SUSTAINABLE TECHNOLOGIES EVALUATION PROGRAM: WATER/LAND COMPONENT

DISCUSSION PAPER

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Preface

The Sustainable Technologies Evaluation Program (STEP) is a multi-agency program led by TRCA that helps to fulfill the goals of several regional initiatives, including the Toronto Region Remedial Action Plan, Drinking Water Source Protection Plans and TRCA's Living City strategic vision of a sustainable and more livable community in the Greater Toronto Area (GTA). Its major objectives are to monitor and evaluate clean water, air and energy technologies with respect to the environment and human health, and to work with municipal partners and other groups to disseminate study results and foster broader implementation of the technologies. A web site highlighting sustainable technology monitoring and research by STEP and other agencies will be hosted by Seneca College to assist with technology transfer. While the initial geographic focus of the program will be the TRCA jurisdiction, which roughly corresponds to the Toronto and Region Remedial Action Plan Area of Concern (AOC), this limited focus does not preclude consideration of projects outside of the Toronto AOC, especially if better opportunities for study of a particular technology exist elsewhere, and transfer of study results to areas within the TRCA jurisdiction is possible.

STEP will address sustainable technologies in two general areas: water/land and energy/air. Linkages between these areas will be recognized and strengthened through individual technology evaluations, but the program will operate with unique funding and organizational structures for each resource stream. This discussion paper focuses on the water/land technology evaluation component of STEP. Prevention and mitigation of stormwater impacts is a specific focus of this component in recognition that stormwater is a major cause of the degradation of rivers and waterfront areas, and that stormwater management, as it is currently practiced in Ontario, does not provide sufficient protection to receiving water systems. The proposed mandate and organizational structure for the water/land component builds upon experiences from the Stormwater Assessment Monitoring and Performance (SWAMP) program and feedback from various agency and industry representatives. The air/energy technology component will be the subject of a future discussion paper.

1.0 INTRODUCTION

Stormwater best management practices (BMPs) are widely used to mitigate the effects of urbanization on aquatic ecosystems, human life, health and property. These practices have evolved rapidly over the past three decades to incorporate new knowledge and research into the environmental impacts of urban runoff, and to develop new technologies aimed at mitigating these impacts. Despite these advances, however, there is general agreement that stormwater management, as it is currently practiced within Ontario, does not provide sufficient protection to aquatic life, although this is an important objective of the practices. In large part, the technologies and conceptual approaches required to improve the effectiveness of management practices have been developed, but many of these require further research and demonstration at a site or subwatershed scale before they can be adopted more widely by municipalities and other agencies.

As part of the Toronto and Region Conservation Authority's (TRCA) strategic direction towards its vision of a Living City, the TRCA partners with the Government of Canada's Great Lakes Sustainability Fund, the Ministry of the Environment, member municipalities, community groups, the land development industry and other governmental and non-governmental agencies to promote and improve stormwater management in the Greater Toronto Area.. These improvements are effected through development of watershed/ subwatershed plans, drinking water source protection plans, preparation of stormwater retrofit strategies, monitoring and evaluation of stormwater BMPs, as well as through participation in municipal and regional initiatives, such as the Toronto Wet Weather Flow Management Master Plan (WWFMMP), the Toronto Remedial Action Plan (RAP), the Oak Ridges Moraine Conservation Plan and other multi-agency partnership programs aimed at improving the health of area streams and Lake Ontario. The watershed and subwatershed plans provide a context for managing urban runoff by characterizing existing conditions and developing ecosystem objectives and targets based on current and projected land use within the watershed or subwatershed. Technology monitoring projects, such as have been undertaken under the Stormwater Assessment Monitoring and Performance (SWAMP) program, provide the detailed justification for evaluating whether or not the technologies employed have successfully met design and environmental objectives, and are suitable for replication elsewhere.

