementation are important factors in determining the success of the TMDL in restoring water quality. Developing a reliable funding stream is also essential to the ultimate success of the plan. Securing funding for each phase of implementation is critical for ensuring water quality improvements and maintaining stakeholder faith and investment as the project progresses.

2. **Stakeholder Engagement** Developing a TMDL implementation plan is a resource-intensive undertaking, requiring significant investments of time, money and technology. Without stakeholder engagement, the return on such investments can be disappointing. Early stakeholder involvement can also speed the implementation process. Achieving meaningful stakeholder involvement in the development of the TMDL implementation plan results in stakeholders with ownership of the plan and a willingness to implement the recommended BMPs. Development of a formal public involvement

process not only engages stakeholders, but also facilitates a government – stakeholder relationship.

3. **Government Agency Involvement and Cooperation** Successful TMDL implementation also requires a coordinated effort between engaged, local stakeholders, local governments and state agencies. Lack of communication and coordination between local governments and responsible agencies hinders implementation success.

4. **Sufficient Data** Successful TMDL implementation depends on the availability of monitoring data to assess progress in meeting the TMDL and inform adaptive management decisions. Case studies of successfully implemented TMDL plans consistently report the need for watershed monitoring both prior to TMDL implementation and after BMP installation. Further, the Center for TMDL and Watershed Studies identified the lack of monitoring data as a significant factor that hindered successful implementation of TMDL plans.

5. **Staging** Staged implementation is another common characteristic of successfully implemented TMDL plans. Staged implementation means that the implementation process follows a step-wise approach, with interim goals and milestones. This approach is an effective way to efficiently allocate limited resources. For example, a TMDL implementation plan can recommend BMPs in high priority areas in the impaired watershed during the first stage of implementation. Monitoring after the first stage can inform decisions about BMP implementation in subsequent stages. When resources are limited for TMDL implementation, staging provides a practical approach for comprehensive BMP implementation. Depending on the availability of tools and resources that exist in the watershed when implementation commences, certain BMPs can be installed up front, while plans are developed and funding streams established for the implementation of additional required practices. EPA fully supports this concept as a means of implementing TMDLs. (See Best-Wong Memo, EPA 2006)

6. **Adaptive Management** EPA also recognizes that staging can go hand in hand with adaptive management. (See Best-Wong Memo, EPA 2006). Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of practices and programs that are underway. In the adaptive management approach, first round stormwater controls are identified and implemented through permits (e.g. individual or general) or other strategies (e.g. municipal ordinances controlling discretionary runoff) in order to implement the TMDL. After an implementation period, monitoring is conducted and, based on an evaluation of the monitoring data, additional actions are required. This process may involve successive iterations of permitting, implementation, monitoring and evaluation.

Chapter Two - An Overall Implementation Framework for Vermont

In order to increase the chance of successful implementation and develop the most scientifically sound, cost-effective and administratively feasible implementation framework to serve as the foundation for issuing implementation permits, the Department:

- Researched existing TMDL implementation approaches across the country and federal and state permitting options available to the Department.

- Reconvened and held numerous meetings with the Vermont Stormwater Advisory Group (SWAG) to discuss implementation issues, approaches, and strategies. Active SWAG participants included representatives of state agencies (including VTrans, and Act 250), the U.S. Environmental Protection Agency, Conservation Law Foundation, Vermont Natural Resources Council, affected municipalities (including, Burlington, Winooski, Essex, South Burlington, Colchester, Shelburne, Rutland, St. Albans), the business community, individual homeowners, consulting firms, UVM, Lake Champlain Committee and regional planning associations.

- Developed a computer-based best-management-practice (BMP) decision support system to identify different BMP options and associated costs. This system will guide the development of watershed-specific BMP plans that will identify the full suite of BMPs required to meet TMDL flow targets.

- Actively engaged responsible parties in developing WQRPs for the five stormwater-impaired watersheds.

- Crafted an implementation framework that incorporates the Vermont Environmental Court's August 28, 2008 Judgment Order in In re: Stormwater NPDES Petition (Conservation Law Foundation Appeal) Docket No.14-1-07 Vtec. The Court's Order granted CLF's 2003 "Petition for Determination that Existing Discharges in Potash, Englesby, Morehouse, Centennial and Bartlett Brooks Contribute to Water Quality Standards Violations and Require NPDES Permits." The Order directed ANR to begin notifying existing unregulated dischargers of their obligation to apply for NPDES permits pursuant to the Department's RDA authority.

During the SWAG stakeholder meetings on implementation issues, a number of SWAG members gave support to the concept of placing the initial responsibility for TMDL implementation on the MS4 permittees. This approach requires the MS4 permittees to work with the Agency to develop watershed-specific BMPs plans that will then be implemented through the most effective combination of municipal-led and private entity-led retrofit projects. The use of the RDA permit for TMDL implementation was not a part of SWAG discussions and was not considered by the Department in formulating its initial thoughts on implementation. The RDA

permit was incorporated into the Department's implementation framework as necessitated by the Vermont Environmental Court's Judgment Order.

The main components of the Department's implementation framework for remediation of Vermont's seventeen stormwater-impaired waters are:

- Remediation of the twelve urban stormwater-impaired waters will commence through a combination of permits issued pursuant to Vermont's federally delegated National Pollutant Discharge Elimination System (NPDES) permitting program. These permits include a reissued and enhanced NDPES permit for small municipal separate storm sewer systems (MS4s) and a NPDES RDA permit to certain designated discharges to five of the urban stormwater-impaired streams.

- On January 22, 2010, the Department issued a draft General Permit (3-9014) for Stormwater Discharges from Small Municipal Storm Sewer Systems (MS4s). This permit requires coverage for the designated MS4s in the urban area municipalities of Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, and Winooski, the University of Vermont, the Burlington International Airport and the Vermont Agency of Transportation. This draft permit contains detailed stormwater TMDL implementation requirements, including:

    - Within the first three years of the permit, each MS4 permittee, in consultation with the Agency, shall work cooperatively with other MS4 permittees that discharge into the same stormwater impaired watershed to develop and submit a single, comprehensive Flow Restoration Plan for the stormwater-impaired watershed. The FRP shall contain the following elements: 1) an identification of the suite of necessary stormwater BMPs that will be used to achieve the flow restoration targets; 2) a design and construction schedule for the stormwater BMPs that have been identified as necessary to achieve the flow restoration targets; 3) a financing plan that estimates the costs for implementing the FRP and describes a strategy for financing the FRP; 4) a regulatory analysis that identifies and describes what, if any, additional regulatory authorities, including but not limited to the authority to require low impact development BMPs, the permittee will need in order for the permittee to implement the FRP; and 5) an identification of regulatory assistance that the permittee will need from the Secretary in order to effectively implement the FRP.

    - Within ten years of the effective date of the permit, the permittee shall implement measures necessary to meet the flow restoration target.

- The draft MS4 General Permit by design places the initial responsibility on the MS4 permittes for controlling discharges from the MS4 system to the impaired streams to meet the flow restoration targets. The permit recognizes that responsibility for site-specific BMP implementation may be shifted to either a local or regional utility or to individual dischargers into the MS4 system as necessary to ensure implementation. The Department may issue additional RDA permits as necessary to ensure that any private dischargers into the MS4 system that are identified as a necessary component of BMP implementation participate in implementation activities.

- The Department has also issued a NPDES RDA permit with TMDL implementation requirements to over 450 individual dischargers to five of the 12 urban stormwater-impaired waters pursuant to the Vermont Environmental Court's August 28, 2008 Judgment Order which granted CLF's 2003 "Petition for Determination that Existing Discharges in Potash, Englesby, Morehouse, Centennial and Bartlett Brooks Contribute to Water Quality Standards Violations and Require NPDES Permits." The Department notified these dischargers of their obligation to apply for permit coverage by December 16, 2009. These identified stormwater discharges go directly to these impaired streams and do not enter or commingle with the stormwater discharges regulated under the MS4 permit. The TMDL implementation requirements in the RDA permit are geared for three categories of discharges, including:

    - Designated Discharges from Property with Existing Impervious Surfaces that are Subject to a Previously Issued State Stormwater Permit. These dischargers must by June 30, 2011, conduct and submit to the Department an Engineering Feasibility Analysis (EFA) to determine the best opportunities for upgrading stormwater treatment on their site. No later than eighteen (18) months after the Secretary's approval of the analysis and associated BMP design plans, the permittee shall implement the stormwater BMPs for the designated discharge in accordance with the approved plans.

    - Designated Discharges from Property with Existing Impervious Surfaces Greater than One Acre that do not have a Previously Issued State Stormwater Permit. These dischargers must by December 31, 2010 conduct and submit a Site Assessment (SA) performed in accordance with the Department's VTDEC Procedure for Site Assessments. If the Department determines after review of the SA and other available information that stormwater BMPs or other measures must be implemented or undertaken for the subject property in order to implement the applicable TMDL, the Secretary shall reopen the permit to specify and require implementation of these stormwater BMPs or other measures by the permittee. The Secretary shall require that these BMPs or measures be completed within 18 months of the effective date of the amended permit. Any amendment of the permit shall be subject to a formal notice and comment period. Also, by no later than October 15, 2010, the permittee shall maximize infiltration of stormwater runoff, prevent soil and eliminate soil erosion, and prevent and eliminate delivery of pollutants to stormwater conveyances. The Department has created a "Small Sites Guide for Stormwater Management" to assist property owners in meeting these requirements.

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- The implementation framework discussed in this report acknowledges that the Department will use staged adaptive implementation and management in TMDL implementation. Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of practices and programs that are underway. In the adaptive management approach, first round stormwater controls are identified and implemented through permits (e.g. individual or general) or other strategies (e.g. municipal ordinances controlling discretionary runoff) in order to implement the TMDL. After an implementation period, monitoring is conducted and, based on an evaluation of the monitoring data, additional actions are required. This process may involve successive iterations of permitting, implementation, monitoring and evaluation.

- The Department will continue to pursue federal funding for implementation activities and monies for studying the feasibility of a regional stormwater utility to foster remediation efforts.

- The Department will continue to work with responsible parties in developing Water Quality Remediation Plans (WQRPs) for Vermont's five stormwater-impaired mountain watersheds and will issue permits as appropriate to foster implementation. .

In conclusion, the Department believes that the use of the MS4 permit to require the MS4-led development of watershed-specific BMP plans is the most efficient and cost-effective first step toward successful TMDL implementation. This process allows for the initial focus to be given to the best and most cost effective placement of BMPs rather than to considerations of property boundaries. Working with the Department, the MS4s will identify the retrofit BMP projects that will be used to remediate the streams. Once these watershed-specific plans are developed, it will be determined whether municipal-led BMP implementation, private entity BMP implementation, or a combination, will be used. In many cases, municipal-led BMP retrofits may be the most cost-effective approach, especially if municipalities develop steady funding sources, such as stormwater utilities, stormwater fees, etc.

Underlying Implementation Framework Assumptions

During the SWAG stakeholder process, several key assumptions underlying the Department's implementation strategy were discussed. These include: the role and use of the Department's BMP Tool, and the interrelated concepts of staged implementation, adaptive implementation and adaptive management.

Use of a Decision Support System Tool

As previously discussed, a critical component of any implementation strategy is to identify the most appropriate BMPs to achieve the TMDL targets and to understand and plan for BMP costs. In order to ensure successful and cost-effective implementation, the Department, in collaboration with EPA-contractor, TetraTech, Inc, has developed a BMP modeling tool (the "BMP tool") that considers type, sizing, and placement of BMPs and produces results that can be compared to TMDL targets. The Department will use the BMP tool to aid MS4s in identifying the most

appropriate and cost-effective mix of BMPs to achieve each watershed TMDL target. The BMP tool can also be used to estimate the costs associated with each identified implementation scenario.

The Department plans to use the BMP tool throughout TMDL implementation to evaluate the efficiency and cost of various BMP scenarios that are considered in preparing watershed specific BMP plans. The Department will "ground truth" BMP tool modeling exercises with the help of the MS4 permittees and private parties as implementation planning proceeds to ensure that proposed remediation activities are designed with a maximum awareness of existing constraints. For example, the BMP tool does not take into consideration potential site constraints, such as underground utilities, that might prevent siting BMPs on certain properties.

Staged Adaptive Implementation and Management

The number and scope of stormwater best management practices (BMPs) required to meet the TMDL flow reduction targets in these highly developed urban impaired watersheds will be significant. The associated costs will be high and both public and private resources are limited. There is limited environmental data and scientific uncertainty as to the extent of the work necessary and the timing as to when remediation targets will be met, and differing opinions on the efficacy of proposed BMPs to achieve water quality standards.

Given the three acknowledged "truths" of implementation – scope and number of required BMPs, significant costs, and limited resources - the Department has studied the concepts of "staged implementation", "adaptive management" and "adaptive implementation" and is committed to applying a blend of these concepts during TMDL implementation. In response to a number of comments seeking clarity on our overall approach, the Department has coined the term "staged adaptive implementation and management" to described the approach it will use.

Before describing how these concepts will inform implementation, it is important to understand each. These concepts are summarized as follows:

Staged Implementation

Staged implementation involves implementation in several distinct steps, whereby implementation actions are taken in a step-wise fashion over a period of time. The implementation process includes interim goals and milestones for each stage. Generally, TMDLs with staged implementation are not expected to require any significant adjustments in the load and wasteload allocations.

Adaptive Management

Adaptive management is a process of "learning by doing" despite the existence of uncertainty. Adaptive management recognizes that the scientific models used for decision-making are approximations and that there is never enough data or resolution about uncertainty. In adaptive management, an action plan is designed based on best professional judgment. As implementation occurs, monitoring is conducted and the data are evaluated to judge the

effectiveness of the actions in achieving the desired outcomes, the condition of the waters, and the validity of the modeling upon which the action plan was based. Based on monitoring results, adjustments are made in the action plan and implementation continues. In sum, this adaptive process allows decision-makers to proceed with initial decisions based on available data and modeling and then to update plans and decisions as experience and knowledge improve.

Adaptive Implementation

Adaptive implementation is an iterative implementation process that combines the concepts of staged implementation and adaptive management. Adaptive implementation makes progress toward achieving water quality goals while using any new data and information to reduce uncertainty and to adjust implementation activities. In 2001, the National Research Council (NRC), at the request of Congress, established a committee to examine the scientific basis of EPA's TMDL program. A specific concern addressed in the resulting report entitled "Assessing the TMDL Approach to Water Quality Management" is that the uncertainty in TMDLs and in the predictions of the efficacy for control actions is often large, with the consequence that implementation actions might be ineffective and therefore wasteful of limited resources. The NRC committee recommended that this uncertainty was most effectively addressed through a "learning while doing" approach. This approach, known as "adaptive implementation," is the process whereby a water quality implementation plan is prepared and initial control actions implemented. Then, based on an ongoing assessment of the efficacy and costs for the actions, including carefully targeted monitoring, revisions are made to the implementation plan and additional control actions implemented as necessary. With this new knowledge, the original watershed analysis, water quality analyses and models can be revised to update the estimates of current and future pollutant loads and the resulting water quality in the impaired water body. The new information is used to revise and modify the implementation plan of the original TMDL.

Staged Adaptive Implementation and Management

The Department may use a combination of these three concepts - staged implementation, adaptive implementation and adaptive management – in moving forwarding with TMDL implementation. Regardless of the term coined or used, the Department will implement as follows:

- As described in this report, the Department will use the MS4 permit to require that MS4 permittees, in consultation with the Department, prepare watershed specific BMP plans. These plans will include a BMP implementation schedule and a monitoring plan.

- Each watershed specific BMP plan will selectively identify and prioritize a "first round" set of structural and non-structural BMPs using maximization of environmental benefit and cost effectiveness as the primary objectives. The Department's BMP tool will be used to identify these first, and subsequent, phases of BMPs.

- Upon implementation of the initial round of BMPs, monitoring will be conducted as specified in the BMP Plan. Based on the performance of these BMPs and the resulting response of the stream to these controls, then several choices may exist:

    - Improve monitoring: The Department may monitor for additional parameters to determine whether changes in flow regime or aquatic biota have occurred or to provide better information for informing additional implementation steps.

    - Implement next phase of controls: Stormwater controls in an implementation stage may prove to be more or less effective than originally anticipated. The Department may identify additional parties and strategies and require implementation of an additional round of stormwater controls.

    - Conduct a Use Attainability Analysis (UAA): Subsequent data and analysis may indicate that the current water quality standard for a stream or class of streams is unattainable and needs to be revised to reflect realistic and attainable endpoints.

- This process may involve successive iterations of permitting, implementation, monitoring and evaluation.

- This process of "learning by doing" will also be used in implementing the WQRPs for the five stormwater-impaired mountain watersheds.

The Department's approach is supported by EPA and EPA-funded research. In EPA's 2006 memo entitled "Clarification Regarding 'Phased' Total Maximum Daily Loads (Benita Best-Wong), EPA indicated support for both the concepts of adaptive implementation and staged implementation. This support was noted in an EPA-funded report entitled (Draft Adaptive Implementation of Water Quality Improvement Plans: Opportunities and Challenges, June 25, 2007), which stated that the literature and the 2006 memorandum clearly indicate that it is possible to fit the general adaptive management approach "within the current CWA parameters and regulations governing the USEPA and the states' compliance with the Act." (p. 11). This report went on to state that adaptive implementation should occur where uncertainty is substantial and the "costs of error" are deemed significant.

> What is meant by "error" and the "costs of error"? Standard implementation in the face of uncertainty creates the real possibility that strict adherence to the original implementation plan over time will cause resources to be spent on controls at sources and locations that will not produce desired water quality outcomes. This scenario can be avoided using the adaptive implementation approach. Another benefit of the adaptive implementation approach is the possibility of continual learning and future implementation flexibility, even while initial controls move forward. This possibility may resolve stakeholder deadlocks, where disputes over defining the "perfect" long-term plan became the enemy of taking any action at all. (p. 6).

Likewise, support for adaptive implementation was expressed by the National Resources Council in its report entitled "Assessing the TMDL Approach to Water Quality Management (2001).

The Department believes that, regardless of the term used, this step-wise approach of implementation of initial controls, monitoring, evaluation, plan revision, and implementation of additional controls is appropriate given limited resources and the inherent and underlying uncertainties in current stormwater modeling and science. These scientific uncertainties were discussed earlier by the SWAG during the Water Resources Board's Stormwater Docket proceeding and are set forth in the report from that Docket, entitled "*A Scientifically Based Assessment and Adaptive Management Approach to Stormwater Management (Stormwater Cleanup Plan Framework).*"

These uncertainties are briefly summarized as follows:

- The stormwater TMDLs were developed to establish targets to be used in guiding the design of subsequent remediation plans needed for achieving water quality standards in these streams. These streams are currently failing to meet the water quality standard for the full support of aquatic biota.

- The TMDLs were developed using hydrological modeling to simulate in-stream flow duration curves, and two levels of surrogates (stormwater runoff flows as a surrogate for sediment loading, particularly from in-stream sources; and attainment stream flow duration curves to provide targeted thresholds for remediation efforts) used for predicting flow targets for an otherwise unpredictable criteria – aquatic life support.

- Based on current stormwater modeling and science, it is presumed that the construction/upgrade of stormwater controls within a watershed will result in a change in the flow regime, improvements in the aquatic habitat, and will, over time, result in positive changes in aquatic biota. The specifics and timing of any response in the flow regime and aquatic biota, however is unknown. By implementing a first stage of controls the Department will be able to observe the ensuing response of the stream system, therefore allowing fine-tuning of the modeling and science that supports the predictions in the TMDL – in other words, will the required stormwater controls reduce flow sufficiently to change the flow regime and will the stream-system and aquatic biota respond positively? These questions must be answered.

Implementation will also take into account the following realities:

- Permit deadlines will need to reflect the fact that time will be needed to conduct engineering feasibility studies to determine if and what stormwater retrofits are feasible, in light of both site constraints and costs. In some cases, it may take a few years before stormwater retrofits are "in the ground" and another few years before monitoring will be useful in detecting any changes in the in-stream response. In other words, patience must be exercised – it will take years, maybe decades, before improvements in aquatic biota are seen, particularly for streams that are currently geomorphically very unstable. This conclusion was also reached during the Water Resources Board's previous Stormwater Docket proceeding.

- In the case of municipalities, which may have many stormwater discharges, priorities will need to be set, budgets developed, and stormwater utilities formed (or some alternative local stormwater control), if desired by the municipality – all of these steps will require time, and permit deadlines will need to be set accordingly.

Chapter Three - Specific Components of Vermont's Implementation Framework as Discussed with SWAG

Additional components of Vermont's framework for remediation of the twelve urban impaired watersheds and five mountain watersheds are more fully described below. It is important to note that this framework embodies an overall implementation strategy, one that will then become more finely tuned in watershed specific BMP plans. This framework is specifically designed to share similarities with typical implementation plans as recommended by EPA in that it addresses planning, implementation actions, stakeholder involvement, costs and funding, scheduling, and measurable goals and milestones. However, this framework is much more ambitious than the typical implementation plan, which generally involves a single TMDL for a single watershed. The initial phase of the Department's TMDL implementation effort involved developing two necessary support elements, including: development of the overarching implementation strategy and obtaining necessary funding.

A significant number of the SWAG participants agreed that the most sound, efficient and potentially cost effective way to ensure successful implementation of TMDLs for the twelve urban impaired streams is through the creation of a stormwater utility that would be responsible to plan for, manage, and fund implementation. While the SWAG did not define the scope of such a utility, options discussed included individual municipal utilities, a regional utility encompassing geographic areas with stormwater impaired watersheds, and a state utility that could serve to both implement these TMDLs and prevent future water quality impairments in other watersheds. It was agreed by most SWAG members that a stormwater utility evaluation would be helpful in defining the scope of the utility best suited to manage and/or fund TMDL implementation.

It is important to understand that although this implementation framework reflects the agreement of a large number of SWAG participants, certain elements of this framework have been further developed by the Department. It was the Department's goal to build upon and refine the concepts developed in the SWAG.

Continue to Include SWAG as Necessary and Appropriate during Implementation

A total of nine SWAG meetings were held during Summer 2008, including both group and sub-group meetings focused on particular issues, such as technical, phasing, funding, and municipal involvement. This process constituted the Department's first step in obtaining stakeholder involvement in development of an implementation strategy. The SWAG participants included representatives of state agencies (including VTrans, and Act 250), the U.S. Environmental Protection Agency, Conservation Law Foundation, Vermont Natural Resources Council, affected municipalities (including, Burlington, Winooski, Essex, South Burlington, Colchester, Shelburne, Rutland, St. Albans), the business community, individual homeowners, consulting firms, UVM, Lake Champlain Committee and regional planning associations The SWAG fulfilled all of its goals, including reaching agreement with many of the SWAG participants on

the fundamental concepts of this Plan. The Department will continue to engage SWAG as necessary and appropriate during the implementation of these TMDLs.

Incentivize Upgrades of Existing Stormwater Systems and Renewal of Expired Permits

The SWAG strongly supported legislative changes and funding incentives to encourage the voluntary upgrade of previously permitted existing stormwater systems. Although the Department is not currently pursuing these changes, they are included in this report for informational purposes.

Since stormwater impairments are due to excess stormwater volume, it makes intuitive sense that as more stormwater controls in a watershed are implemented, the stream will benefit. Given this, the SWAG felt that the law should be written to encourage the construction and upgrading of stormwater systems. Vermont's current stormwater law, 10 V.S.A. 1264a, has had the opposite effect by discouraging dischargers from upgrading existing stormwater systems, and by discouraging the renewal of expired permits. Under Section 1264a, the Department may renew an expired stormwater permit for an existing discharge only if the existing stormwater system is upgraded through application of an engineering feasibility analysis to meet as closely as possible the water quality, recharge and channel protection standards in Vermont's Stormwater Management Manual. In addition, any remaining sediment load must approximate "natural conditions". This standard is difficult to meet and can typically be obtained only through the use of offsite offset projects on other properties, which are difficult to find and expensive to undertake. As a result, this statutory requirement has had the effect of discouraging existing dischargers from seeking renewal of their permits and upgrading their stormwater systems. This has resulted in a loss of the potential benefit to the stream from these upgrades.

In those watersheds that are not currently affected by the Environmental Court's Judgment Order, SWAG's recommended legislative changes would provide immediate benefits to these streams during the interim years that it will take to plan for and construct BMPs pursuant to watershed specific implementation plans. SWAG members suggested the following potential legislative changes:

- The state permit offset requirement for renewal of existing discharges should be eliminated.

- Expired state permits should be allowed to be renewed or reissued if the existing stormwater system is upgraded to the maximum "technically feasible" extent (using an engineering feasibility analysis developed by the Department.

- Any renewed permit for a voluntary retrofit should specify that additional upgrades will not be required unless site conditions change (e.g. redevelopment or new development of impervious surface over a regulatory threshold) that require additional controls to implement the TMDL.

Some SWAG members expressed concern that even if these changes are made, there may be no real incentive for private parties to voluntarily upgrade since it will not be known until watershed-specific BMP plans are developed whether or not treatment and control measures are needed at a particular site. Another possible disincentive to early voluntary treatment upgrades is the fact that if a stormwater utility is formed, it might assume the responsibility for both implementing and financing system upgrades.

The Department has considered these comments and responds as follows:

- Creating incentives for near term upgrades are not intended to suggest that existing systems with expired permits will not be targeted for upgrading later during implementation. In fact, after on-the-ground examination of these systems, the Department believes that upgrading existing systems could result in a real environmental benefit to these streams at an overall reasonable cost. Owners of these systems that voluntarily upgrade their systems in the near term and receive a renewed permit or new permit should receive a permit with a provision that additional upgrades will not be required unless site conditions change (e.g. redevelopment or new development of impervious surface over a regulatory threshold) and those site changes require additional controls to protect water quality.

- The Department is aware that even though title protection is provided by the statutory "title deferral" provisions there have been instances where the marketability of properties in these watersheds has been negatively impacted. Voluntary upgrades in the near term and the renewal of these expired permits or issuance of new permits would clear up this perceived marketability problem.

- Even if a stormwater utility is formed, the exact form of that utility will not be known for possibly 2-3 years, and it is possible that if a utility is formed, it may not assume responsibility for all system upgrades or the costs thereof. Since costs of stormwater treatment and control measures are likely to continue to rise over the next few years, if not indefinitely, it may be significantly less expensive for private parties to upgrade their systems sooner rather than later.

Create Incentives for Voluntary BMP Implementation for Currently Unpermitted Impervious Surfaces

There are currently a significant number of unpermitted impervious surfaces in these impaired watersheds that predate stormwater permitting requirements and therefore never had or needed a stormwater permit. Members of SWAG expressed interest in encouraging the voluntary installation or upgrading of stormwater systems for these surfaces. Recommendations to the Legislature would be similar to those described above for existing systems with expired permits.

The Department is available to work with private land owners to provide technical and funding assistance where available, to identify, design, and construct new or retrofitted stormwater systems for existing discharges. This effort will necessarily involve public education and outreach and close interaction with municipalities. In addition, permits will need to be issued for

this work. Installation of these voluntary BMPs is anticipated prior to the development and implementation of watershed specific BMP plans, thereby beginning the remediation of the impaired streams in the near term.

Remove Impediments to Permitting – Modification of Interim Permitting Offset Requirements

During the SWAG stakeholder meetings discussions were had regarding the offset requirements in Vermont's stormwater law. The tough "zero discharge" standards for new development and redevelopment during the interim period before TMDLs are implemented can generally only be met through the use of offsite offset projects. 10 V.S.A. Section 1264a. Current law only allows treatment of discharges initiated prior to 1978 (currently unpermitted) and treatment of discharges from sites that are below permit thresholds to be used as offset projects. In addition, offset projects may include culvert replacement, stream bank stabilization and other riparian corridor protection projects. Permittees that create their own offset projects on property that they own or control, are authorized to undertake the offset project pursuant to their stormwater discharge permit. Permittees that can't create their own offset projects on their own property must seek assignment of offset credits generated by stand-alone offset projects that are performed by another individual or entity in the same stormwater-impaired watershed. These stand-alone offset projects must obtain a stand-alone offset project permit. If no offset project opportunities are available, then development and redevelopment projects cannot proceed in stormwater-impaired waters.

The Department plans to consider provisions for permit coverage of new development and redevelopment that modifies the offset requirement for new development and redevelopment by requiring that in lieu of implementing offset projects, developers would have the option to pay (based on impervious acreage) into a fund that would be used to implement stormwater control projects identified by the Department as necessary to implement the TMDL. Municipalities will most likely be in the best position to implement these Department-identified projects. Unlike current offset projects, that are usually implemented based on expediency, these Department-identified projects would be targeted to provide the best benefits to the affected stream.

Coordination of Permitting Across State Agencies/Programs

SWAG members expressed repeated concern about possible impediments to TMDL implementation caused by the realities of multiple permit requirements within and across state agencies. Of most concern, was how Act 250 and U.S. Army Corps requirements might impede upgrades to existing stormwater systems. The Department acknowledged this concern and committed to resolving internal permit coordination problems, which has been an ongoing effort over the past year. Additionally, the Department engaged Act 250 representatives in the SWAG process and has committed to working with Act 250 and the Army Corps on these issues.

Involvement of MS4 Permittees

Issue MS4 Permit

In consultation with USEPA, the Department will reissue the MS4 General Permit with requirements for implementing the stormwater TMDLs. Vermont's thirteen MS4 permittees include: Burlington, South Burlington, Essex, Essex Junction, Colchester, Winooski, Milton Shelburne, Williston, the Burlington International Airport, UVM and VTrans. Three of the twelve urban stormwater impaired streams (Moon Brook, Rugg Brook, and Stevens Brook) are located in municipalities that are not currently designated as MS4s (Rutland City and Town, Mendon, and St. Albans City and Town). Rutland City and St. Albans City and Town were represented in the SWAG. The Department will discuss appropriate implementation strategies with the municipalities associated with Moon, Stevens and Rugg Brooks.

It is currently anticipated that MS4 permit conditions relating to TMDL implementation will, among other things, require MS4 permittees to:

- **Develop watershed specific BMP plans that identify and prioritize projects necessary to implement TMDLs and Include Public Participation**. The Department will work with the MS4 permittees to develop watershed BMP implementation plans. These plans will be developed during the first years of the MS4 permit. The Department will complete the initial modeling with the BMP Tool prior to meeting with the MS4 permittees. The Department will then meet with the MS4 permittees to check the accuracy of the information and assumptions made in the initial modeling and update the model as needed. Subsequently, the Department will use the BMP Tool in working with the MS4 permittees to craft a watershed-specific BMP plan and take into account the individual needs of the communities in the watershed. The BMP plans will include schedules for design, permitting and implementation as well as watershed specific public participation and outreach plans.

- **Identify and Implement Low-Cost Upgrades to Existing MS4 Permittee Discharges**. This effort will occur during the first years of the MS4 permit and is expected to result in up-front and cost-effective benefits to the impaired streams. The Department will assist the MS4 permittees in identifying these low-cost upgrades and provide other technical assistance as requested. The Department will work toward expediting and coordinating the issuance of permits for these projects to provide immediate progress toward watershed remediation.

- **Require Prioritization and Implementation of Projects Identified in Watershed Specific BMP Plans.** The MS4 permit will require that the watershed-specific BMP plans identify who will have responsibility for implementation of site specific BMPs. The MS4 permit will place initial responsibility on the MS4 permittees for controlling MS4 discharges to the impaired streams to meet the TMDL targets. The permit will recognize that responsibility for site-specific BMP implementation may be shifted to either a local or regional utility or to individual dischargers into the MS4 system as necessary to ensure implementation. The Department may exercise its residual

designation authority as necessary to ensure that any private dischargers into the MS4 system that are identified as a necessary component of BMP implementation participate in implementation activities

- **Non-Traditional MS4 Permittees**. Vermont's MS4 permittees include three "non-traditional" MS4s including the Burlington International Airport, UVM and VTrans. The MS4 permit will require that these entities work in cooperation with the Department and MS4 municipal permittees during preparation of watershed-specific BMP plans, cooperate with the appropriate MS4 municipal permittee during BMP implementation and assume responsibility for the treatment and control of their stormwater discharges, either individually or in cooperation with the affected MS4 municipal permittee.

Acquisition of Necessary Funding Sources

The SWAG members unanimously agreed that adequate funding is essential to successful TMDL implementation. As described below, there are immediate funding needs for ongoing stream monitoring efforts, development of watershed BMP plans for TMDL implementation, and exploration and development of a regional stormwater utility.

Funding for Monitoring

Successful TMDL implementation depends on the availability of monitoring data to assess progress in meeting the TMDL and inform adaptive management decisions. Case studies of successfully implemented TMDL plans consistently report the need for watershed monitoring both prior to TMDL implementation and after BMP installation.

Availability of monitoring data prior to TMDL development establishes a baseline from which progress in meeting the TMDL can be measured. Monitoring is also crucial after BMP installation to assess progress in meeting the water quality goals established in the TMDL and to inform managers of when targets have been met and when additional measures are needed.

The SWAG's funding subgroup discussed a number of potential state and federal funding sources. It was agreed that funding is essential for the following monitoring activities: biomonitoring, stream hydrology, stream geomorphic assessment, and BMP installation and effectiveness.

The Department will continue to work with EPA to identify federal funding sources for monitoring and other implementation activities.

Seed Funding to Ensure MS4 Permittee Involvement – Funding for Exploration of Stormwater Utility Options, Development of Watershed Specific BMP Plans, and Implementation of BMPs

This framework reflects the notion that the most sound, efficient and potentially cost effective way to ensure successful implementation of the urban watershed TMDLs is through the creation of a stormwater utility to plan for, manage and fund implementation and long term maintenance.

While the scope of such a utility was not defined, options discussed included individual municipal utilities, a regional utility encompassing geographic areas with stormwater impaired watersheds and a state-wide utility. Agreement was reached that a stormwater utility evaluation should be conducted in order to define the scope of the utility best suited to managing and funding TMDL implementation.

The Department is currently exploring the availability of federal funding for stormwater utility evaluation and formation. For example, the Department applied for an EPA 2009 State Innovation Grant in the amount of $297,000 to evaluate a potential stormwater utility model for Vermont. Although its request for this grant was recently denied, the Department continues to explore alternative federal funding sources. The Department is also working with EPA to identify potential funding options for monitoring. If a stormwater utility is formed, it is expected that revenues generated by the utility will fund BMP installation and maintenance. Additional funding for BMP installation and maintenance may be required in the future if a utility is not formed, or if a MS4 permittee chooses not to join the utility.

Non-MS4 Discharges

The Department recognizes that certain discharges may enter impaired waters directly and not drain through a MS4 system. As discussed earlier, the Department has recently issued a NPDES RDA permit to require coverage for over 450 of these dischargers in five stormwater impaired brooks in Chittenden County pursuant to a Vermont Environmental Court Judgment Order. These included stormwater discharges to Bartlett, Centennial, Englesby, Potash, and Morehouse Brooks, that are not currently regulated by the MS4 permit or do not have a state stormwater permit or on-site controls that result in a no net contribution to the impaired stream. For purposes of the Department's designation, any stormwater runoff that enters or commingles with a MS4 system was considered to have coverage under the MS4 permit.

Mountain Watersheds – Implementation

EPA regulations recognize that alternative pollution control requirements may obviate the need for a TMDL. Impaired waters are not required to be included on the section 303(d) list (i.e. waters in need of a TMDL) if other pollution control requirements are stringent enough to implement applicable water quality standards within a reasonable period of time. EPA guidance acknowledges that the most effective method for achieving water quality standards for some water quality impaired segments may be through controls developed and implemented without TMDLs. "Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b) and 314 of the Clean Water Act, US EPA Office of Water, 7/2005.

The stormwater-impaired mountain watersheds include the North Branch of the Deerfield River, Roaring Brook, East Branch of Roaring Brook, Rice Brook, and Clay Brook. These watersheds differ substantially from the remaining urbanized "lowland" watersheds in terms of density of development, geographic position, hydrology, impairment source, and land ownership. Based on these factors, the Department has concluded that use of the so-called "4b alternative," a non-TMDL based alternative pollution control strategy, is the best implementation strategy.

In general, the mountain watersheds do not appear to be under the same hydrologic stress as the lowland watersheds, and may in fact be impaired more due to sediment wash-off from developed land, as opposed to stream-channel modification. This generalization is supported by geomorphic assessment data, preliminary hydrologic modeling, and observations of Vermont remediation efforts.

The mountain watersheds also differ substantially from the lowland watersheds in terms of land ownership. Whereas in the lowland watersheds there may be hundreds of owners within a given watershed, the mountain watersheds all have one owner that owns the vast majority of developed land, and a relatively small handful of other owners. This near singularity of ownership provides an opportunity for the owners to craft remediation strategies in partnership with the Department that are fully-integrated into development plans. This last point strongly affects the cost and feasibility of the implementation plan. As explained to the SWAG, the Department is working with ski-area owners and their representatives on a case-by-case basis to evaluate existing development and stream conditions, as well as existing remediation efforts. Thus far, a remediation plan strategy based on a unitized sediment loading target derived from an attainment watershed, in conjunction with hydrologic controls, appears to have the greatest merit. This strategy can be implemented via the traditional TMDL route, or via the 4b alternative.

Of the five mountain watersheds, two water quality remediation plans (WQRPs) have been submitted for review, the remaining three are still under development by the major stakeholder.