The SWAMP program was formed in 1995 as a joint initiative of the Government of Canada's Great Lakes Sustainability Fund (formerly Great Lakes Clean-up Fund 2000), the Ontario Ministry of the Environment, the Ontario Ministry of Transportation, the Toronto and Region Conservation Authority, and the Municipal Engineer's Association. Other individual municipalities and owner/operator agencies participated in one or more individual SWAMP studies. The program objectives were to evaluate stormwater management technologies and disseminate study results and recommendations within the stormwater management community. Technologies evaluated by the program included wet ponds and constructed wetlands, an underground storage tank, a flow balancing system, conveyance exfiltration systems and oil grit separators. As the second phase of the program nears completion, there is a need to re-evaluate the program's mandate and scope and explore how the program may be reformulated to reflect advances in the field of stormwater management and better address the evolving needs of stormwater practitioners, and the needs of the public more generally.

The purpose of this discussion paper is to propose a framework for the water component of a new program led by TRCA, called the Sustainable Technologies Evaluation Program (STEP). The water component of the program will help to address stormwater monitoring and research needs identified by stakeholders, with a focus on providing improved protection of receiving water bodies, aquatic life and human health. The word 'technology' is defined broadly to include individual stormwater controls as well as preventative measures, restoration strategies, implementation protocols, alternative urban site designs and combinations of environmental protection measures implemented in series. Sustainable air and energy evaluation components of the program will be the subject of a future discussion paper.

The following sections provide a context for the water component of STEP and describe how the program would operate in practice. Section 2 summarizes agency roles and responsibilities with respect to stormwater management and their respective interests in stormwater monitoring and applied research. Section 3 reviews feedback provided by participants of a workshop hosted by the Canadian Water Resources Association on February 12, 2003 entitled '*Stormwater Monitoring and Research in Ontario: Finding the Way.*' The final section outlines, for discussion purposes, a mandate, organizational structure, and scope for the new program.

2.0 AGENCY INTERESTS IN STORMWATER MANAGEMENT AND MONITORING

A general context for agency involvement in water quality management is provided by the Great Lakes Water Quality Agreement (GLWQA) between Canada and the United States, which was signed in 1972 in recognition of the urgent need to improve environmental conditions in the Great Lakes. The initial focus of water quality management under the agreement was on reducing water pollution from point sources, including industrial discharges and sewage treatment plants. In the 1980s the focus was broadened to include illegal sanitary connections to storm sewers, spills, combined sewer overflows and rural non-point source controls. It was not until the mid 1980s to early 1990s that stormwater quality came to be identified as a major concern, and various initiatives (*e.g.* stormwater management guidelines, stormwater quality retrofit strategies) were developed to reduce water quality impacts from these sources.

The Great Lakes Water Quality Agreement was amended in 1978 to include the objective of controlling persistent toxic substances. The new agreement also incorporated the ecosystem approach to environmental management.

In 1987, the Canadian and U.S. governments signed a protocol that identified local Areas of Concern (AOC's) where beneficial uses of the ecosystem had been significantly degraded. Remedial Action Plans (RAP's) were to be prepared by various levels of government for the AOC's. The plans would contain strategies to clean up problem areas in the Great Lakes region. In addition, the 1987 protocol included annexes addressing specific subjects such as non-point contaminant sources and contaminated sediments.

2.1 Federal Government

The federal government has several programs that address stormwater and wet weather pollution issues in Ontario. These range from granting programs that fund various initiatives to the National Water Research Institute that conducts original research on a range of water related issues, including stormwater management and combined sewer overflow control.

The Great Lakes Sustainability Fund (GLSF) is a grant program managed through the Great Lakes Basin 2020 Action Plan. The GLSF supports the implementation of remedial actions falling within federal responsibilities that will lead to the restoration of beneficial uses in Canada's 15 Great Lakes Areas of Concern (5 of which are shared between the United States and Canada). The fund builds on past successes and is administered by Environment Canada on behalf of eight Government of Canada departments. Established in 2000, the five year, 30 million dollar fund is in its last year of implementation. It is not known yet whether the fund will be renewed.