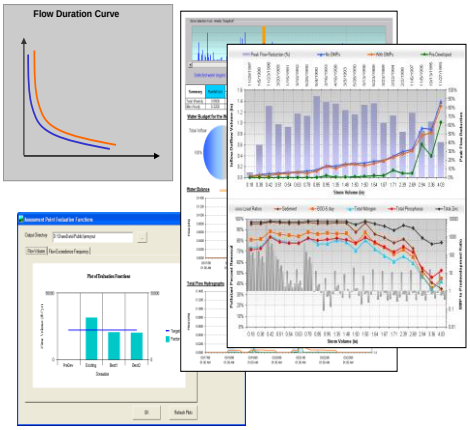
Appendix A – Costs and Complexity of Stormwater TMDL Implementation

Development of BMP Tool and Estimated Costs of Implementation

The number and scope of best management practices (BMPs) required to meet the TMDL flow reduction targets in these highly developed watersheds will be significant. Examples of typical structural and non-structural BMPs that might be required include: stormwater ponds, stormwater wetlands, swales, and various infiltration practices.

In order to ensure successful and cost-effective implementation, the Department, in collaboration with EPA-contractor, TetraTech, Inc, has developed a BMP modeling tool that considers type, sizing, and placement of BMPs and produces different combinations of results that can be compared to TMDL targets. The Department is using the BMP tool to identify and calibrate the most appropriate and cost-effective mix of BMPs to achieve each watershed TMDL target. Because there is a large number of BMP type, size, and location combinations, this type of analysis is time consuming and requires numerous computer model iterations and a significant data pre- and post-processing effort.

VTDSS Analysis Tools



Stormwater best management practice computer modeling tools developed for the Vermont Best Management Practice Decision Support System.

The BMP Tool can also be used to estimate the cost associated with each identified implementation scenario. Initial modeling results of different BMP implementation scenarios using the BMP Tool estimate that there will be an extremely high aggregate cost involved in the remediation work across all of the stormwater impaired streams. The Department's initial modeling scenario for Potash Brook based on one potential suite of BMPs is in the range of $25 million. Appendix I of this report discusses in more detail the assumptions of the modeling runs and the cost formula used in the BMP Tool.

It is important to understand that these preliminary cost estimates are rough, and due to the overall complexity of an effort of this magnitude, these costs are expected to rise significantly as implementation proceeds. There are numerous implementation issues that may drive costs upward, including:

- The inherent spatial limitations of the twelve urban impaired watersheds will make them particularly difficult and time-consuming to evaluate when planning which BMPs to implement. Limited space also makes many BMPs impractical – e.g. construction of new stormwater ponds.

- In some watersheds with significant TMDL flow reduction targets, remediation activities may require implementing a large number of small-scale BMPs, even down to the household level. This may require the creation of new permitting programs or ordinances

(e.g. to require downspout disconnections) and the inherent enforcement issues associated with such an effort.

- There is limited environmental data and scientific uncertainty as to how and when remediation targets will be met – if at all - and differing opinions on the efficacy of proposed BMPs to achieve water quality standards. This will lead to disputes, and even potential litigation.

- Implementation is complicated by the need to include multiple parties in any proposed solution. Who should implement BMPs and what those BMPs should be will be disputed.

- Landowners will face difficult implementation issues such as physical site constraints, and difficulties in managing stormwater runoff to and run-on from properties over which they have limited control or access.

- The high cost of stormwater system retrofits is well documented. These costs only increase over time.

- BMP implementation may require the purchase of land for placement of stormwater ponds. Land costs are high and the need for any particular parcel of land under an implementation plan may drive its value upward.

- There is a limited pool of consulting firms in Vermont to perform the planning and implementation work necessary to implement seventeen TMDLs. The scarcity of firms will drive up consulting costs.

- Implementation of such a large number of TMDLs, each of which will require significant BMP implementation and high costs, is likely to inspire litigation and its associated costs.

Appendix B – Common Characteristics of Successful TMDL Implementation

Before embarking on its own implementation efforts, the Department felt that it was critical to investigate other states' TMDL implementation efforts. These would hopefully illustrate the factors that aid and hinder implementation efforts and provide guidance to the Department.

Although there are currently no case studies of TMDL implementation efforts that are identical in nature or scope to the task now faced by Vermont, there is information that points to the general characteristics of successful TMDL implementation. These factors are best summarized in a 2006 Report prepared for EPA by the Virginia Tech Center for TMDL and Watershed Studies, which analyzed seventeen TMDL implementation case studies. Although the TMDLs in the case studies are not specifically for stormwater, they do involve pollutants associated with stormwater runoff, including sediment, nutrients, dissolved oxygen, bacteria and temperature. The characteristics that foster or hinder TMDL implementation are briefly summarized below.

Adequate Funding

Successful TMDL implementation depends on the availability of resources to fund program development and operation. TMDL program coordinators from across the county report that the identification of funding sources and a commitment to funding projects throughout TMDL implementation are the most important factors in determining the success of the TMDL in restoring water quality. (Benham, 2006)

Developing a reliable funding stream is also essential to the ultimate success of the plan. In Hutton Creek in Virginia, "Stable financial and technical resources that were available over multiple years facilitated one-on-one contacts and participation in incentive-based NPS control programs." (Benham, 2006) The consistent funding of implementation in Hutton Creek has resulted in significant water quality improvements and Hutton Creek is now an EPA Section 319 Nonpoint Source Success Story. (USEPA, 2005)

Securing funding for each phase of implementation is critical for ensuring water quality improvements and maintaining stakeholder faith and investment as the project progresses. In the Lower Nooksack River Basin in Washington, budgetary constraints reduced both the technical and financial assistance for TMDL implementation after considerable water quality gains had been made. "These setbacks are threatening the attainment of water quality goals established by the TMDL, causing the re-closure of some of the shellfish beds that were recently reopened." (USEPA, 2005) In addition to a reduction in water quality gains, the loss of funding during implementation "resulted in a reduced involvement of local stakeholders" in the Cascade Reservoir in Idaho. (Benham, 2006) Regaining stakeholder support for implementation once the momentum for the project is lost is an extra hurdle that can be prevented with a secure, diversified financing plan.

While developing a financing plan requires significant time and effort, "local jurisdictions that are proactive in developing and implementing comprehensive, sustainable financing strategies will find it easier to contend with the water quality management challenges ahead." (Maryland,

2006) To assist local governments, the Maryland Department of the Environment (MDE) has developed a comprehensive TMDL Implementation Guidance that details a financial plan framework for TMDL implementation. The financing framework includes six steps, from educating decision makers about financial needs and securing start-up funding to identifying the technical elements of the plan and developing the funding system. Each step in creating the financial plan requires considerable research and development and therefore should be addressed early in the TMDL implementation process.

Stakeholder Engagement

Developing a TMDL implementation plan is a resource-intensive undertaking, requiring significant investments of time, money and technology. Without stakeholder engagement, the return on such investments can be disappointing. (Jesiek, 2007) Engaging stakeholders at the onset of implementation planning is critical for maintaining support throughout the TMDL implementation process. Stakeholder engagement begins with education about the water quality problems in the watershed. Information about how the TMDL was developed and why it is important to protect and restore impaired streams establishes a knowledge base and empowers stakeholders. Additionally, when stakeholders understand and accept the problem in the watershed they are more willing to spend resources on cleanup. (Jesiek, 2007)

Early stakeholder involvement can also speed the implementation process. In the Aquilla Reservoir in Texas, stakeholders began implementing Best Management Practices (BMPs) as soon as the cause of water quality impairment was identified. Early implementation of BMPs increased awareness about the water quality issues and encouraged more public interest in the cleanup. As a result of the proactive stakeholder involvement, implementation preceded the completion of the plan and water quality targets established in the TMDL were met ahead of schedule. (Benham, 2006)

Achieving meaningful stakeholder involvement in the development of the TMDL implementation plan results in stakeholders with ownership of the plan and a willingness to implement the recommended BMPs. One way to promote public participation and stakeholder involvement in the planning process is to develop a stakeholder involvement strategy. (Benham, 2006, Appendix E) "A strategy that reflects the interests and concerns of stakeholders within the watershed is likely to generate meaningful participation." (Benham, 2006, Appendix E) A stakeholder involvement strategy identifies all of the potential stakeholders, assesses their awareness of the watershed issues, educates them about the TMDL, permitting approaches and BMPs, and identifies opportunities for participation. (Benham, 2006, Appendix E) A specific, tailored public involvement strategy can efficiently engage stakeholders across the watershed and motivate them to take action to implement recommended BMPs.

Development of a formal public involvement process not only engages stakeholders, but also facilitates a government – stakeholder relationship. In the development of the Hutton Creek implementation plan in Virginia, state Department personnel and municipal leaders had the opportunity to interact with local stakeholders throughout the planning process. This process was "instrumental in securing stakeholder participation and buy-in during the TMDL implementation plan process and subsequent BMP implementation." (Benham, 2006)

Government Involvement and Cooperation

Successful TMDL implementation also requires a coordinated effort between engaged, local stakeholders, local governments and state agencies. In their review of successful TMDL implementation plans, the Center for TMDL and Watershed Studies found that the "lack of communication and coordination between local governments and responsible agencies hindered implementation success." (Benham, 2006)

In Iowa's Slip Bluff Lake TMDL implementation plan, both national and state agencies cooperated to implement the TMDL. Instrumental to the success of the plan was the clear identification of BMPs and the respective party responsible for implementation. (Benham, 2006). In addition to working cooperatively to identify potential BMPs and responsible parties, local and state governments can work together to develop strategies for selecting the appropriate mix of required BMPs. Chen and Herr, in a paper on stakeholder involvement, suggest the use of a "decision-support system (DSS) that can calculate various combinations of point and nonpoint loads that can meet the water quality criteria, and ultimately support a decision making process that requires negotiation and compromise among stakeholders." (Jesiek, 2007).

Sufficient Data

Successful TMDL implementation depends on the availability of monitoring data to assess progress in meeting the TMDL and inform adaptive management decisions. Case studies of successfully implemented TMDL plans consistently report the need for watershed monitoring both prior to TMDL implementation and after BMP installation. Further, the Center for TMDL and Watershed Studies identified the lack of monitoring data as the most significant factor that hindered successful implementation of TMDL plans. (Benham, 2006)

Availability of monitoring data prior to TMDL development establishes a baseline from which progress in meeting the TMDL can be measured. In the implementation of the DuPage River and Salt Creek TMDL in Illinois, stakeholders chose to make monitoring a priority. The stakeholder group cooperatively made monitoring decisions that have helped identify the sources of impairment and potential restoration locations. The group also works together to analyze monitoring data to track implementation progress. "Using this collaborative, science-based approach to decision-making helps to achieve buy-in from the (stakeholder group) members, ensuring credibility, trust, and transparency." (USEPA Region 5, 2007)

"In addition to its evaluation function, monitoring information can also be used to target the location of implementation activities." (Maryland, 2006) When water quality managers can analyze a comprehensive dataset from an impaired watershed, they can work to place Best Management Practices (BMPs) in the most cost effective manner. This approach was successful in the implementation of the Hutton Creek TMDL in Virginia. In Hutton Creek, managers used "spatial analyses of monitoring data to identify subwatersheds where initial implementation would result in (the) greatest water quality improvement. This approach ensured optimal utilization of resources and avoided over-implementation." (Benham, 2006)

Monitoring is also crucial after BMP installation to assess progress in meeting the water quality goals established in the TMDL. Regular monitoring after BMP implementation informs managers of when targets have been met and when additional measures are needed. In Nine

Eagles Lake in Iowa, lack of sufficient monitoring data following BMP installation resulted in sediment reductions that exceeded the TMDL targets. (Benham, 2006) If monitoring had more closely tracked the BMP implementation, resources used in this watershed could have been transferred to other projects. It is important to note that monitoring data should be collected at regular intervals after BMP implementation. "Evaluation monitoring should be conducted at the appropriate restoration stage, and over enough years to account for potential lag-times before drawing conclusions." (Maryland, 2006) By establishing a monitoring plan, progress in meeting the TMDL can be systematically assessed, resulting in the most efficient use of resources.

Staging

Staged implementation is another common characteristic of successfully implemented TMDL plans. Staged implementation means that the "implementation process follows a staged approach, with interim goals and milestones." (Benham, 2006) This approach is an effective way to efficiently allocate limited resources. For example, a TMDL implementation plan can recommend BMPs in high priority areas in the impaired watershed during the first stage of implementation. Monitoring after the first stage can inform decisions about BMP implementation in subsequent stages. This approach was used during the implementation of the Hutton Creek, VA TMDL. After BMPs were installed in critical areas in the watershed, monitoring results showed that the TMDL targets were close to being met, and as a result fewer BMPs were necessary to meet the WLA. (Benham, 2006).

When resources are limited for TMDL implementation, staging provides a practical approach for comprehensive BMP implementation. Depending on the availability of tools and resources that exist in the watershed when implementation commences, certain BMPs can be installed up front, while plans are developed and funding streams established for the implementation of additional required practices. EPA fully supports this concept as a means of implementing TMDLs. (Best-Wong Memo, EPA 2006)

Adaptive Management

EPA also recognizes that staging can go hand in hand with adaptive management. (Best-Wong Memo, EPA 2006). "Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of practices and programs that are underway." (Watzin, 2007). This approach is supported by EPA and reflected in 10 V.S.A. § 1264(f)(3) and in the Department's Stormwater Management Rule for Stormwater-Impaired Waters. In the adaptive management approach, first round stormwater controls are identified and implemented through permits (e.g. individual or general or other strategies (e.g. municipal ordinances controlling discretionary runoff) in order to implement the TMDL. After an implementation period, monitoring is conducted and, based on an evaluation of the monitoring data, additional actions are required. This process may involve successive iterations of permitting, implementation, monitoring and evaluation.

An adaptive management approach has been successfully used in TMDL implementation plans across the county. The City of Portland, OR is using an adaptive management approach in the implementation of the Columbia Slough TMDL through their Municipal Separate Storm Sewer System (MS4) permit. The MS4 permit requires that the municipality develop benchmarks to assess progress in meeting the TMDL's WLAs. If the established benchmarks are not met, then

the City must adapt the implementation plan to meet the benchmarks. (USEPA Region 5, 2007) This adaptive approach to TMDL plan implementation results in regular monitoring and evaluation of installed BMPs and careful consideration about the installation of additional practices; ultimately resulting in the most efficient path to meeting water quality targets.

Appendix C – National examples of stormwater - TMDL implementation efforts

As a part of the SWAG effort, Department staff spent considerable time researching and reviewing TMDL implementation activities across the country. This research confirmed what the Department has long known – that to date no other state has actually fully implemented a stormwater TMDL requiring the level of effort that will be required by Vermont's stormwater TMDLs, That is, neither the EPA nor any other state has to date required extensive construction of stormwater treatment practices for both public and private existing discharges.

Water quality impairments due to stormwater sources are increasingly prevalent across the county and TMDLs to address stormwater pollutants are commonly developed for sediment, pathogens, nutrients, and metals. To date, the NPDES MS4 permit for municipal discharges is most commonly used to implement stormwater TMDLs. (See Appendix H: Stormwater TMDL Implementation: Case Study Summaries for examples of what other states are doing to implement stormwater TMDLs through the MS4 permit)

Examples of how the MS4 permit is being used to implement stormwater TMDLs around the country are summarized below. These summaries are based on both document reviews as well as conversations with staff at the involved state environmental agencies. More detailed descriptions of these case studies are provided in Appendix E.

Case Studies

<u>Eagleville Brook TMDL, Mansfield, CT</u>

Eagleville Brook in Mansfield, CT is impaired for 'pollutants transported by stormwater.' Currently, the state is developing a "Roadmap" for the implementation of the Eagleville Brook TMDL. The result of the Roadmap development will be a plan for what should be implemented, where BMPs should be placed, and how much they will cost. Implementation will be accomplished through incorporating an adaptive management strategy. The strategy will include: 1) reducing impervious cover (IC) where practical, 2) disconnecting IC from the surface waterbody, 3) minimizing additional disturbance to maintain existing national buffering capacity, and 4) installing engineered BMPs to reduce the impact of IC on receiving water hydrology and water quality.

While Eagleville Brook is not currently within a regulated MS4, if future biological monitoring indicates non-attainment of aquatic life goals, then the State will consider designating municipalities within the Eagleville Brook watershed as small MS4s under the MS4 permit program.

Worcester, MA Draft MS4 Permit

EPA, which administers the federal stormwater program in Massachusetts, has issued a draft MS4 permit for the city of Worcester that requires the municipality to take measures to implement applicable phosphorus TMDLs. Conditions in the permit require the municipality to ensure the performance of retention and detention ponds which discharge to, or receive stormwater from, its MS4. This includes municipal and privately-owned ponds. Further, the municipality must annually inspect all such retention or detention ponds and remove accumulated solids to restore full solids capture design capacity where found to be in excess of 50% design capacity.

Minnesota MS4 Permit

The State of Minnesota is planning to re-issue its MS4 permit in 2011 with requirements for municipalities to implement TMDLs for impaired waters within their jurisdictions. The state is currently working on crafting specific guidance to MS4s so that the municipalities can easily incorporate TMDL implementation plans into their Stormwater Pollution Prevention Plans ("SWPPPs"). One potential option for implementing the TMDL through the 5 year MS4 permit includes allowing the MS4s to develop a compliance schedule for multiple permit terms. Before an MS4 can renew their permit, they must assess their progress in meeting the TMDL goals and re-evaluate their implementation schedule to stay on track with pollutant load reduction goals.

Oyster Bay and Mill Neck Creek TMDL, Long Island, NY

Oyster Bay and Mill Neck Creek on Long Island are impaired for pathogens. Stormwater discharges have been identified as one source of the impairment. The Oyster Bay TMDL stipulates that MS4s discharging to certain areas of Oyster Bay Harbor provide stormwater controls beyond the six minimum measures that are required in the MS4 permit. The MS4s are required to develop and implement a retrofit program to correct or reduce the impairment. This includes establishing procedures to identify implementation sites and establishing procedures for project selection, permitting, design, funding, construction and maintenance. By the 3rd year of the MS4 permit term, the MS4 must develop and submit plans and schedules for completing the retrofit projects to address the impairment.

Columbia Slough TMDL, Portland, OR

The city of Portland, OR is one of the MS4 communities implementing the Columbia Slough TMDL through the MS4 permit. The MS4 permit requires the city to implement BMPs that are designed to achieve reductions in the TMDL pollutants and to implement a monitoring plan to gauge the effectiveness of the BMPs. The city must also evaluate the TMDL pollutant load reductions when applying for MS4 permit renewal. If load reductions have not been met, the city must use adaptive management and determine what additional BMPs are practical.

Six minimum control measures in the MS4 Permit

In sum, the six federally required minimum measures in the MS4 permit are being used by states to require municipalities to take steps to implement TMDLs. The six minimum control measures are designed to treat and prevent contaminated stormwater runoff from municipally controlled discharges and include: Public Education and Outreach, Public Participation/Involvement, Illicit Discharge Detection and Elimination, Construction Site Runoff Control, Post-Construction Runoff Control, and Pollution Prevention/Good Housekeeping. MS4 permits also include requirements that measures must be taken by a municipality to ensure consistency with any TMDL targets established for the municipal discharges. Federal regulations at 40 CFR 122.34(e)(1) specifically provide: "You must comply with any more stringent effluent limitations in your permit, including permit requirements that modify, or are in addition to, the minimum control measures based on an approved TMDL or equivalent analysis. The permitting authority may include such more stringent effluent limitations based on a TMDL or equivalent analysis that determines such effluent limitations are needed to protect water quality.

The public education and public participation minimum control measures are being used by municipalities to engage local residents and stakeholders in the TMDL implementation process. For example, municipalities implementing pathogen TMDLs often develop pet waste clean-up campaigns and programs to reduce geese habitat on residential properties. Through public awareness about the pathogen sources and public action to reduce pathogen contributions, significant gains can be made towards meeting the goals of the TMDL. The pollution prevention and good housekeeping minimum control measure is also commonly used by municipalities to implement stormwater TMDLs. Impairments caused by sediment are often addressed through enhanced good housekeeping measures. This ranges from improved storage of municipal sand piles to an increase in street sweeping frequency. Stormwater TMDLs are also implemented through the post-construction runoff control minimum control measure. Through this measure, municipalities can develop ordinances requiring Low Impact Development (LID) and stormwater treatment practices for new development. While this is important to prevent further stream degradation due to stormwater flows, it does not correct an existing problem of too much or too little runoff. This is the unique challenge that Vermont is facing. No other states have yet to require structural treatment practices on such a large scale to address existing sources of stormwater flow.

Appendix D – Vermont's Stormwater Management Program

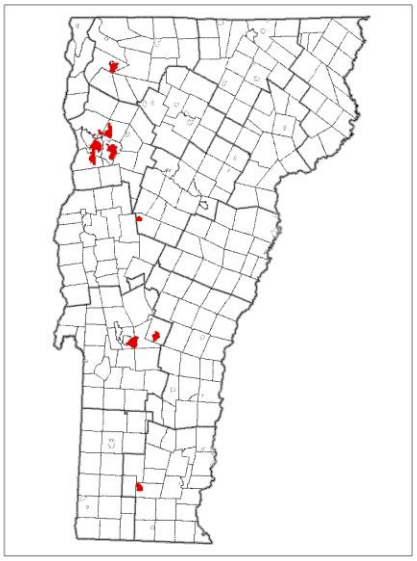
Vermont's Stormwater Program is one of the most comprehensive and stringent state programs in the country. The Program implements both a state-law permitting program for post-construction stormwater management of all impervious surfaces greater than one acre and a federally delegated NPDES permitting program for stormwater discharges associated with industrial activities, stormwater discharges from construction activities that disturb greater than one acre and stormwater discharges from 13 designated municipal stormwater systems, commonly known as "MS4" systems. All together, approximately 2,500 post-construction stormwater permits have been issued to date. Future permitting estimates include approximately 430 post-construction permits per year, 450 construction stormwater permits per year and approximately 3,500 entities potentially subject to permit requirements for stormwater discharges associated with industrial activities.

The Department's Stormwater Program is also involved in the development of Total Maximum Daily Loads (TMDLs) and remediation plans for Vermont's seventeen stormwater-impaired waters. A TMDL establishes the allowable pollutant loading from all contributing discharges at a level necessary to attain the applicable water quality standards, while a TMDL implementation plan specifies the remedial measures that must be taken by identified discharges to meet the TMDL targets. Therefore, Vermont's TMDL effort involves two distinct phases: the development of independently derived and scientifically based remediation targets that are embodied in USEPA-approved TMDLs; and the development of implementation plans that identify both regulatory and non-regulatory strategies designed to meet the water quality standards.

Appendix E - Overview of Stormwater TMDL Development

Impaired Streams and Vermont's 303(d) List

Biological communities in streams draining developed watersheds are subjected to many stressors associated with stormwater runoff. These stressors are related either directly or indirectly to stormwater runoff volumes and include increased watershed pollutant load (e.g. sediment), increased pollutant load from in-stream sources (e.g., bank erosion), habitat degradation (e.g. siltation, scour, over-widening of stream channel), washout of biota, and loss of habitat due to reductions in stream base flow. The stressors associated with stormwater runoff may act individually or cumulatively to degrade the overall biological community in a stream to a point where aquatic life uses are not fully supported and the stream does not attain the Vermont Water Quality Standards (WQS).



Once a stream is determined to be "impaired", therefore not meeting Vermont's WQS, the Department is required pursuant to Section 303(d) of the federal Clean Water Act to list the stream on the state "303(d) list" and prepare a TMDL. Seventeen Vermont streams have been listed on Vermont's 303(d) list as principally impaired due to the effects of stormwater runoff (Figure 1). Twelve of these stormwater impaired streams are in urban areas; the remaining five involve mountain watersheds.

Vermont's Hydrologic Stormwater TMDLs

Vermont's twelve urban impaired stream TMDLs incorporate an innovative "hydrologic" based approach to target setting. In sum, each TMDL establishes a flow reduction target aimed at reducing the quantity and rate of stormwater runoff reaching the impaired stream. Through a reduction in stormwater flows, it is expected that positive changes will take place in the stream regime, thereby allowing the restoration of the stream's biological communities as necessary to meet Vermont's WQS. Appendix B contains a detailed description of this hydrologic approach to TMDL development.

This hydrologic TMDL approach is nationally recognized and fully supported by EPA, and is the outgrowth of a collaborative docket process initiated by the Vermont Water Resources Board in September, 2003 to explore the scientific uncertainties in remediating stormwater impaired waters. The docket hearings drew a large number of participants from the business community, consulting groups, EPA, state agencies, environmental groups and the general public. The Board's conclusions are set forth in "A Scientifically Based Assessment and Adaptive Management Approach to Stormwater Management" (Stormwater Cleanup Plan Framework) and referenced in 10 V.S.A. § 1264. The Board's report proposes a framework for developing cleanup plans for Vermont's stormwater impaired waters. The key elements in the report are:

- Agreement on a technically feasible way to design stormwater cleanup plans, including a methodology to predict and measure success towards restoring impaired waters to meet the VWQS based on actions taken to reduce stormwater pollution.

- Agreement that for most stormwater impaired waters, it is unlikely that the Vermont Water Quality Standards can be achieved in five years following implementation of the cleanup plan. However, the docket concluded that a specific stormwater cleanup plan could be developed using hydrology and sediment as surrogates for how aquatic biota will respond to actions to reduce stormwater pollution, and that using these surrogates will allow the Department to provide reasonable assurance that a particular stormwater cleanup plan will result in compliance with water quality standards, even though more than five years will be necessary to achieve compliance in most instances.

- Agreement that monitoring is a key component of any stormwater cleanup plan and that the plan should be adjusted periodically based on the monitoring results.

- Agreement that designing a plan using hydrology and sediment as surrogates for how the aquatic biota in impaired waters will respond makes it feasible for the Department to develop and implement TMDLs for stormwater impaired waters.

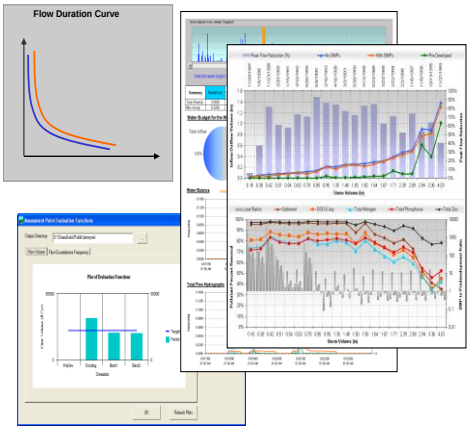
As a result of the Board's final docket report, the Department initiated a collaborative effort in the Summer/Fall of 2004 to help guide the Department in the development of stormwater TMDLs. This effort involved the formation of a Stormwater Advisory Group ("SWAG) consisting of representatives from EPA, UVM, national stormwater experts such as Tetratech, legislators, environmental groups, consulting engineers, municipal officials and the general public. The SWAG met throughout 2004-06, to discuss hydrologic models developed by TetraTech, discharge and stream data being gathered by the Department and a host of technical issues. In addition, the SWAG participated in the initiation of the development of the Department's Best Management Practices – Decision Support Tool (The BMP Tool). The BMP Tool is discussed further below and in Appendix I of this report.

With the development of these stormwater TMDLs, Vermont is leading the nation with a new and innovative approach to restore its stormwater impaired streams. In the past two years the Stormwater Program has spent over one million federal and state dollars to develop this comprehensive watershed approach based on common sense and sound science. Using this money the Program contracted for stream geomorphic assessments (SGA), subwatershed mapping, flow and precipitation monitoring, and impervious surface mapping of each of the stormwater impaired waters. These efforts are described more fully in Appendix B. In addition, modeling projects were undertaken for TMDL flow duration curve development and to create the BMP Tool. The BMP Tool is a computer modeling tool which will identify the appropriate BMPs to achieve the TMDL targets. The tools output will ultimately form the basis of each watershed specific implementation plan and the permits that will be issued to implement the TMDLs. This approach has been presented at many conferences around the country and met

with interest and enthusiasm. EPA is currently engaged with TetraTech in developing a similar tool for use around the country.

In order to ensure successful and cost-effective implementation, the Department, in collaboration with EPA-contractor, TetraTech, Inc, has developed a BMP modeling tool that considers type, sizing, and placement and produces results that can be compared to TMDL targets. The Department is using the BMP tool to identify and calibrate the most appropriate and cost-effective mix of BMPs to achieve each watershed TMDL target. Because there is a large number of BMP type, size, and location combinations, this type of analysis is time consuming and requires numerous computer model iterations and a significant data pre- and post-processing effort.

VTDSS Analysis Tools



Stormwater best management practice computer modeling tools developed for the Vermont Best Management Practice Decision Support System.

The BMP Tool can also be used to estimate the cost associated with each identified implementation scenario. Initial modeling results of different BMP implementation scenarios using the BMP Tool estimate that there will be an extremely high aggregate cost involved in the remediation work across all of the stormwater impaired streams. The Department's initial modeling scenario for Potash Brook based on one potential suite of BMPs is in the range of $25 million. Appendix I of this report discusses in more detail the assumptions of the modeling runs and the cost formula used in the BMP Tool.

Appendix F –The Stormwater Advisory Group (SWAG) and Development of an Overall Implementation Strategy for Vermont

Stormwater Advisory Group Reconvened

Faced with a statutory directive to implement these TMDLs and well aware of the complexities and costs of implementation, the Department reconvened the Stormwater Advisory Group (SWAG) in April 2008. SWAG participants included representatives from EPA, UVM, environmental groups, consulting engineers, municipal officials, and homeowners associations. A total of nine SWAG meetings were held, including both group and sub-group meetings focused on particular issues, such as technical, phasing, funding, and municipal issues. A summary of the meetings and minutes are included at the end of this appendix.

The Department's principal goals in reconvening SWAG were to:

- Identify the essential components of TMDL implementation plans
- Identify the characteristics of successful TMDL implementation
- Review similar TMDL implementation efforts around the country
- Discuss the complexities and costs of implementation and describe the development and uses of the BMP Tool
- Identify the critical factors that will most likely foster successful implementation of Vermont's stormwater TMDLs
- Reach broad consensus, if possible, on an overall implementation strategy.

As described below, all of these goals were met. The Department considers the recent SWAG process to have been a great success and is grateful to all who participated.

Components of Successful Implementation Plans

The Legislature has asked the Department to prioritize the development of implementation plans for the stormwater impaired watersheds. Thus, as a first step, the Department investigated what the contents of such a plan should include.

An implementation plan can be generally described as a watershed management plan or roadmap designed to implement a TMDL toward the goal of restoring water quality. EPA recognizes the importance of implementation plans in ensuring successful TMDL implementation. Implementation plans generally include the following components:

Review of TMDL This section describes the impairment, watershed characteristics, including land use and watershed maps, water quality monitoring and water quality modeling, watershed and pollutant source characteristics, and allocation results and necessary pollutant load reductions.

Public Participation Public participation facilitates dialogue between local stakeholders and government agencies to commit resources to TMDL implementation, such as funding and technical support. This section of the implementation plan should contain a description of the process used to engage the public and stakeholders. Public and stakeholder participation may occur at several levels, for example: public informational meetings, interest-centered focus or working groups (e.g. MS4s, commercial, residential) and/or TMDL implementation steering committees. Focus groups provide a way to address specific implementation issues and a steering committee may consider recommendations formulated by focus groups and provide overall oversight to the implementation process.

Implementation Actions This section will contain descriptions and numbers of the implementation actions (e.g. BMPs) that will be needed to attain the TMDL allocations and to restore water quality. This section may describe the types and quantities of technical assistance needed to implement the actions. A general compliance schedule may be described based on a consideration of recommended BMPs, permit cycles, funding availability, etc. This section may also include a discussion of ordinance and policy changes recommended by stakeholders to implement the TMDL, and a description of needed education and outreach activities and those responsible for conducting these activities.

Costs and Funding Sources The plan should include a description of the technical services and financial resources necessary to implement the TMDL. It may discuss both current and future funding needs, as well as explain the funding sources and strategies to meet those needs.

Measurable Goals and Milestones The implementation plan should contain a discussion of how progress toward the TMDL and water quality standards will be assessed and tracked. Both implementation and measurable milestones and goals to be achieved during implementation may be described in this section. In addition, the type and extent of monitoring required during implementation is included here. The costs of monitoring should be estimated and funding sources identified.

Stakeholder Roles and Responsibilities The roles of various stakeholders, including federal, state and local governments, local businesses, community organizations and private citizens are described in this section. These roles can include promoting public awareness through education and outreach, and supporting implementation efforts through local programs.

Critical Factors Identified by SWAG as Essential for Successful Implementation of Vermont's Stormwater TMDLs

As the SWAG process progressed, discussions kept returning again and again to certain common themes that SWAG members considered important in developing an overall implementation strategy for the impaired watersheds. These common themes, which are discussed in detail below, include:

- The importance of "fairness" in terms of who is required to implement and/or pay for TMDL implementation
- The necessity of funding, both for BMP implementation and long-term maintenance
- The critical role that a stormwater utility could play in implementation, by performing up-front planning and BMP implementation, providing a stable funding source, and by sharing costs across the watershed, rather than placing the costs solely on the backs of a subset of dischargers, many of whom may not have the resources to perform the required work
- The necessity of staged implementation, whereby the implementation process follows a staged approach, with interim goals and milestones
- The need for continued monitoring of these streams in the short-term and as implementation proceeds and the need for clearly identified metrics for measuring stream response to BMP implementation, movement toward the TMDL target and the restoration of aquatic biota.
- The importance of stakeholder involvement by municipalities, business, homeowners, watershed groups, etc.
- The need to encourage voluntary upgrades of existing stormwater systems in the short term by municipalities and individual dischargers
- The majority of SWAG members prefer implementation over litigation

Fairness

"Fairness" was repeatedly stressed by a majority of the SWAG members as essential to the success of implementation. SWAG members understand that the impairment is due to stormwater runoff from many dischargers in each watershed and that the BMP tool can generate a variety of BMP implementation scenarios to reach the TMDL targets. SWAG members also understand the expected high costs and complexities of implementation. Finally, SWAG members understand that discharges to these watersheds include many small businesses and homeowners that will likely not have ready money to plan and implement BMPs. Given these factors, SWAG members expressed a desire to have BMPs chosen and funded so that the costs and burdens of implementation are spread fairly and not concentrated on only a small group of selected discharges. The concept of fairness continually drove conversation toward the benefits of creating a regional stormwater utility, which is described in more detail below.

Funding

The Department is working diligently to prepare cost estimates for the seventeen impaired watersheds. To date, the Department has estimated that it will cost over $65 million to remediate five urban watersheds (Potash, Centennial, Englesby, Morehouse, and Bartlett Brooks) which, adjusted for the rate of inflation, could be as much as $75 million by the year 2013. While this estimated cost is based on one possible scenario of implementation for these watersheds, the final cost will be a function of the actual BMPs chosen, and how the implementation is finally staged or structured. While the exact costs for remediating all twelve of Vermont's urban stormwater impaired waters are not yet known, it is certain that these costs will be substantial. In order to have any chance at successful implementation of the TMDLs, a federal funding program is critical. Currently, there is no federal program with sufficient resources to fund implementation of these TMDLs. Neither the state nor local communities can absorb the costs of such a program.

While there are no legal requirements for ANR to consider how implementation will be financed, research into TMDL implementation around the country has concluded that "the primary characteristics that hindered implementation success were lack of data and lack of funding."(Benham, 2006). The SWAG group agreed that funding needs to be considered for implementation of the TMDLs, i.e. permitting, engineering, construction costs, and collection of monitoring data. The SWAG funding subgroup attempted to identify a range of funding options based on the acknowledgement that adequate financial resources are required for successful implementation. Types of funding options discussed by the SWAG funding subgroup include:

- 319 grants which are federal funds that are given to the states to award to projects. These funds cannot be used to implement federal permit requirements, but could potentially be used for implementing a state permit. However, there are limited funds for this grant and preference is usually given to voluntary projects, not projects required by regulation. This federal grant program is inadequate to address the funding needs for implementation of the TMDLs.

- State Funds could be established; for example, the Underground Storage Tank replacement fund which is funded through a gasoline tax. A state stormwater tax could be used both for remediation of stormwater impaired waters as well as for taking preventative measures to ensure that other streams do not become impaired. However, the Department is not proposing such a measure.

- A Statewide Bond could be acquired. However, the Department is not proposing such a measure.

- Stormwater utilities could be formed, either locally, regionally, or statewide, to collect fees from those in the affected watersheds to implement TMDLs. It is still imperative that federal funds be made available for the development of utilities, and for construction of stormwater treatment systems. Local communities cannot bear the full financial burden of implementing the TMDLs.

- Monies could be appropriated by the Legislature to either partially or entirely fund remediation efforts, such as the stormwater "Orphans Program". That program was initiated in 2006 as a pilot project whereby notification was sent to homeowners in subdivisions with orphan permits (issued long ago and expired) of their obligations to renew these permits. Grants were issued to the local municipality (which became a co-permittee) to cover the costs associated with upgrading/maintaining the systems and the permit renewal process. This program was funded by state money appropriated by the Legislature. The pilot project was intended to expand to the stormwater impaired waters at a future date. However, the Department is not proposing such a measure.

- The SWAG funding subgroup, as well as the larger SWAG group, concluded that it is difficult to identify precisely the types of funding that may be available or created for implementation absent further research and a better understanding of what

implementation will look like. Many members of the group felt that it would be helpful to seek the assistance of banking and financial organizations and experts to further explore funding options. Other members, in recognition of the existing economic downturn and the fact that both federal and state dollars will be hard to come by, indicated that creation of a stormwater utility may be the way to go, since it allows for the spreading of costs and can provide a steady source of funding. In sum, it was recognized that funding for implementation and monitoring is essential. As stated above, it is necessary that federal funds be made available for the development of utilities, and for construction of stormwater treatment systems. Local communities cannot bear the full financial burden of implementing the TMDLs. The Department is pursuing funding for this program.