Canada and Ontario have had Great Lakes environmental agreements in effect since 1971. The latest version of the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA) was signed in June 2002. The agreement provides the framework for systematic and strategic coordination of shared federal and provincial responsibilities for environmental management in the Great Lakes basin. The main objectives are to restore degraded areas, to prevent and control pollution, and to conserve and protect human and ecosystem health.

The Federal Department of Fisheries and Oceans (DFO) and Environment Canada have an interest in stormwater management and receiving water assessments as the administrator of Section 36 of the Federal Fisheries Act. This section is in place to prohibit the deposit of any deleterious substance into water bodies that are inhabited or frequented by fish species.

The federal government's National Water Research Institute (NWRI) has been a leader in stormwater research through its Urban Water Management group, which is part of the Aquatic Ecosystem Management Research Branch. Investigations include evaluations of the effect of stormwater technologies on sediment quality, water, and benthic communities, and the development of methods and processes for assessing and treating combined sewer overflows and stormwater. Stormwater management has been the subject of special issues of the Water Quality Research Journal of Canada in 1997 and 2000. Another special issue devoted to research on stormwater and combined sewer overflows is currently being prepared. NWRI scientists partner closely with university faculty and other federal, provincial and industry researchers.

In November 2001, the Federal government established the Canadian Water Network (CWN), one of four national Centres of Excellence in Canada. CWN aims to 'develop and support technological advances in the management and sustainable use of water resources.' Based out of the University of Waterloo, their research program is supported by a $15-million grant over 4 years from the Federal Government, and matching funds from industry and institutional partners. The program focuses broadly on issues related to the quality, safety and availability of water resources, policy and governance, problems associated with aging infrastructure, wastewater management and climate change impacts. CWN research does not currently appear to have a specific emphasis on stormwater management issues.

2.2 Provincial Government

The provincial government of Ontario has an interest in stormwater management as the administrator of the Ontario Water Resources Act (OWRA), the Ontario Environmental Protection Act (OEPA), the Environmental Assessment Act (EAA), the Planning Act, and other partnership programs such as the Remedial Action Plans (RAPs) and the Canada-Ontario Agreement. The Ministry of the Environment is the lead agency for all of these initiatives, except for the Planning Act, which falls under the jurisdiction of the Ministry of Municipal Affairs and Housing (MOH). MOE input into the development planning process occurs through its preparation of Regional Environmental Profiles, which delineate watershed areas that are sensitive and important for water management. Plans for land use changes in these sensitive areas are circulated to the MOE for review and input.

Under section 53 of the OWRA, stormwater is treated as sewage. Treatment of stormwater 'sewage' therefore requires a Certificate of Approval (CoA) as do the treatment of other wastes.

The MOE provides technical guidance to professionals involved in managing stormwater through development of the *Stormwater Management Practices Planning and Design Manual.* Originally published in 1994, and recently revised and updated in 2003, the manual recommends stormwater management plans be developed within a watershed or

subwatershed context with emphasis on source and non-structural controls first, followed by conveyance and end-of-pipe controls.

The Ontario Ministry of Natural Resources (MNR) has an interest in stormwater management from the perspective of protecting water resources and natural heritage systems. In this context, rehabilitating or preserving natural heritage systems is viewed as a crucial element of stormwater management during the land development process. The MNR issues permits under the Lakes and Rivers Improvement Act.

Stormwater management and remediation of combined sewer overflows are integral to the restoration of RAP areas of concern. The Environmental Monitoring and Reporting Branch of the MOE has undertaken several programs aimed at restoring beneficial uses to Lake Ontario and its tributaries, especially as it relates to monitoring of priority pollutants identified under the Canada Ontario agreement. Stormwater technology assessments have been supported by the Standards Development Branch under the SWAMP program.