Stormwater Utilities

SWAG actively and repeatedly discussed the possible formation of a utility to help with funding, planning and implementation. Although no consensus was reached as to the scope of a utility, three general options were discussed: local municipal utilities, a regional utility encompassing the impaired watershed areas and a state utility, which might serve to implement the TMDLs and potentially serve as a funding source to prevent stormwater impairments from occurring in other watersheds subject to development pressures.

Discussions regarding the benefits of a utility focused on:

- A utility would best address the “fairness” issue in that costs could be spread to all dischargers throughout the watersheds.
- A regional utility would handle some functions more easily and cost effectively (i.e. leveraging and distributing funds, inspections, permitting) then the municipalities could handle individually.
- Municipalities would get some benefits of being in a regional utility without having to form one of their own and still be able to control most of their day to day activities, such as maintenance.
- A utility could provide a steady, reliable funding source for implementation, and preventative measures so that future impairments do not occur.

While some SWAG members did not agree fully with the utility concept, in general broad support was expressed by the majority of the representatives from the affected municipalities and other SWAG members.

It was recognized by SWAG members that municipalities will be essential participants in implementation since most of the stormwater impaired streams are located in municipalities that are designated municipal separate storm systems (MS4s) under federal law. In November 1999 the EPA issued new federal stormwater regulations, known as Phase II, for the census defined metropolitan areas of less than 100,000 people. Nine Vermont municipalities with municipal separate storm sewer systems were required to come into compliance with the Phase II regulations. These communities are Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, and Winooski. In addition, three publicly owned 'non-traditional' separate storm sewer systems were also designated as MS4s. These systems are owned or operated by the University of Vermont, Burlington International Airport and the

Vermont Agency of Transportation. The regulations apply to areas served by each MS4 that are located either within the Census Bureau urban census designated area or watersheds that are principally impaired by stormwater.

Designated MS4's were required to apply for coverage under a federal NPDES MS4 permit by March 2003. There are six minimum measures required of each designated municipality under the Phase II rules and the MS4 permit. These measures are: (1) Public Education and Outreach, (2) Public Participation/Involvement, (3) Illicit Discharge Detection and Elimination, (4) Construction Site Runoff Control, (5) Post-Construction Runoff Control and, (6) Pollution Prevention/Good Housekeeping. Permits issued to designated MS4s must also be consistent with any TMDLs into which the MS4 discharges. Amendments made by the 2000 Vermont Legislature to 10 V.S.A. §1264 specify that the new state stormwater program should encourage municipal governments to utilize existing regulatory and planning authority to implement improved stormwater management by providing technical assistance, training, research and coordination with respect to stormwater management technology. In addition, USEPA Phase II regulations require designated Chittenden County communities to implement comprehensive stormwater management planning. The concept of a stormwater utility, which could provide a stable long-term source of revenue for municipal stormwater management, is nationally becoming the solution for addressing these types of stormwater management problems.

As discussed by SWAG, a stormwater utility could be formed at the municipal, state or regional level to help with the implementation and funding of the TMDLs. Significant time and effort goes into setting up a utility. South Burlington took 3 years and $500,000 for three consultants (AMEC Environmental, Hoyle, Tanner & Associates, and Pioneer Environmental), to guide the process. SWAG members agreed that a utility evaluation should be conducted which includes a review of the types of individual municipal utilities and regional utilities that have been established throughout the country, as well as an evaluation of the South Burlington municipal stormwater utility and existing regional utilities such as the Champlain Water District and the Chittenden Solid Waste District as service providers.

Staged Implementation

Staged implementation was discussed in the large SWAG group and in all subgroup meetings. These discussions focused mainly on the reasons for staging (i.e. cost, implementability, etc.) and the time frame for the different stages. As discussed earlier, staged implementation is an effective way to efficiently allocate limited resources. Applying this concept, a TMDL implementation plan might recommend BMPs in high priority areas in an impaired watershed during the first stage of implementation. Monitoring after the first stage can inform decisions about BMP implementation in subsequent stages. After BMPs are installed in critical areas in the watershed, monitoring results may show sufficient stream response so that fewer BMPs are required in the future, subsequent rounds of implementation. This may lead to a more cost efficient implementation.

When resources are limited for TMDL implementation, staging provides a practical approach for comprehensive BMP implementation. Depending on the availability of tools and funding that exist in the watershed when implementation commences, certain BMPs can be installed up front, while plans are developed and funding streams established for the implementation of additional

required practices. Regardless of the basis and time frame of staging, a desire was expressed in all groups to have a complete implementation strategy developed up front, which lays out all stages needed to meet the targets. The Implementation Plan attached to this report was prepared in response to SWAG.

There was also acknowledgement that individual BMP plans with schedules will need to be developed for each watershed. These BMP plans would identify the particular structural and non-structural BMPs to be implemented and prioritize and schedule implementation. It was acknowledged that municipalities would play a critical role in preparing BMP plans and assisting others in preparing plans given their "on the ground" knowledge of watershed discharges. Additionally, a desire was expressed that the first stage of implementation should include enough work (BMP implementation) to result in measurable changes to the stream-flow regime.

Monitoring

SWAG members agreed that there was a need for continued monitoring of these streams in the short-term to document the level of impairment. Members also expressed the need for clearly identified metrics for measuring stream response to BMP implementation, movement toward the TMDL target and the response of the aquatic biota. It is well recognized that adequate data and monitoring are essential characteristics of TMDL implementation.

Monitoring and Adaptive Management in Stormwater-Impaired Waters

Monitoring of stream health and watershed characteristics will be critical at all stages of implementation. The Department's Stormwater Program, Rivers Program, Biomonitoring and Aquatic Studies Section, and several contractors have compiled a substantial data set on aquatic biology, stream flow and precipitation, stream geomorphology, and impervious cover. SWAG members agreed that data gathering is critical in using an adaptive management approach to implementation. Monitoring data is used to determine action thresholds prior to commencing implementation. Adaptive management is a commitment to taking additional implementation actions in response to monitoring data gathered after the prior implementation phase. The following section summarizes SWAG discussions regarding monitoring and the metrics to be used to measure the effects of implementation.

Biomonitoring

Although the TMDLs use a hydrologic target, and the implementation plans are designed to achieve these targets, a stream's biological condition is the ultimate arbiter of remediation efforts. There was strong interest among SWAG participants for the Department to ensure that biomonitoring data for all streams be updated in 2008, or as soon thereafter as possible. The Department expects to complete monitoring in the majority of watersheds in 2008, with the remainder completed in 2009. Such monitoring may be limited to macroinvertebrates and fish sampling. This data will ensure remediation activities will only occur in impaired streams – as opposed to streams that may have recently recovered – and serve as an important baseline for evaluating changes in aquatic health. SWAG members agreed that following 2008, annual sampling should occur at a subset of monitoring stations on each stream in order to identify unexpected or short-term changes in stream health that could warrant an otherwise unscheduled

intensive sampling of all or most sampling stations. Finally, the SWAG agreed that sampling schedules need to be coordinated with implementation plan management cycles to maximize the chance of identifying trends in changes to the health of aquatic organisms.

In terms of adaptive management, SWAG technical subgroup members agreed that setting interim biota-based action thresholds is difficult given the absence of clearly predictable management-action to biological-response relationships. Instead, adaptive management during the implementation plan phase should focus on assessing trends in condition.

The technical subgroup agreed that the implementation schedule should reflect the likelihood that improvements in the biological condition will lag behind completion of stormwater-remediation activities; a specified period should be identified in the schedule to allow for biota recovery. Following this period, if the stream fails to meet standards, the plan would need to be amended to implement a second phase of remediation efforts. The subgroup discussed the possibility that a second implementation phase may include controls focused on secondary stressors including non-stormwater discharges, and stream-channel modifications.

Hydrology

The Department has been collecting precipitation and stream flow data in the stormwater-impaired streams since 2005. These data served as the basis for formulating the TMDLs, and are essential for evaluating stream response to remediation activities. There is strong SWAG support for continuing these efforts for the duration of remediation plan activities, and likely until such time the streams are no longer impaired, or management objectives change.

Although there is strong support for continuing to collect flow and precipitation data, the SWAG technical subgroup members agreed that further evaluation of flow metrics for measuring stream response to remediation activities in the short term is necessary. That is, the TMDL flow targets are based on a flow-duration curve (FDC). The FDC shows the percentage of time during a period of record that flow exceeds a certain value. For the impaired watersheds a synthetic FDC was developed using a computer model (P8 UCM) and a 10-year precipitation record. There does not appear to be a statistically meaningful way of comparing a limited period of flow record (e.g. two years of flow measurements post remediation activities) to the FDC. Consequently, metrics for evaluating flow response to remediation actions are needed for these periods.

The Department is considering two approaches to evaluating flow response. First, at intervals tied to significant implementation of new stormwater practices the Department agreed to use current flow data to verify the model's predictive capabilities for discrete runoff-producing rainfall events. For example, once detention practices are implemented on a certain percentage of existing impervious surfaces, the model will be updated to include these practices. The model will be re-run with recorded precipitation data for one or more events, and the estimated flow evaluated against measured flow. A second approach involves evaluating rainfall to runoff ratios. The Vermont Stormwater Flow Monitoring Project's 2006 Annual Report (Bowden and Curling, 2007) identified a significant difference in the average runoff to rainfall percentage in the attainment watersheds versus the impaired watersheds; runoff in the impaired watersheds was 50% greater than the attainment watersheds. As remediation activities are implemented, it is

expected that the runoff percentage will decrease as more precipitation is infiltrated to groundwater. Regular evaluation of these ratios will provide a useful verification of the predictive capability of the model, and will identify trends in stream response to remediation activities that would not be readily identified via FDC analysis.

In terms of adaptive management, SWAG technical subgroup members agreed that watershed specific implementation or BMP plans should specify the periods at which stream flow response will be evaluated, the metrics to be used to evaluate flow response, and appropriate error bounds for evaluating metrics. In the event that measured flow response deviates substantially from the predicted response, the implementation plan should be formally revised to account for actual flow response.

Stream Geomorphic Assessment

Phase I and II geomorphic assessments have been completed for the stormwater-impaired waters. There was consensus in the technical subgroup that ongoing geomorphic assessment should take place during the implementation period, however, such assessment should be limited to a subset of geomorphic indicators. The Department agreed to identify these indicators through a collaborative effort involving the Stormwater Program, the Rivers Management Program, and members of the SWAG technical sub-group. From an adaptive management perspective, the technical subgroup members agreed that it is unlikely geomorphic indicators will be used to amend the implementation plan, given the relatively long time scale associated with geomorphic adjustment, versus that of changes to the flow regime as a result of BMP implementation.

Impervious Cover Mapping

The Department has mapped the impervious surface of each stormwater-impaired watershed using QuickBird satellite data with assistance from the University Of Vermont School Of Natural Resources. The technical subgroup supported an effort to update impervious cover data every five years, and to have data that are no more than 3 years old at the commencement of implementation plan activities. Such data will be important for establishing an appropriate baseline from which to evaluate the extent of ongoing development. The technical subgroup agreed that further evaluation is needed to determine whether impervious area should serve as an adaptive management action threshold itself, or- and more likely- whether it will serve to inform other monitoring activities and the management thresholds associated with them.

Stormwater Treatment Practice Installation and Effectiveness

SWAG members described the potential benefits of measuring the actual performance of one or more stormwater treatment practices. Such monitoring would not be a high priority for the Department given current financial constraints for completing more essential monitoring. However, in the event that such monitoring could be financed, monitoring of the hydraulic performance of stormwater infiltration practices would be of the highest benefit. Pollutant removal measurement has been widely documented as difficult, with the performance of individual practices greatly affected by individual site characteristics. Additionally, given that the TMDLs are flow-based, identifying meaningful links between the pollutant-removal

performance of specific practices, and the response of stream biota to remediation activities would be difficult. Currently the USGS in collaboration with DEC, the City of Burlington and the Lake Champlain Basin Program is conducting a long term evaluation of stormwater best management practices in the Englesby Brook Watershed. This data should provide some base line information on individual BMP performance as well as watershed wide response to the implementation of TMDL requirements.

The technical subgroup agreed that monitoring of specific treatment practices would be of increased usefulness in cases where such a practice plays a relatively large role in the implementation plan. This is a likely scenario in some of the mountain watersheds where a single practice may constitute the majority of remedial activities. In such cases, the watershed specific management plan could be linked to the actual hydraulic and sediment removal performance. In addition, the Department is currently collecting technical data for all existing significant stormwater treatment practices (including ponds, infiltration basins, constructed wetlands, etc.) in impaired watersheds. Technical information including pond volume, drainage area and detention time is being collected through permit review. This data collection will be on-going throughout implementation on any new or upgraded BMPs. The SWAG technical subgroup agreed that there may be merit in evaluating the performance of individual BMPs, either existing or proposed, as part of special study. Such a study would likely focus on the hydraulic functioning of detention or infiltrative practices.

SWAG Meeting Dates:

April 30, 2008, Best Western, Waterbury
May 29, 2008, State Office Complex, Waterbury
July 9, 2008, State Office Complex, Waterbury – Technical Sub-group
July 9, 2008, State Office Complex, Waterbury – Financial Sub-group
July 16, 2008, State Office Complex, Waterbury – Phasing Sub-group
July 16, 2008, VLCT Office, Montpelier – VLCT Municipal Meeting
July 30, 2008, Hazen's Notch, State Office Complex, Waterbury
August 21, 2008, CCRP, South Burlington – VLCT Municipal Meeting
August 28, 2008, Hazen's Notch, State Office Complex, Waterbury

SWAG Minutes:

April 30, 2008 - Best Western, Waterbury

Attendees: Laurie Adams, Aaron Adler, Gretchen Alexander, Jon Anderson, Milly Archer, Jon Armstrong, Erik Bailey, Joanne Bisceglio, Breck Bowden, Dave Braun, Doug Burnham, Gina Campoli, Matt DeWolfe, Craig DiGiammarino, Judith Dillon, Tom DiPietro, Steve Fiske, Evan Fitzgerald, Steve Goodkind, Kim Greenwood, Jon Groveman, Chuck Hafter, Bruce Hoar, Anthony Iarrapino, Jim Jutras, Bob Kort, Dennis Lutz, Megan Moir, Jeff Nelson, Joel Nipper, Jim Pease, Eric Perkins, Staci Pomeroy, Mike Rapacz, Steve Roy, Alan Shelvey, Michaela Stickney, Andres Torizzo, Mike Winslow, George Crombie, Laura Pelosi, Pete LaFlamme, Mary Borg, Jenn Callahan, Tim Clear, Emily Schelley, Padraic Monks.

At the April 29th meeting the Department presented a summary of the status of TMDL and implementation plan development, and framed specific issues of which the Department was seeking SWAG's participation.

Technical issues presented included the status of the "Vermont BMP Decision Support System" (VTBMPDSS). The VTBMPDSS is the Department's primary analytical tool for evaluating the range of options for meeting the TMDL targets, and was recently developed for the Department by Tetra-Tech, Inc.

Three items received considerable attention during group discussion: permittee assurance; financial assistance; and future SWAG process.

Regarding permittees assurance, concerns were raised that the Department and SWAG should focus on establishing an interim permitting system under which dischargers who meet current permit renewal standards (i.e. best-fit retrofit) would not be required to perform additional corrective measures post-TMDL implementation.

Financial concerns were discussed. Several participants suggested that financial assistance for ongoing and future work was essential, and that funding options, including the Vermont Legislature and the United State congress should be explored by SWAG.

SWAG participants discussed the Department's proposed SWAG meeting schedule and proposal for a sub-set of SWAG to address specific issues. SWAG suggested that sub-group participation be open, and that sub-groups would present to the larger group at regular intervals. Consequently, sub-groups latter formed to address technical, financial, and municipal aspects of TMDL implementation.

May 29, 2008 - State Office Complex, Waterbury

Attendees: Alan Shelvey, Steve Berkett, Eric Perkins, Padraic Monks, Jim Pease, Jim Jutras, Anthony Iarrapino, Kim Greenwood, Milly Archer, Andres Torizzo, Andy Mikell, Mike Winslow, Dennis Lutz, Craig DiGiammarino, Jonathan Armstrong, Tom DiPietro, Jeff Nelson, Michael Mittag, Laura Pelosi, Pete LaFlamme, Mary Borg, Jenn Callahan, Emily Schelley, Christy Witters

The goal of the May 29th meeting was to discuss implementation issues, begin discussion on phased implementation, and to set up the subgroups. Additionally, substantial discussion of monitoring and metrics, and financial issues occurred.

A significant concern raised by SWAG participants regarding monitoring is that existing biological data may not be sufficiently current to represent actual conditions, and that some streams may have improved since the latest data were acquired due to remediation efforts. There appeared to be consensus to update biological data. Monitoring and metrics, and the role of SWAG are discussed in detail in earlier in this appendix.

SWAG discussed the importance of funding ongoing monitoring, with Department representatives identifying the absence of funding beyond the current year. More broadly,

SWAG discussed the need to provide a funding source for TMDL implementation, including the possibility of stormwater utilities (State and municipally controlled), and a possible state-wide stormwater tax.

July 9, 2008 – Technical Sub-group

Laundry Building Conference Room, State Office Complex, Waterbury, VT

Attendees: Mark Vorhees, Breck Bowden, Craig DiGiammarino, Kim Greenwood, Mary Watzin, Christy Witters, Emily Schelley, Eric Perkins, Dennis Lutz, Megan Moir, Tim Clear, Jenn Callahan, Padraic Monks, Jeff Nelson.

SWAG discussed monitoring issues related to biology, impervious cover mapping, geomorphic assessment, stream flow and precipitation, BMPs, and their role in adaptive management. These issues are discussed in detail earlier in this appendix.

July 9, 2008 - Financial Sub-group

Laundry Building Conference Room, State Office Complex, Waterbury, VT

Attendees: Jenn Callahan, Mark Vorhees, Eric Perkins, Jon Groveman, Megan Moir, Padraic Monks, Dennis Lutz, Dawn Francis, Jim Pease, Emily Schelley, Christy Witters, Kim Greenwood, Craig DiGiammarino.

The Financial Sub-group met to discuss options for funding TMDL implementation. One of the Department's primary interests in this meeting was to gauge the group's view on the extent to which it is appropriate for the Department to address financing issues. SWAG participants noted that there are no legal requirements for ANR to consider how implementation will be financed. However, the group clearly indicated that it is appropriate for SWAG, ANR, and affected parties to identify the complete range of funding options based on the acknowledgement that adequate financial resources are required for successful implementation.

The sub-group discussed several potential sources of state and federal funding, including:
Federal 319 grants; these are federal funds which are given to the states to award to projects. These funds cannot be used for federal permits but could potentially be used for implementing a state permit. However, there are limited funds for this grant and preference is usually given to voluntary projects, not projects required by regulation.
Examples of State funds discussed were the Stormwater Orphans program and the Underground Storage Tank replacement fund which is funded through a gasoline tax.
A State Stormwater Tax was discussed which could have the benefit of addressing issues in non-impaired waters to try and prevent additional streams from being impaired due to stormwater.

The possibility of a Statewide Bond was also discussed, but did not appear to receive strong support given that it would require the State to acquire additional debt.

Utilities
The group devoted substantial time to discussing the possibility of forming a utility to fund the implementation of the TMDLs. Such a utility could be formed at the municipal level or at the

regional level, and could provide a range of services potentially including funding, technical expertise, administrative support, and maintenance. Substantial investigation of the options, as well as public dialogue would be required to identify the specifics of any utility.

Participants pointed out that significant time and effort goes into setting up a utility. For example, South Burlington's process for forming a utility took several years and $500,000 for three consultants (AMEC Environmental, Hoyle, Tanner & Associates, and Pioneer Environmental),, to guide the process. There was recognition that additional utility formation and expansion would require a similar process be followed in several communities.

Participants also discussed the importance of incentives in utility formation. For example, a clear incentive to the municipalities, such as a guaranteed source of funding, would need to be identified in order to encourage utility formation.

In discussing the pros and cons of multiple local utilities versus a larger regional utility, it was acknowledged that a regional utility might be able to handle financial leveraging, the distribution of funds, inspections, and permitting more efficiently then multiple smaller utilities. A strong case was made that it might be difficult for such a regional utility to take on actual maintenance operations given the large investment required in equipment and staff and the difficulties in effectively employing these assets year-round. Consequently, these activities may be better undertaken by the individual municipalities where the equipment and staff can serve multiple purposes such as stormwater maintenance in the summer, and snow-plowing in the winter.

Sources of Expertise
A desire was expressed to include experts in the funding discussion, citing a lack of knowledge about the workings of federal, state, and local funding processes. Suggestions included, Environmental Finance Center in Maine, Vermont Legislature, Vermont League of Cities and Towns, State Treasurer's Office, and Vermont Municipal Bond Bank. Additionally, the group discussed bringing in a party with expertise on forming a utility such as AMEC.

Expertise should be sought at such time the general approach for TMDL implementation is decided upon.

July 16, 2008 – Phasing Sub-group Hazen's Notch, Waterbury VT

Attendees: Emily Schelley, Jenn Callahan, Mary Borg, Craig DiGiammarino, Jim Jutras, Alan Shelvey, Padraic Monks, Megan Moir, Kim Greenwood

The Phasing Sub-group met to discuss the potential staged implementation of the TMDL implementation plans. The group differentiated between "phasing" and "staging" for purposes of this effort. In TMDL implementation, "phasing" refers to broad categories of remedial activities. In the case of the stormwater-impaired waters, the first phase of TMDL implementation refers to all necessary stormwater corrective actions. Whereas staged implementation refers to implementing the stormwater-remediation phase over a specified period of time based on appropriate logistical and scientific factors.

EPA recognizes that some TMDLs will require "staged" implementation, particularly if they include nonpoint sources, and that in many of these cases the staging will be significant. This staging can also go hand in hand with adaptive management, such that some clearly needed control measures are implemented, while others await additional information.

Staging Under Federal and State Law
The Department presented its view of staging under Federal and State law. Under Federal law, staged implementation is most often considered in the context of TMDLs involving nonpoint sources. NPDES permits issued to implement a TMDL must include limits to meet any specified WLA for the discharge in order to be considered "consistent" with the TMDL and meeting water quality standards.

Under State law, the Vermont Stormwater Management Rule for Stormwater-Impaired Waters provides: General permit shall be reasonably designed to implement the TMDL taking into account the unique characteristics of the watershed, the scientific uncertainly in remediation stormwater-impaired waters and that the time needed for remediation may vary greatly across watersheds. A General Permit may include any "requirements deemed necessary by the Secretary to implement the TMDL," Additionally, a General Permit can be written for a period longer than 5 years to allow for flexibility and phasing of implementation.

Potential Basis for Staging
The potential basis for staging was discussed by the group. The stages of implementation could be based on a number of different factors including cost, availability of funding, municipal vs. private discharges, feasibility of the corrective measure, degree of contribution to the impairment, and location of the discharge within the watershed.

Time Frame for Staging
The group discussed the need for a reasonable time frame for implementation. The amount of time needed may vary substantially depending on the extent of corrective measures required in the watershed. Specific time frames for staging in individual watersheds were not identified.

A clear desire was expressed to have a complete implementation plan developed that identifies all required corrective measures, and which also explains the framework and basis for staging. There was also agreement that the first stage, at a minimum, needs to implement sufficient corrective measures to result in measurable progress towards meeting the target.

July 16, 2008 – VLCT Municipal Meeting VLCT Office, Montpelier

Attendees: Milly Archer, Alan Shelvey, Jim Pease, Jon Armstrong, Tom DiPietro, Dan Lindley, Emily Schelley, Padraic Monks, Jenn Callahan, Dennis Lutz, Jessica Andreoletti, Gina Campoli, Jim Jutras, Craig DiGiammarino, Charlie Baker, Pete LaFlamme, Mary Borg

The VLCT hosted and organized two meeting of municipal representatives 7/16/08 and 8/21/08) to discuss their role in stormwater-impaired waters remediation. DEC participated in these meetings to further our understanding the interests, obligations, and limitations of municipal interests in the implementation plan development process.

The initial discussion focused on what potential responsibility municipalities have for existing stormwater discharges. Four categories of properties, and their resulting discharges, were described. The first category is the municipality owns the infrastructure (e.g. stormwater system or roads) and therefore would be responsible for these properties. The second category is a mixed system in which runoff from private properties flows into or through a municipal system. In most cases there are no clear boundaries where one discharge stops and another starts. Different towns approach these properties differently. The third category involves private discharges that do not connect to the municipal infrastructure at any time. Municipalities do not current view these discharges are their responsibility. The fourth category includes discharges from an entity such as the state or federal government. The municipalities did not view these discharges as their responsibility.

There was also much discussion regarding the potential services a stormwater utility could provide, possible formats, and the issues involved with their creations. Regional, state-wide, and watershed-based models were discussed. A regional utility could serve all stormwater-impaired watershed communities in the state. A statewide utility would have the benefit of spreading the costs over a larger number of entities and could be used in the unimpaired waters to help prevent waters from becoming impaired.

No representations were made by VLCT on behalf of its members regarding their likelihood for support of any particular approach for addressing TMDL implementation plan requirements.

July 30, 2008 - State Office Complex, Waterbury

Attendees: Emily Schelley, Tom DiPietro, Craig DiGiammarino, Gina Campoli, Jim Jutras, Dennis Lutz, Milly Archer, Kim Greenwood, Eric Perkins, Anthony Iarrapino, Stephen Berkett, Alan Shelvy, Jim Pease, Doug Burnham, Padraic Monks, Christy Witters, Mary Borg, Pete LaFlamme, Jenn Callahan, Michael Mittag, Julie Beth Hinds, Megan Moir, Aaron Adler, Jon Armstrong.

The beginning of the meeting was devoted to the Department presenting the general findings of recent sub-group meetings. The details of these findings are presented in the sub-group write-ups.

The second half of the meeting was spent discussing potential implementation plan details. Three general possible strategies were discussed by the group: issuance of a general permit by DEC identifying selected dischargers and required stormwater BMPs; reissuance of the MS4 with a specific requirement to implement the TMDL target; and development of a detailed staged implementation plan. Discussion again focused on the possible roll of a utility. The group suggested SWAG would benefit from learning from existing utilities, including non-stormwater utilities. Consequently, it was suggested that a sub-group of municipalities meet with Tom Moreau, Executive Director of the Chittenden Solid Waste District to discuss the possibility of a stormwater utility.

August 21, 2008– Vermont League of Cities and Towns (VLCT) Municipal Meeting

Chittenden County Regional Planning Commission, South Burlington
Attendees: Karen Horn, Dan Senecal-Albrect, Pete LaFlamme, Milly Archer, Jon Armstrong, Dennis Lutz, Jim Jutras, Laurie Adams, Julie Potter, Jessica Andreoletti, Emily Schelley, Jennifer Callahan, Christy Witters, Padraic Monks, Alan Shelvey, Tom DiPietro, Steve Goodkind, Bruce Hoar

This was the second of two VLCT-hosted meetings in which the Department participated. The purpose of this meeting was to gain a better understanding of the issues involved in creating and managing a utility in Vermont.

Tom Moreau, Executive Director of the Chittenden Solid Waste District (CSWD) presented on the formation of the CSWD. Primary issues identified by Mr. Moreau included the following. Joining the CSWD is voluntary; municipalities joined as their need arose. The CSWD was formed in part to increase the cost effectiveness of solid waste services by consolidating the appropriate resources into one organization, versus replicating them redundantly across multiple municipalities. The CSWD has realized that increased efficiency, and is also better able to advocate on behalf of its members for needs related to solid waste management than individual municipalities are able to.

The group identified that any regional or multi-watershed utility would need to be a fairly large entity with many people to manage just the stormwater impaired watersheds. The start up would be expensive and time consuming. There was consensus that the CSWD was a valuable model for utility formation, despite the differences in services provided.

Discussion was also had that in the event communities decided to form a utility to address TMDL implementation plan requirements, it would be beneficial if regulatory requirements allowed several years for development of a utility, and that BMPs would be required to be implemented following the creation of the utility.

Finally, if municipalities chose to further explore developing a utility, expert consulting services would be beneficial. Identifying funding sources for such services would be necessary.

August 28, 2008 - State Office Complex, Waterbury

Attendees: Eric Perkins, Craig DiGiammarino, Emily Schelley, Jenn Callahan, Christy Witters, Jim Pease, Mary Borg, Pete LaFlamme, Juli Beth Hinds, Dennis Lutz, Alan Shelvey, Michael Mittag, Steve Berkett, Anthony Iarrapino, Tom DiPietro, Marc Lucas, Gina Campoli, Jeff Nelson, Padraic Monks, Jim Jutras, Mick Schramm, Megan Moir, Derick Read, Lou Borie, Milly Archer

This was the final meeting of the SWAG process in preparation for this report. The Department presented national examples of successful TMDL implementation plans. Additionally, the Department presented its preferred model for TMDL implementation, based on information obtained from SWAG meetings, regulatory requirements, and broad research of implementation plan alternatives from across the country. The Department's preferred model includes

implementing the stormwater TMDLs through a staged implementation plan via a regional utility, as described in detail in this report. There appeared to be consensus- while not implying any specific endorsements- among participants that this approach was preferable to other identified alternatives. The alternatives presented by the Department include issuing watershed specific general permits identifying dischargers and required corrective measures without an identified supporting organization, such as a utility; and reissuance of the MS4 General Permit with a requirement for the municipalities to implement the TMDL targets with no time or support allotted for the formation of a utility.

Appendix G - Environmental Impacts of Stormwater Runoff

Stormwater runoff is the portion of natural precipitation that runs off impervious surfaces (e.g. rooftops, parking lots and paved and gravel streets) rather than infiltrating into the ground. Streams and other waterbodies draining developed/developing watersheds are subject to many stressors associated with stormwater runoff. These stressors act individually and cumulatively to degrade the overall biological community in waterbodies to a point where aquatic life uses are not fully support and the waterbodies do not meet state water quality standards.

The circumstances leading to aquatic life impairments as a result of excessive stormwater runoff are typically very complex due to the action of multiple stressors and numerous site-specific factors such as watershed soils, topography, riparian vegetation, channel slope, streambank soils and bottom substrate. The main stressors that contribute to aquatic life impairments include hydrologic imbalances, whereby uncontrolled stormwater runoff alters the natural hydrological condition of a watershed, and the addition of watershed pollutants carried by stormwater runoff. These stressors are described briefly as follows:

- Channel Alterations and increased Pollutant Loads from In-Stream Sources.

  Increased stormwater runoff rates from developed impervious areas results in prolonged periods of higher in-stream flow rates which may de-stabilize stream channels and result in the increased generation of in-stream pollutants (i.e. sediment) through bank erosion and scouring. Sediments from in-stream sources may contribute to aquatic life impairments through habitat degradation because of subsequent sedimentation further downstream in the system (i.e. increased embeddedness) and increased turbidity. In addition, channel alterations such as stream over-widening may eliminate pools and other important habitat features.

- Wash-Out of Biota.

  High stream flows resulting from excessive stormwater runoff can physically displace or harm resident biota. Macro-invertebrates and fish may be carried out of the system due to high flow velocities.

- Reduced Stream Base Flow.

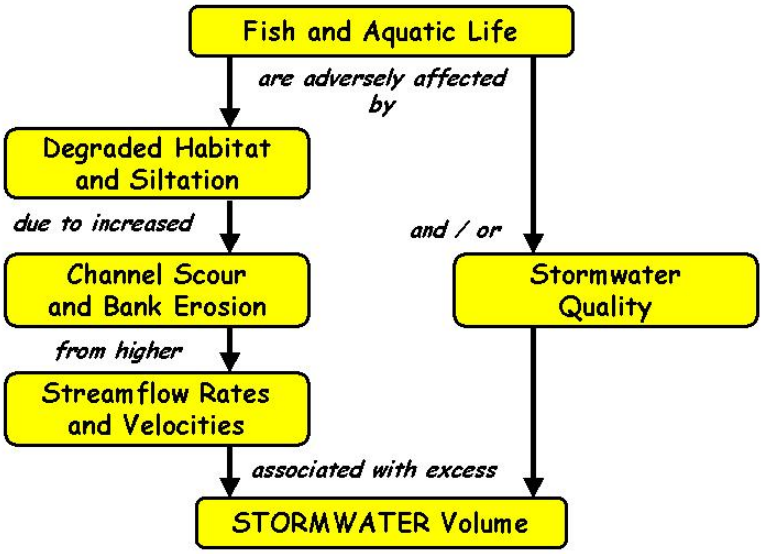
  Increased impervious cover and the resulting increase in surface runoff reduce the amount of rainfall that falls on pervious (e.g. vegetated) watershed areas and that is recharged to groundwater. For many systems, groundwater recharge is the predominant source of stream baseflow. Diminished base flow can further stress aquatic life and cause or contribute to aquatic life impairments through loss of aquatic habitat and increased susceptibility to pollutants.

- Watershed Pollutants

  Stormwater runoff from developed areas contains many pollutants, such as sediment, phosphorus, pesticides, bacteria, metals, and hydrocarbons. Pollutants accumulate on impervious surfaces and are washed off during rain events and during snow melt. Paved surfaces and piped drainage systems efficiently transport these pollutants from the watershed to lakes, streams and rivers. Some of these pollutants directly affect aquatic life while others degrade the quality of the habitat.

Hydrologic TMDLs

TMDL calculations are commonly used in situations where a water is impaired by a specific pollutant (e.g. phosphorus, E. coli, etc.) and the goal is to determine how much that pollutant needs to be reduced for the water to attain water quality standards. For aquatic life impairments, there often is not one specific pollutant of concern; instead, the impairment may be caused by a mix of pollutants and physical alterations to the stream system. In these cases, it is desirable to select one or more surrogate parameters for use as TMDL targets. When an aquatic life impairment is related to stormwater impacts, such as is the case with the 17 streams in Vermont, the watershed's hydrologic condition (and the stormwater runoff patterns that drive it) can serve as an effective surrogate for both pollutant and non-pollutant stressors contributing to the impairment. The TMDLs utilize the surrogate of stormwater runoff volume in place of the traditional "pollutant of concern" approach. The combination of stressors is represented by the surrogate of stormwater runoff volume. The use of this surrogate has the primary benefit of addressing the physical impacts to the stream channel caused by stormwater runoff such as sediment release from channel erosion and scour from increased flows. These physical alterations to the stream are substantial contributors to the aquatic life impairment. Also, reductions in stormwater runoff volume will help restore diminished base flow (increased groundwater recharge), another aquatic life stressor.



Target Setting

The Department contracted with UVM to help develop a protocol that can be used to objectively identify targets for stormwater reduction. This overall UVM project expands upon the Water Resources Board Docket (Docket) of 2004 and the stormwater simulation project completed by

TetraTech in 2005. The Docket identifies a reference watershed approach whereby hydrologic targets are developed by using similar "attainment" watersheds as a guide. The TMDLs use the attainment watershed approach for target setting and identifies hydrologic targets based on the hydrologic characteristics of similar watersheds where the VTWQS aquatic life criteria are currently met.

In using the attainment approach, a process needed to be developed to select appropriate attainment streams, which, ideally, are as similar to the impaired watershed as possible in physical makeup, such as slope, soils, climatic patterns, channel type, and land use/cover, etc. Using a statistical method of watershed clustering on these variables, natural groupings of watersheds that included both impaired and attainment streams were identified. The Department is using these groupings, and their attainment mean high and low flow values as the targets for the corresponding impairment watersheds for the TMDLs. A detailed report for this study (a Statistical Analysis of Watershed Variables) can be found at http://www.vtwaterquality.org/stormwater/htm/sw_impairedwaters.htm

Hydrologic Modeling and Flow Duration Curves

In an effort to identify appropriate targets and corresponding load allocations that are necessary to attain applicable water quality standards, the Department embarked on a study that involved definition of hydrologic conditions for both impaired and attained watersheds using hydrology models. The objective of stormwater modeling is to simulate time series flow to develop flow duration curves (FDC) and use this information to identify appropriate targets that are necessary to attain applicable water quality standards. The P8-UCM model was selected after a detailed review of study needs, model capabilities, data availability, and budget and time considerations.

Hourly precipitation, daily temperature, land use, soil types, slope, and percent imperviousness are the primary data inputs to apply P8-UCM model for small watersheds. The model was initially calibrated using daily flow data from selected small USGS gauges in the Lake Champlain region. The model calibration was further improved using hourly flow data collected by the University of Vermont (UVM) during the summer of 2004. In order to enhance the model's capability of simulating ground water base flow, a simple linear-reservoir algorithm was developed and the results were tested with observed streamflow data collected by UVM.

Calibrated models were employed to estimate hourly time-series flow values for small watersheds that are impaired by storm water runoff, as well as for attained watersheds that are presently supporting aquatic life uses. FDCs were developed using model simulated flow during a ten-year (1990-1999) period for all of the impaired and attained watersheds. The results were used in identifying appropriate hydrological targets for each impaired watershed. This work was funded by both state and federal money, a detailed report (Stormwater Modeling for Flow

Duration Curve Development in Vermont) can be found at
http://www.vtwaterquality.org/stormwater/htm/sw_impairedwaters.htm

Data Collection

The Stormwater Program managed several contracts that were necessary to collect and process information used in the development of the stormwater TMDLs, and that will also form the basis of an ongoing monitoring program for the stormwater-impaired streams. The elements of this data collection process are described below.