2.3 Municipalities

Municipalities are ultimately responsible for translating stormwater management guidelines into sustainable practice within a watershed and subwatershed context. Their legislative authority over the review of stormwater management strategies is provided through the Planning Act, the Municipal Act, the Drainage Act, the Local Improvements Act and local By-laws (e.g. site alteration). Municipal by-laws, codes, criteria and subdivision agreements with developers address specific aspects of municipal concern (e.g. erosion control by-laws, building codes). Master drainage and wet weather flow plans provide implementation plans for stormwater management, infrastructure development and operations and maintenance practices. Since municipalities are responsible for long term maintenance of stormwater management facilities, they have a strong interest in ensuring that the facilities achieve design objectives in the most cost effective manner.

The degree to which municipalities participate in stormwater monitoring activities varies widely depending on their size, land use and age. Large urban municipalities, such as Toronto, with significant combined sewer infrastructure, have developed in-house capacity for stormwater monitoring and research. In 2003, Toronto completed a Wet Weather Flow Management Master Plan, which addresses impacts and proposes solutions to wet weather flow issues within a watershed context. Over the last decade, Toronto has conducted several detailed monitoring studies of various types of stormwater and combined sewer overflow treatment facilities. Some of these have been undertaken through the SWAMP partnership, others by Toronto alone, or with other partners, such as NWRI. Ottawa is another example of a large municipality that has actively invested in stormwater monitoring and research.

Smaller municipalities rarely have the resources to devote staff specifically to stormwater monitoring, although many have conducted sophisticated investigations into stormwater facility operation and maintenance issues. Their interests in monitoring are often carried out through partnerships with other organizations, such as SWAMP, or with funding assistance from other levels of government. These monitoring projects may be associated with demonstration

facilities (e.g. Markham pond-wetland; Harding Park retrofit pond) or related to a specific issue, such as the potential for stormwater ponds to act as a breeding ground for mosquitoes carrying the West Nile Virus (e.g. City of Brampton, Regional Municipality of Durham).

Stormwater monitoring may also be conducted by a municipality to serve as a basis for guideline or by-law development, or to satisfy an Environmental Assessment. For example, the Town of Richmond Hill evaluated the rates of accumulation and quality of sediment in stormwater ponds to refine sediment management practices required as part of its stormwater management facilities operations and maintenance program. These types of monitoring studies contribute significantly to our knowledge of the function and effectiveness of stormwater technologies, but reports are often not broadly circulated. Integrating data from studies such as these into a larger body of stormwater monitoring data, and providing easy access to the database is one of the goals of STEP.

2.4 Conservation Authorities

The 38 Conservation Authorities in Ontario develop and implement programs for the management of water and natural resources on a watershed basis. Conservation Authorities are created and given their mandate under the Conservation Authorities Act and involve a partnership of the municipalities within a watershed and the Province of Ontario. As an approval agency under the Planning Act, Conservation Authorities review stormwater management plans to ensure that proposed development will not affect the overall integrity of the natural environment and to ensure compliance with TRCA policies. Other stormwater services provided include the development of stormwater management strategies, the design and implementation of stormwater retrofit projects, education and promotion of stormwater management BMPs, and monitoring of stormwater management facilities.

Under proposed provincial legislation, Conservation Authorities are assigned a lead role in preparing watershed based source protection plans. Source protection plans are considered a first step in a multi-barrier approach to protecting drinking water supplies. They will address a range of specific issues, including stormwater management and the protection of natural areas. TRCA has been designated as the lead CA for the Greater Toronto watershed region, which includes the Credit Valley Conservation Authority jurisdiction to the west and the Central Lake Ontario Conservation Authority jurisdiction to the east.

The TRCA is also the local coordinating agency for the Toronto Area of Concern Remedial Action Plan. In this role, the TRCA works with the provincial and federal government to develop and sustain implementation of the Toronto and Region RAP, as per the goals of “Clean Waters, Clear Choices” (RAP stage II), the Canada-Ontario Agreement and Annex 2 of the Great Lakes Water Quality Agreement.

2.5 Universities/Colleges

A broad range of research has been and continues to be conducted on stormwater management issues by Universities and Colleges in Ontario and other Canadian provinces and territories. A synopsis of the many stormwater topics researched by university/college faculty

and students is beyond the scope of this paper. Study topics are typically classed as 'original research' and are conducted to a level of scientific rigor sufficient for publication in peer reviewed academic journals.