Stream Geomorphic Assessment

To help develop the implementation plans and support the monitoring phase of stream remediation efforts, the Program has contracted with UVM and various consultants to develop a consistent baseline of stream geomorphic assessments (SGAs) for the stormwater-impaired streams. The SGA data will be used to help focus the remediation efforts. Additionally, this data can be used as a point of comparison for future assessments to document improvements or degradation of these streams on a set of reaches from stormwater-impaired streams. Phase I and II SGAs have been completed for all 17 of the stormwater impaired streams.

Subwatershed Mapping

The objective of this project is to identify discharge points within the stormwater-impaired watersheds and delineate the associated watersheds for those discharge points. The previously available subwatershed data was of varying quality. In some cases, there was data on stormwater collection systems and discharge points; however, all of the watersheds took a substantial amount of work to get an accurate subwatershed delineation. The delineation of these sub-watersheds is helping to focus management efforts on higher risk areas within each stormwater-impaired watershed. The subwatershed mapping data for all of the 17 watersheds was completed in 2006.

Flow Gaging and Precipitation Monitoring

Altered hydrology within the stormwater-impaired watersheds is the dominant factor in causing the impairments. To support the monitoring phase of stream remediation, the Program hired a consultant to establish and operate stream flow and precipitation recording stations within each of the stormwater-impaired waters. This data will form an essential part of the adaptive management approach as stream flow is anticipated to reflect the initial response to the implementation of the stormwater management plans. In addition to the streamflow data collected by the contractor in 2005, the Department contracted with UVM to do three additional years of streamflow monitoring.

Impervious Surface Mapping

The Program is mapping the impervious surface area of each stormwater-impaired watershed. This data is being used in the development and implementation of the stormwater management plans. The impervious surface mapping is being done using QuickBird satellite imagery. This project will be completed in conjunction with the School of Natural Resources at UVM. The QuickBird satellite acquires high-quality satellite imagery for map creation, detection of change over time, and image analysis.

Imagery of a residential subdivision.

Impervious surfaces mapped on the residential subdivision.

The Program has ordered QuickBird Data for the stormwater-impaired watersheds and will perform the digital analysis of the data for these watersheds. UVM will apply advanced object oriented eCognition classification techniques to potentially improve the mapping accuracy for the previously analyzed data using the QuickBird satellite data. The Program currently has impervious data for all twelve of the urban impaired watersheds.

Engineering Feasibility Assessment

To help develop the implementation plans, the Program is currently collecting technical data for all significant stormwater treatment practices (including ponds, infiltration basins, constructed wetlands, etc…) in impaired watersheds. Technical information including pond volume, drainage area and detention time is being collected through permit review and site modeling using HydroCAD software. Once information is collected, site visits are conducted to ensure the accuracy of data. In addition to data collection, the program is also conducting a limited engineering feasibility analysis at each site to estimate what may reasonably be achieved at the site in regards to stormwater detention and infiltration. Data collection has been completed for all twelve of the urban impaired watersheds.

Appendix H - Stormwater TMDL Implementation: Case Study Summaries

Eagleville Brook TMDL – Mansfield, CT

Pollutants: Pollutants transported by stormwater

Sources: Impervious cover as surrogate for stormwater pollutants, expressed as % Impervious cover. TMDL implementation objective is a reduction in impervious cover, achieved by improved stormwater management.[1]

Stakeholders: Town of Mansfield, University of Connecticut, area conservation organizations

Implementation through existing NPDES Permits:

MS4 –

- "If a TMDL is approved for any waterbody into which the permittee discharges, the permittee shall review its Stormwater Management Plan if the TMDL includes requirements for control of stormwater discharges. If the stormwater discharge(s) do not meet the TMDL allocations, the permittee shall modify its Stormwater Management Plan to implement the TMDL within four months of the TMDL's approval and notify the Commissioner of this modification." [2] (p.20)
- Eagleville Brook is currently not within a regulated MS4.[1] If future biological monitoring indicates non-attainment of aquatic life goals, then the State will consider designating municipalities within the Eagleville Brook watershed as Small MS4s under the MS4 Permit Program.

Phasing: Implementation will be "accomplished through incorporating an adaptive management strategy. The strategy will include:
1) reducing IC where practical,
2) disconnecting IC from the surface waterbody,
3) minimizing additional disturbance to maintain existing national buffering capacity, and
4) installing engineered BMPs to reduce the impact of IC on receiving water hydrology and water quality."

Funding: Currently, the state is using a 319 grant to develop a "Roadmap" for the implementation of the Eagleville Brook TMDL. The result of the Roadmap development will be a plan for what should be implemented, where BMPs should be placed, and how much they will cost. The cost of the Roadmap project is approximately $400,000. The plan is to develop the Roadmap for Eagleville Brook and use it as a guidance document for future IC TMDLs.[3]

Future Growth: Future development should be constructed and operated to limit the effect of stormwater from impervious cover on the aquatic life in Eagleville Brook.[1]

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[1] A Total Maximum Daily Load Analysis for Eagleville Brook, Mansfield, CT. CTDEP. February 8, 2007. http://www.ct.gov/dep/lib/dep/water/tmdl/tmdl_final/eaglevillefinal.pdf

[2] General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems. CTDEP. January 9, 2004. http://www.ct.gov/dep/lib/dep/Permits_and_Licenses/Water_Discharge_General_Permits/MS4_gp.pdf

[3] Christy Witters conversation with Chris Bellucci, CT DEP. July 11, 2008.

Draft MS4 Permit – Worcester, MA

Existing Discharges to an Impaired Water with an Approved TMDL:

- The Permittee shall include these BMPs in its SWMP and address in its SWMP and annual reports how the discharge of the pollutant(s) identified as causing the impairment will be controlled such that they comply with the requirements of Part I.C.2.

Measure 6: Infrastructure Operations and Maintenance:

- I.E.6(i) - The Permittee shall ensure the performance of retention or detention ponds which discharge to, or receive stormwater from, its MS4
    - Ponds owned by Permittee
    - Privately-owned ponds (where Permittee maintains an easement)
    - Permittee shall annually inspect all such retention or detention ponds and remove accumulated solids to restore full solids capture design capacity where found to be in excess of 50% design capacity.
- I.E.1. The Permittee shall ensure that it obtains or maintains the necessary and enforceable legal authority established by statute, ordinance, rules and regulations, permit, easement, contract, order and any other means, to prohibit or control the contribution of pollutants to its MS4, including the authority to:
    - (c) optimize the performance and pollutant removal efficiency of privately-owned retention or detention ponds that discharge to or receive discharge from its MS4, by ensuring the performance of adequate inspection and maintenance activities;

Resources:

EPA Region 1, Worcester Draft MS4 Permit: http://www.epa.gov/region1/npdes/worcester/index.html

Minnehaha Creek Watershed Lakes (Nine Lakes) TMDL – Minneapolis St. Paul, Minnesota

Pollutants: Nutrients

Sources: Stormwater runoff: municipal, industrial, and construction permitted stormwater point sources and non-NPDES-regulated nonpoint sources

Implementation through existing NPDES Permits:

MS4 –

- MS4 permit "requires that MS4s who discharge to a waterbody with an approved TMDL review the adequacy of the MS4 SWPPP to meet the WLA set for stormwater sources. If the SWPPP does not meet the applicable requirements, schedules, and objectives of the TMDL, the permittee must modify the SWPPP, as appropriate, within 18 months after TMDL approval."[4]
- MN is planning to implement TMDLs through the next MS4 Permit (current permit expires in 2011). They are currently working on crafting specific guidance to MS4s so that the municipalities can easily incorporate TMDL implementation plans into their SWPPPs.[5]

MSGP – The current MSGP is expired and does not include requirements for facilities that discharge to impaired waters. "…the reissued permit for stormwater discharges associated with industrial activity will include language requiring permittees to comply with WLAs in approved TMDLs."[4]

CGP –

- Permittees that discharge sediment or parameters associated with sediment transport to an impaired water must implement BMPs that are sufficient to comply with WLA in the TMDL. The SWPPP must also comply with the requirements of the TMDL. [4]
- "One way the TMDL could quantify the allocation for construction sites is to build into the TMDL the "ultimate loading scenario" identified in the MCWD Comprehensive Water Resources Management Plan. This scenario contrasts existing loading projections with future loading to quantify the impacts of development on resources. The approach could be used to quantify the construction activity component of the WLA." [4]

Phasing:

- Future options for meeting the TMDL WLA through the 5yr MS4 permit[5] (current permit expires in 2011)
  1. Prescribe specific BMPs or
  2. Allow MS4s to set up a compliance schedule for multiple permit terms
     - Ex) X number of rain gardens by 2016 permit
       X number of ponds by 2020
     - Before permit renewal, MS4 must assess progress and re-evaluate implementation schedule to stay on track with pollutant load reduction targets

- MS4 permit must meet WLA. Their interpretation is that a multiple year, multiple permit term, mapped out strategy for meeting the WLA is acceptable. [5]

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[4] The Minnehaha Creek Watershed District (Minnesota) Nine Lakes TMDL. EPA Case Study Factsheet. 2005. http://www.epa.gov/owow/tmdl/stormwater/pdf/nine_lakes_case_study.pdf

[5] Christy Witters conversation with Mike Trojan of MN Pollution Control Department– Stormwater Section. July 8, 2008.

- "This type of iterative approach is supported by EPA under *The Interim Permitting Approach for Water Quality-Based Effluent Limitations in Stormwater Permits* (August 26, 1996)." [4]

- Through NPDES permits, permittees can be required "to develop proposed reduction milestone timelines and goals. These timelines and goals could include BMP performance measures as well as pollutant load reduction benchmarks for TMDL parameters." [1]

Resources:

Minnesota Stormwater Programs and Impaired Waters Homepage with links to plans, implementation and policies. http://www.pca.state.mn.us/water/stormwater/impairedwaters.html

Minnehaha Creek Watershed District: Comprehensive Water Resources Management Plan homepage: http://www.minnehahacreek.org/Draft509Plan.php

Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits. EPA Federal Register Notice. Federal Register: August 26, 1996 (Volume 61, Number 166)] http://www.epa.gov/fedrgstr/EPA-WATER/1996/August/Day-26/pr-21017DIR/pr-21017.html

Oyster Bay and Mill Neck Creek TMDL– Long Island, NY

Pollutants: Pathogens

Sources: Point source - wastewater treatment plants (WWTPs); stormwater discharges, drain pipes and culverts, from streets and parking areas and direct overland runoff flows from street ends and boat ramps. Nonpoint source – 39 residential and 4 other units dispose of domestic waste using cesspools; freshwater inputs from several creeks and ponds; boats, marinas, and mooring areas

Allocations:

- *Point source* – In one of the Oyster Bay zones, the TMDL requires a 20 percent reduction in the stormwater load which included stormwater drainage, and in another zone, the TMDL requires a 90 percent reduction in stormwater which included urban runoff.
- *Nonpoint source* – In one of the zones in Oyster Bay, the TMDL requires a 95 percent reduction in boat and marina loadings.

Implementation through existing NPDES Permits:

MS4 –
Oyster Bay TMDL:

- MS4s discharging to two of the zones within Oyster Bay Harbor will be required to provide controls beyond the six minimum measures.[6]
- "If an MS4 is not meeting the TMDL stormwater allocations, it must, within six (6) months of the TMDL's approval, modify its stormwater management program to ensure that reduction of the pollutant of concern specified in the TMDL is achieved. Modifications must be considered for each of the six minimum measures. The revised management program must include an updated schedule for implementation."[7] (p.8-4)

NY MS4 Permit:

- Additional BMPs required in pathogen impaired waters (Part IX. C.5.)[8]
    - Within 3 years of the effective date of the permit...Develop and commence implementation of a retrofit program to correct or reduce pathogen loading
        - Establish procedures to identify sites
        - Establish policy and procedures for project selection
        - Establish policy and procedures for project permitting, design, funding, construction and maintenance
        - By march 9, 2011, (3 years into permit) develop and submit approvable plans and schedules for completing retrofit projects

Nassau County MS4 Annual Report[9] (p.21):

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[6] Total Maximum Daily Loads with Storm Water Sources: A Summary of 17 TMDLs. USEPA. April 2007. http://www.epa.gov/owow/tmdl/17_TMDLs_Stormwater_Sources.pdf

[7] Pathogen Total Maximum Daily Loads for Shellfish Waters in Oyster Bay Harbor and Mill Neck Creek, Nassau County, New York. New York State Department of Environmental Conservation (NYSDEC). September 2003. http://www.dec.ny.gov/docs/water_pdf/oystbay.pdf

[8] NYDEC SPDES General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (MS4). NYDEC. May 1, 2008. http://www.dec.ny.gov/docs/water_pdf/ms4permit08.pdf

[9] County of Nassau Municipal Compliance Certification Form and Stormwater Management Program Annual Report. County of Nassau. Year 5 Report. March 9, 2008. http://www.nassaucountyny.gov/agencies/DPW/documents/2008AnnualStormWaterReportFinal.doc

- The Oyster Bay storm sewersheds were mapped and 12 sites were identified for stormwater improvement projects. Proposed BMPs include: wet swales, dry swales, catch basin inserts, sedimentation basins and infiltration trenches.
    - Plan for 2008 – meet with new committee and determine which projects have the most impact, identify funding, and scheduling.

Funding:

- NYSDEC will continue to work with these municipalities to identify funding sources and to evaluate locations and designs for stormwater control BMPs throughout the watershed. Under the State's Environmental Protection Fund (EPF), $3.4 million will be provided this year (2003) through an application process to assist communities in implementing the Stormwater Phase II regulations. In addition, $380,000 from New York's federal nonpoint source grants and $800,000 in partnership funding has been committed to its implementation.[7] (p.8-5)

Columbia Slough TMDL – Portland, OR

Pollutants: Chlorophyll *a*, Dissolved Oxygen, pH, Phosphorus, Bacteria, DDE/DDT, PCBs, Pb, Dieldrin and 2,3,7,8 TCDD

Sources: Industrial discharges, combined sewer overflows, groundwater, urban storm water, landfill leachate, airport de-icing, clean up sites

Stakeholders: City of Portland, Portland International Airport, City of Gresham, City of Fairview, City of Wood Village, Multnomah County, OR Department of Agriculture, OR Department of Transportation

Implementation through existing NPDES Permits:

City of Portland MS4 Permit[10] (one of the MS4s in the Columbia Slough) –

- A Stormwater Management Plan (SWMP) is required that includes BMPs designed to achieve reductions in the TMDL pollutants and a monitoring plan designed to gauge the effectiveness of the SWMP in reducing TMDL pollutant loads to the maximum extent practicable.
- Progress in achieving the WLA is measured through performance measures and pollutant load benchmarks. Performance measures are estimates of BMP effectiveness. Benchmarks are pollutant load reduction estimates.
- The permittee must evaluate TMDL pollutant load reductions when applying for permit renewal. If load reductions have not been met, the permittee must use adaptive management and determine what additional BMPS are practical.
- Current BMPs include: in-stream flow control, riparian tree planting, culvert replacement, streambank restoration, education programs, and stormwater management facilities

MSGP – Columbia Slough Industrial General Permit (1200-COLS) for industrial stormwater discharges in the Columbia Slough Watershed. WLAs are translated to effluent concentrations and expressed as a benchmark. Industrial facilities must monitor discharges and implement BMPs to meet the benchmark level.[11]

CGP – "Includes specific BMPs for projects which discharge to streams that are impaired by sedimentation or turbidity or additional monitoring to prove no impacts."[12] (p. 28)

Phasing: "The TMDL will utilize a phased approach through which the effectiveness of controls will be assessed with a monitoring program and additional controls required if waste loads, loads and TMDL are not being achieved."[12] (p. 3)

Funding: MS4 - City of Portland assesses Stormwater Development Charges to fund the MS4 Program; $17.33/mo for single family residential units.[13] (p. 11). The City has implemented the

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[10] *City of Portland, OR MS4 Discharge Permit.* OR DEQ. July 27, 2005. http://www.deq.state.or.us/wq/wqpermit/docs/individual/npdes/ph1ms4/portland/permit.pdf

[11] *Total Maximum Daily Loads and National Pollutant Discharge Elimination System Stormwater Permits for Impaired Waterbodies: A Summary of State Practices. USEPA Region 5. September 15, 2007.* http://www.epa.gov/region5/water/wshednps/pdf/state_practices_report_final_09_07.pdf

[12] Columbia Slough TMDL. OR DEQ. September 1998. http://www.deq.state.or.us/wq/TMDLs/docs/willamettebasin/columbiaslough/tmdl.pdf

Clean River Rewards Program which grants up to 100% discount for onsite stormwater management

Future Growth: Future growth and development will either have to demonstrate that adequate reserve capacity exists in the TMDL or trade effluent with the City of Portland, PDX, or other DMA.[4] (p.16)

Resources:

Stormwater Management in Portland, OR homepage: http://www.portlandonline.com/bes/index.cfm?c=31892

Oregon DEQ TMDL homepage: http://www.deq.state.or.us/wq/TMDLs/tmdls.htm

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[13] *City of Portland, OR Permit Year 12 Annual Compliance Report (2006-2007)*. http://www.portlandonline.com/shared/cfm/image.cfm?id=174326

Reservoirs in the New York City Water Supply Watershed TMDL- 'East of Hudson' Croton Watershed, NY

Pollutants: Phosphorus

Sources: stormwater runoff from impervious surfaces, agricultural land and construction sites, excessive fertilizer use, leachate from septic systems and effluent from wastewater treatment plants

Stakeholders:

Implementation through existing NPDES Permits:

MS4 –

- NY MS4 Permit: Additional BMPs required in pathogen impaired waters (Part IX.A.5.b)[1]
    - Within 3 years of the effective date of the permit...Develop and commence implementation of a Retrofit Program that addresses runoff from sites to correct or reduce existing erosion and/or pollutant loading problems, with a particular emphasis placed on the pollutant phosphorus. At a minimum, the MS4 shall:
        - Establish procedures to identify sites with erosion and/or pollutant loading problems;
        - Establish policy and procedures for project selection. Project selection should be based on the phosphorus reduction potential of the specific retrofit being constructed/installed; the ability to use standard, proven technologies; and the economic feasibility of constructing/installing the retrofit. As part of the project selection process, the *permittee* should participate in locally based watershed planning efforts which involve the *Department*, other *permittees*, stakeholders and other interested parties;
        - Establish policy and procedures for project permitting, design, funding, construction and maintenance.
        - For permittee's that develop their own retrofit program, by March 9, 2009 develop and submit approvable plans with schedules for completing retrofit projects, including identification of funding sources. Upon DEC approval of those schedules, the plans and schedules shall become enforceable requirements of this permit.
        - Pursuant to Part IV. F (Cooperation Between Permittees Encouraged), retrofit projects can be completed in cooperation with other permittees in the East of Hudson Watershed through the formation of a cooperative entity with other MS4s. Participating MS4s shall work with the Department and other members of the cooperative entity in implementing the requirements of i, ii and iii above. In addition, each permittee that becomes a member of the cooperative entity shall work closely with the Department and other members of the cooperative entity to, by December 31, 2009, develop and submit approvable plans and schedules for completing retrofit projects, including identification of funding sources. Upon DEC approval of those plans and schedules, the plans and schedules shall become enforceable requirements of this permit.

Implementation Plan:

- Croton Watershed Phase II Phosphorus TMDL Implementation Plan [2]

- MS4 operators must provide adequate resources to fully implement the Stormwater Management Plan (SWMP) no later than January 8, 2013.
    - Emphasis on illicit connection elimination, septic repair, retrofits and other phosphorus reduction activities.
    - Stormwater Retrofits
        - Prioritized High Intensity Developed (HID) land use first
        - Modeled phosphorus loading for 12 reservoir watersheds and further divided loading to individual MS4 communities
        - Allocated 5-year phosphorus reduction values for MS4s, which will meet MS4 permit plan requirements
            - Values were established assuming that approximately 50% of the HID phosphorus load can be achieved; aim to achieve this goal over a 10 year period.
        - HID recommended retrofits will achieve approximately 20% of the TMDL required phosphorus reductions

Phasing:

Funding:

- Potential funding sources include grants from the Safe Drinking Water Act, EOH Water Quality Investment Program Funds, Water Quality Improvement Projects, Watershed Environmental Assistance Program, Drinking Water State Revolving Fund, Water Quality Planning and Implementation Grants for NYC Watershed Communities, Brownfield Opportunity Areas Program

Future Growth:

Resources:

[1] NYDEC SPDES General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (MS4). NYDEC. May 1, 2008.
http://www.dec.ny.gov/docs/water_pdf/ms4permit08.pdf

[2] PHASE II PHOSPHORUS TOTAL MAXIMUM DAILY LOADS FOR RESERVOIRS IN THE NEW YORK CITY WATER SUPPLY WATERSHED, June 2000.
http://www.dec.ny.gov/docs/water_pdf/nycjune2000.pdf.

Interim Report: Nonpoint Source Implementation of The Phase II Phosphorus TMDL in The New York City Watershed, March 2002. http://www.dec.ny.gov/docs/water_pdf/nycphos.pdf

Croton Watershed Phase II Phosphorus TMDL Implementation Plan, January 2009.
http://www.dec.ny.gov/docs/water_pdf/jan09crotontmdl.pdf

Draft Croton Watershed Phase II Phosphorus Total Maximum Daily Load ("TMDL") Nonpoint Source Implementation Plan ("TMDL Implementation Plan") Response to Comments: January 15, 2009 http://www.dec.ny.gov/docs/water_pdf/jan09crotonresp.pdf

Technical Background For Retrofitting Practices, EOH MS4 Heightened Criteria, January, 2009.
http://www.dec.ny.gov/docs/water_pdf/jan09retrofit.pdf

Appendix I - Explanation of BMP Tool Modeling Runs

The costs, infiltration and detention volumes, and the impervious area treated given in this report were obtained using the Vermont Best Management Practice Decision Support System (BMPDSS). The BMPDSS is a hydrologic modeling tool, developed for Vermont by TetraTech Inc, to help the Department compare effectiveness and cost of various scenarios to implement the stormwater TMDLs.

Housed in the ESRI ArcGIS© environment, the BMPDSS provides visualization and GIS processing support for developing networks including sequences of land uses, BMPs, and stream reaches. ArcGIS also serves as an interface for BMP placement, BMP attribute data input, and a platform for managing the decision optimization component. The system then launches a stand-alone BMP simulation and evaluation module. Since the module is a process based simulation model for BMPs, it provides a technique that is sensitive to local climate and rainfall patterns as well as BMP size, design, and relative placement on the site. The system incorporates a meta-heuristic optimization technique to find the most cost-effective BMP placement and implementation plan that best satisfies a controlled target and/or that fits within a fixed cost budget (Tetratech Inc., Application of BMP Decision Support System for Evaluating Combine Sewer Overflow in Anacostia Watershed, 7/2005.

Background

The first step in modeling a watershed is to input parameters to recreate the current condition of the watershed. Several sources of data must be input into the model including landuse, soils, impervious surfaces, rainfall, parcels, information on the streams, as well as existing BMPs and their drainage areas. This information creates a base scenario to which the TMDL targets are applied. After the base scenario has been developed, any new BMPs, such as offsets or newly permitted projects, are added to the model to give credit to the ongoing work that has been done in many of the watersheds in the interim.

Once the watershed has been accurately modeled in its current condition, additional BMPs must be added to achieve the TMDL flow targets. For this analysis one theoretical detention and one infiltration BMP were placed in each subwatershed. The BMPDSS identifies the parcels that contain an acre or more of impervious surface and creates BMPs for that area in each subwatershed, sized to meet the 2002 standards. Only the parcels with an acre or more of impervious surface are considered, as that is the current jurisdictional threshold for requiring a state stormwater permit. To help ensure that there is sufficient open space to place the BMPs, an additional calculation is done that the BMP footprint cannot exceed 50% of the open space available for the detention BMPs. For infiltration BMPs, the open space must also be located on soils in the hydrologic groups A or B, to ensure adequate infiltration rates. These BMPs represent the maximum detention and infiltration BMP volumes available to each subwatershed. The BMPDSS

may select the full BMP, a smaller version of the BMP, or not to put a BMP in that subwatershed at all.

An optimization is then run, comparing different combinations and sizes of these BMPs while trying to meet the TMDL targets while minimizing the cost. The cost function and its variables are described in the next section.

Cost Functions

The cost of stormwater best management practices (BMP) generally includes construction cost, maintenance and inspection cost, and land opportunity cost (Wossink and Hunt, 2003). In BMPDSS (Cheng et al., 2006), a generic cost function is employed as described below.

Total Cost = Installation Cost [**I**] + Land Cost [**L**] + Fixed Cost [**F**]

Installation Cost [**I**] represents the material and labor expenses related to the construction of the BMP. Land Cost [**L**] represents the land value. Land cost is negligible if the BMP are installed in small areas, such as bioretention or infiltration, and underground storages. Fixed Cost [**F**] represents the cost associated with designing and permitting activities. Due to the unavailability of the cost information on maintenance and inspection, these costs were not included in the equation.

In the Vermont BMPDSS, a detention BMP (assumed a wet pond) represents to control the high flow and a bioinfiltration BMP represents to control the low flow. The following equations represent the selected BMPs.

> ***Detention BMP:***
> Cost = (**I** * Detention Volume (ft^3)) + (Detention Surface Area (acres)***L**) + **F**
>
> **I** = \$5 per ft^3 and **L** = \$ 217,800 per acre, were based on USEPA (1999a) similar to the Prince George's County model.
> **F** = [\$ 2,000 per BMP)
>
> ***Infiltration BMP:***
> Cost = **I** * BMP volume (ft^3) + **F**
>
> **I** = \$6 per ft^3, was based on USEPA (1999b) similar to the Prince George's County model.
> **F** = [\$ 2,000 per BMP**]**

One of the challenges to apply the BMPDSS in Vermont was to identify appropriate cost variables to be input into BMPDSS that represent Vermont's site specific environment. Tetra Tech, along with Vermont Department of Environmental Conservation, has conducted a limited research on BMP cost information available for Vermont

environment, including data and reports from University of Vermont (UVM) and the City of South Burlington.

The cost information available at the City of South Burlington excludes the resources that were directly provided by the City (for example, the staff time of City employees, the use of City owned equipments, etc.). Therefore, the data is not complete enough to be represented in the BMPDSS. A review further revealed that the cost information available at UVM Redesigning American Neighborhood (RAN) program are based on USEPA data (1999 a & b) that is the same used in the Prince George's County BMPDSS, from which the Vermont BMPDSS was developed.

Due to the unavailability of the site-specific cost data for Vermont and USEPA (1999 a & b) data are presently used in UVM Redesigning the American Neighborhood program, Tetra Tech has employed the cost information of existing BMPDSS model. As more site specific information becomes available, the variables can be easily updated in BMPDSS. Although the changes in these variables will result in changes in the total cost for implementing BMP, the optimization and other BMPDSS results, such as sizing and locations, have no impact due the changes.

Appendix J – Stormwater Treatment and Control Projects

Municipal Stormwater Management Activities To Date

It is noteworthy that over the past decade the 12 regulated MS4s and the municipalities of Rutland City, St. Albans City and St. Albans Town have accomplished a significant amount of work towards the goal of cleaning up the 12 lowland stormwater impaired streams. Since 2001 over 14.8 million dollars from federal, state and private sources have been invested in stormwater maintenance equipment and stormwater retrofits for treatment and control. Most of these municipalities have created new municipal stormwater management programs resulting in increased maintenance of their stormwater infrastructure, education and involvement of the public, the elimination of municipal wastewater or industrial wastewater connections from drainage systems, and greater oversight of new development during both the design and construction phases. See Tables below.

MS4 MUNICIPAL STORMWATER PROJECTS

TOWN/ WATERSHED **IMPAIRED**/ *NOT* IMPAIRED	PROJECT/ COMPLETION DATE	PROJECT COST ESTIMATED*	PROJECT STATUS
BURLINGTON/ **ENGLESBY**	SHELBURNE RD AND RICHARDSON TERRACE 2005	$1,119,151	**COMPLETED**
BURLINGTON/ **ENGLESBY**	BURLINGTON COUNTRY CLUB 2002	$449,000	**COMPLETED**
BURLINGTON/ **CENTENNIAL**	MAIN ST 2001	NA	**COMPLETED**
BURLINGTON/ LAKE CHAMPLAIN	COLLEGE ST SW PARK	$250,000*	**CONSTRUCT IN 2010**
BURLINGTON CITY	JETTER-VACTOR TRUCK	$230,660	**PURCHASE IN 2009**
CHITTENDEN COUNTY RAIN GARDEN PROJECTS	11 PROJECTS 2006-2008	$25,000*	**COMPLETED**
COLCHESTER/ **SUNDERLAND**	FORT ETHAN ALLEN 2008	$786,078	**COMPLETED**
COLCHESTER /INDIAN	CANYON RD 2005	$222,548	**COMPLETED**
COLCHESTER/ WINOOSKI	MALLETTS BAY OUTFL#1,2 AND VILLAGE DRIVE OUTFL, VALLEYFIELD OUTL. 2006-7	$147,316	**COMPLETED**
COLCHESTER	VACUUM STREET SWEEPER 2007	$174,202	**COMPLETED**
ESSEX/ALDER	TOWN GARAGE FUELING STATION	$91,952	**COMPLETED**
ESSEX/**INDIAN**	COLBERT ST 2008	$92,923	**COMPLETED**
ESSEX/ **SUNDERLAND**	KELLOGG RD	$250,000*	**CONSTRUCT IN 2009**
ESSEX JCT/ **INDIAN**	5 CORNERS NORTH 2007	$331,266	**COMPLETED**
ESSEX JCT/ **INDIAN**	FAIRFIEW FARMS	$199,500	**CONSTRUCT IN 2009**
ESSEX JCT/ **INDIAN**	BROOKSIDE 2006	$83,400	**COMPLETED**
ESSEX JCT	JETTER-VACTOR TRUCK	$350,000	**PURCHASE IN 2009**
FRANKLIN COUNTY RAIN GARDEN PROJECTS	3 PROJECTS 2007-2009	$12,000	**COMPLETED**
MILTON	JETTER-VACTOR TRUCK 2005	$225,000	**COMPLETED**
MILTON/ LAMOILLE	RIDGE FIELD OUTFALL 2007	$36,000*	**COMPLETED**
SHELBURNE/ **MUNROE**	LONGMEADOW DRIVE	$85,000*	**CONSTRUCT IN 2010**
SHELBURNE/ **MUNROE**	HULLCREST PARK 2006	$717,596	**COMPLETED**
SHELBURNE/ MCCABES	SALT-SAND STORAGE SHED 2007	$450,000*	**COMPLETED**

TOWN/ WATERSHED **IMPAIRED**/ *N*OT IMPAIRED	PROJECT/ COMPLETION DATE	PROJECT COST ESTIMATED*	PROJECT STATUS
SO. BURLINGTON	VACUUM STREET SWEEPER 2006	$190,000	**COMPLETED**
SO.BURLING./ **POTASH**	FARRELL ST-CCCC 2007	$1,300,000*	**COMPLETED**
SO.BURLING./ NORTH & **BARTLETT**	SHELBURNE RD - BARTLETT BROOK 2002	$266,100	**COMPLETED**
SO.BURLING./ MUDDY	GREGORY DRIVE 2007	$32,000	**COMPLETED**
SO.BURLING./ **CENTENNIAL**	WILLISTON ROAD-FRONT ROAD	$100,000	**CONSTRUCT IN 2010**
SO.BURLING./ **POTASH**	DORSET ST-SAN REMO DRIVE 2007	NA	**COMPLETED**
SO.BURLING./ **POTASH**	OAK CREEK-BUTLER FARMS	$1,350,820*	**CONSTRUCT IN 2010**
SO.BURLING./ **POTASH**	DORSET ST-I89 2006	$130,612	**COMPLETED**
SO.BURLING./ **POTASH**	OAK CREEK-BUTLER FARMS, Phase 2 2010	$520,000	**CONSTRUCT IN 2012**
SO.BURLING.	JETTER-VACTOR TRUCK	$272,600	**PURCHASE IN 2009**
SO.BURLING./ **POTASH**	POTASH TRIB 3 CITY CENTER	$1,365,000	**CONSTRUCT IN 2010**
SO.BURLING./ **POTASH**	WINDING BROOK, VIL@ DORSET PK, RIDGEWOOD, CARDINAL WOODS, TWIN OAKS	NA	**CONSTRUCT IN 2010**
SO.BURLING./ **POTASH**	FARRELL PARK 2008	$27,000	**COMPLETED**
UNIVERSITY OF VERMONT/ **BARTLETT**	UVM HORT FARM	NA	**CONSTRUCT 2010**
VTRANS/ **CENTENNIAL**	I-89 EXIT 14W SB- 2007	$25,000	**COMPLETED**
WILLISTON/ **ALLEN**	WILLISTON VILLAGE BUFFER PROJECT	$291,500*	**CONSTRUCT 2009**
WILLISTON/ **ALLEN**	WILLISTON HILLS GULLIES A&B 2007	$50,900*	**COMPLETED**
WILLISTON/ **ALLEN**	WILLISTON HILLS GULLY C 2008	240,000	**COMPLETED**
WILLISTON/ **ALLEN**	OAK HILL ROAD SWALE STABILIZATION 2007	$49,537*	**COMPLETED**
WILLISTON/ **ALLEN**	EAST HILL ROAD-SOUTH ROAD CULVERT 2008	$80,000*	**COMPLETED**
WILLISTON/ **ALLEN**	MEADOWBROOK	$147,500*	**CONSTRUCT IN 2009**
WINOOSKI/ **MOREHOUSE**	MALLETTS BAY AVE 48”WEIR & BMPS 2003	$21,750	**COMPLETED**
WINOOSKI/ **MOREHOUSE**	MALLETTS BAY AVE	$550,000	**CONSTRUCT IN 2009**
WINOOSKI	VACUUM STREET SWEEPER 2005	$148,190	**COMPLETED**

TOWN/ WATERSHED **IMPAIRED**/ *NOT* IMPAIRED	PROJECT/ COMPLETION DATE	PROJECT COST ESTIMATED*	PROJECT STATUS
WINOOSKI	VACTOR-JETTER TRUCK	$200,000*	**PURCHASE IN 2009**
TOTAL		**$13,687,101**	

NON-MS4 MUNICIPAL STORMWATER PROJECTS

TOWN/ WATERSHED **IMPAIRED**/ *NOT* IMPAIRED	PROJECT/ COMPLETION DATE	PROJECT COST ESTIMATED*	PROJECT STATUS
RUTLAND/ **MOON**	DA #15 SWIRL SEPARATOR 2008	$119,800*	**COMPLETED**
RUTLAND/ **MOON**	NE SCHOOL POND	$17,000*	**CONSTRUCT IN 2009**
RUTLAND CITY	STREET SWEEPER	$200,000	**PURCHASE IN 2009**
RUTLAND COUNTY RAIN GARDEN PROJECTS	1 PROJECT 2008	NA	**COMPLETED**
ST ALBANS TOWN/ **STEVENS**	SR-DIVERSION POND	$243,000*	**CONSTRUCT IN 2009**
ST ALBANS TOWN/ **RUGG**	SAINT ALBANS TOWN IP	$172,550	**CONSTRUCT IN 2009**
ST ALBANS CITY/ **STEVENS**	DOWNTOWN SWIRL SEPARATORS (9)	$52,000/Unit	**CONSTRUCT IN 2012**
ST ALBANS CITY	VACTOR-JETTER TRUCK 2008	$195,243	**COMPLETED**
TOTAL		**$999,953**	

PRIVATE STORMWATER PROJECTS

TOWN/ WATERSHED **IMPAIRED**/ *NOT* IMPAIRED	PROJECT/ COMPLETION DATE	PROJECT COST ESTIMATED*	PROJECT STATUS
COLCHESTER/ **SUNDERLAND**	EAGLE PARK 2007		**COMPLETED**
RUTLAND/ **MOON**	WYNNMERE-RONALDO COURT 2007		**COMPLETED**
SO.BURLING./ **POTASH**	HEATHERFIELDS 2005	$43,000	**COMPLETED**
ST ALBANS TOWN/ **RUGG**	MAPLEVILLE DEPOT 2008	$100,000*	**COMPLETED**
TOTAL		**$143,000**	

12 MS4 MUNICIPAL STORMWATER PROGRAM ACCOMPLISHMENTS	2003-2008
CATCH BASIN CLEANING	2177.5 TONS
STREET SWEEPING	2661.15 TONS
GREEN-UP & STREAM CLEAN-UPS	256.8 TONS
HAZARDOUS WASTES DISPOSED	1664 TONS (IN COUNTY)
STORMWATER OUTFALLS INSPECTED	1434
CATCHBASIN INSPECTIONS	2665 CATCHBASIN INSPECTIONS EACH YEAR
STORM DRAINS LABELED FOR NO DUMPING	5438
ILLEGAL OR ILLICIT DISCHARGES DETECTED	50
ILLEGAL OR ILLICIT DISCHARGES ELIMINATED	36
CONSTRUCTION EROSION SITE INSPECTIONS	1108 CONSTRUCTION SITE INSPECTIONS EACH YEAR
SITE PLAN REVIEW FOR STORMWATER MANAGEMENT	752 SITE PLAN REVIEWS EACH YEAR
MUNICIPAL STORWATER DISCHARGE PERMIT RENEWALS	94
DOLLARS SPENT ON STORMWATER PROGRAM	$2,000,000/8 MS4s
MUNICIPAL EMPLOYEE TRAINING	483 HOURS
PET WASTE BAGS DISTRIBUTED	720,340
PUBLIC STORMWATER EDUCATON/ADVERTISING	$

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