2.6 Non-governmental Organizations

Decisions made about stormwater management have significant impacts on watershed ecosystems, riparian zones, aesthetics, recreation opportunities and other aspects of public interest. Therefore, it is not surprising that non-governmental organizations and community groups have taken an interest in these issues.

Environmental organizations have traditionally contributed to stormwater management through education, promotion of pollution prevention programs, and research intended to influence government policy decisions. For example, the Riversides Stewardship Alliance in Toronto has been campaigning to ban domestic lot level car washing because it allows detergents, waxes, greases, oils, heavy metals and other contaminants to be discharged to storm sewers and receiving waters without treatment. Similar efforts have been made by other groups to educate and advocate for the reduction in the use of lawn pesticides, prevent dumping of hazardous waste in sewer systems, clean-up landfill sites, regenerate waterfront areas and a host of other stormwater related causes.

Associations and professional organizations (e.g. Canadian Environmental Law Association, Canadian Water Resources Association (CWRA), Water Environment Federation, Municipal Engineers Association) play a role in disseminating information and fostering research. Some of these may also assist with funding or partner to undertake specific activities related to their respective mandates.

2.7 SWAMP Program

As mentioned earlier, the SWAMP program is a joint initiative of a number of agencies, established through a Memorandum of Understanding. The program is guided by a Steering Committee made up of representatives from these agencies. Until May 2003, office space and logistical support was provided by MOE, and funding was provided by all levels of government with TRCA responsible for managing these funds. TRCA now hosts the program as the final phase winds down. Prior to 2003, staffing of the program was achieved through personal service contracts. The staff did most of the monitoring, analysis and report writing.

To date, monitoring has focused on 'performance assessments' of various conventional and innovative stormwater technologies. These assessments have generally involved monitoring influent/effluent characteristics, calculating removal efficiencies and evaluating the overall effectiveness of technologies in water quality, quantity and temperature control. Less effort has been made to understand functional processes of these technologies, or direct effects on downstream aquatic habitat, although some studies have been devoted to these issues where a need was identified.

3.0 STAKEHOLDER FEEDBACK : OUTCOMES OF A WORKSHOP HOSTED BY THE CANADIAN WATER RESOURCES ASSOCIATION

As the second phase of the SWAMP program started to wind down, there was a need to review the program objectives and explore how the program could be improved or re-organized to better serve the evolving needs of the stormwater management community. The workshop hosted by the Canadian Water Resources Association (CWRA) on February 12, 2003, was intended to initiate discussion on these issues. Dr. Andrea Bradford and Dr. Doug Joy from the School of Engineering at the University of Guelph facilitated the workshop on behalf of CWRA. Invitees included representatives from the federal, provincial and municipal governments, conservation authorities, consulting firms, academic institutions and other groups. The following is a brief overview of the workshop discussions, as summarized by Dr. Bradford in the workshop summary document entitled '*Stormwater Monitoring and Research in Ontario: Finding the Way*'. This document, which summarizes discussion in the various workshop sessions, including a list of participants and background discussion paper circulated prior to the workshop, is posted on the CWRA web-site at www.cwra.org

3.1 Need for a Multi-agency Stormwater Monitoring Program

There was generally strong support for the continued existence of a program like SWAMP. The original program objectives of evaluating stormwater technologies and technology transfer were still thought to be relevant. However, participants thought these should be broadened to included greater focus on stormwater pollution prevention, source controls, construction phase measures, cost factors, maintenance, management and operations practices (e.g. street cleaning) and restoration. There were also several recommendations on how the program could be improved from a functional and organizational standpoint.

3.2 Scope of Monitoring and Research

The SWAMP program studies monitored influent and effluent characteristics in order to assess facility performance. These performance assessments used the quality and quantity of effluents to indirectly assess the level of protection afforded to downstream habitat. Participants identified the need to directly link the effect of effluent characteristics on receiving waters by monitoring the pre and post development channel morphology and aquatic health of receiving waters. Including a downstream effects component to monitoring programs would also assist in evaluating monitoring results against the original design criteria of the facility and broader watershed targets (e.g. thermal regimes, aquatic habitat). It was also suggested that public concerns about aesthetics, human health or public safety should be monitored and addressed as part of the technology evaluations, as these factors can strongly influence implementation success.

3.3 Technology Transfer

Participants unanimously agreed that knowledge dissemination remains very important, but it was felt that the target audience should be broadened from the stormwater management industry to include practitioners in the design community, decision makers involved in

approvals process and even the general public. Training in areas such as how to set up a stormwater monitoring project or on the specifics of equipment installation and operation for monitoring should also be provided if a need is expressed. Public advocacy was suggested as a potential function of the program through organizations such as the Association of Municipalities in Ontario (AMO).

Participants suggested the web as a central tool in disseminating results, in addition to an annual conference or meeting. Utilizing consistent monitoring and assessment protocols was identified as an important factor in the transferability of results.

3.4 Other Potential Program Functions

In addition to monitoring and technology transfer, a number of other potential functions for a stormwater monitoring group were identified. One such function is the development and maintenance of a user friendly database containing all the data collected under the stormwater monitoring program, and potentially from other similar programs in Canada. Literature reviews and reference lists for specific subject areas could also be included in the database. It was suggested that this information be made available to universities/colleges and other users free of charge to encourage research and innovation in stormwater management. Another function identified was the development of standard monitoring and data analysis protocols for use across the province, such as has been developed by the United States American Society of Civil Engineers. These protocols and a recommended list of parameters to report for different types of stormwater monitoring studies would help improve the consistency and cross study comparability of results. Some felt a need for better use of existing information through comprehensive reviews and syntheses of literature from within and beyond Ontario.

3.5 Geographic Focus

The SWAMP program studies were conducted in the GTA, mostly in areas with fine textured soils. Participants felt the geographic focus of the program should extend beyond the GTA to other areas with different soil and geological conditions.

3.6 Organizational Structure

Participants expressed a clear need for a core group that co-ordinates the program, preferably not staffed on personal service contracts (as was the case with SWAMP). However, the expanded scope of monitoring would require a broader range of interdisciplinary expertise than could be provided in house. It was suggested that these expertise could be provided by various groups in the private and public sector through an open tender process. Database design, protocol development, and specific aspects of monitoring projects (e.g. modelling) are examples of program activities that could be contracted out.

As in the SWAMP program, a Steering Committee would be needed for selection of monitoring priorities, budget considerations and other functions. Specific technical direction and study review could be performed by Committee members but this would not be an explicit Committee function. Unlike the SWAMP steering committee, the new committee should include representatives from various user groups, rather than being limited to representatives of the

funding organizations. Developing a structure for a new monitoring program should investigate various options including the organization of existing programs, such as the CWN, the Water and Environment Research Foundation and the Centre for Research in Earth and Space Technology (CRESTECH).

3.7 Financial Support

There was a strong sense that the Ontario Ministry of the Environment, as the agency responsible for providing guidance on stormwater management in Ontario, should take a lead role in the program. The provincial mandate of the Ministry would help to avoid a geographical centeredness of the program.

Since the program objectives serve the needs of a variety of agencies, and no one organization is prepared to fund the program alone, it is clear that the program will need to be formed as a partnership among a group of committed agencies.

4.0 WATER/LAND COMPONENT OF THE SUSTAINABLE TECHNOLOGIES EVALUATION PROGRAM

Strong support expressed by workshop participants for a stormwater monitoring program has prompted TRCA to offer its services to manage and host the program, which we propose to call the Sustainable Technologies Evaluation Program (STEP). This section sets forth a set of guiding principles and proposes a set of objectives, structure and function for the water/land component of STEP, with the intention of initiating further discussion and feedback among interested parties.

4.1 Operating Principles

The design and management of all components of STEP will strive to achieve a core set of principles against which the program can be periodically evaluated. Operating principles for the program may include, but are not limited to the following:

Demonstrate relevance: Technology evaluations will help fill a demonstrated need. Project selection criteria will be developed and the merit of various proposals will be evaluated based on, for instance, their relative potential for meeting RAP and watershed/subwatershed goals. Technology evaluations will be conducted together with assessments of the feasibility that the technology can and will be adopted if proven to be effective. If the project goal is, instead, to provide a basis for developing design guidelines, the program must work with provincial staff in charge of guideline development to determine whether this is a realistic expectation.

Consult broadly: Part of the task of ensuring program objectives are relevant to users and the general public is to permit ample opportunity for various groups to provide input. On a technical level, study methodologies, designs and reports must undergo peer review. Input from municipal partners and other funders will be achieved through a working group. Workshops will be held bi-annually to solicit input from the broader industry and public.

Disseminate broadly: The target audience for dissemination of study results and information about sustainable technologies more generally will include all levels of civil society, in recognition that everyone has a stake in creating more sustainable and livable cities. The program web site at www.sutainabletechnologies.ca will be a key component of the communication strategy. Workshops will be held every two years to disseminate results and explore what others are doing.

Build on existing knowledge: A wealth of literature exists on stormwater technologies and related topics. Workshop participants rightly noted that this research could often be better utilized. The program will make a point of synthesizing available research for specific topic areas as part of the process of selecting projects and determining research questions.

Generate products on schedule: The practice of stormwater management continues to evolve rapidly in response to new information and changing needs. If technology evaluations are to exert a practical influence, products must be generated quickly and efficiently. To this end, technical briefs and interim reports will be produced as monitoring proceeds. Information will

be posted at regular intervals on the program web site (hosted by Seneca College), distributed to key individuals and incorporated into the program database so that other researchers working on similar topics can make use of the information. Peer reviews of study designs and reports will be limited to set time intervals to prevent project delays.

Ensure transparency and accountability in financial management*:* Considerable financial complexity is expected from a multi-agency funded program that is implemented through a combination of core staff and private/public sector partners. Revenues and costs for each project component (including those common to all projects, such as the monitoring database) will be tracked through TRCAs budget database and summary spreadsheets will be made available to funding agencies at the end of each fiscal year. Agreements among the various funding partners will be drawn up regarding the ultimate fate of equipment (e.g. autosamplers, flow metres, computers) purchased through the program.

Provide necessary expertise through multi-disciplinary teams: The scope of technology evaluations will often extend beyond what has come to be known as 'performance assessments'. Consequently, individual projects may have components requiring knowledge and expertise from a number of distinct and specialized disciplines. Core program staff are expected to provide expertise in areas relevant to their experience, but when need arises, consulting companies, academia, and/or other public institutions will be invited to participate.

Maximize impact through partnerships: Joining with partners allows individual agencies to achieve multiple benefits at a fraction of the cost that would have been incurred if they had acted alone. Partnerships also create a momentum for change by involving a larger range of stakeholders. The program proposes to work with multiple partners for funding, planning and implementation.

Link knowledge with practice: Technical studies of technologies are often insufficient to encourage widespread adoption of the technology. There is a need, in addition to demonstrating effectiveness, to investigate the financial and practical feasibility of implementation at a broad level. Several source control technologies, for example, have been shown to be technically feasible, but development rules in many jurisdictions make some of them difficult to implement. Carefully assessing these barriers to implementation as part of the knowledge dissemination process will help to strengthen the link between knowledge and practice.

Employ internationally recognized monitoring and data analysis protocols: Prior experience in Canada and the United States has clearly demonstrated the difficulty of comparing studies of like technologies when common monitoring protocols are not used. Recognizing this problem, the American Society of Civil Engineers and U.S. Environmental Protection Agency recommended standard data analysis and reporting protocols for various types of technology evaluation. These will be used as a starting point for project specific protocol development. Where there are physical limitations to using 'best practice' monitoring procedures, an attempt will be made to quantify the error associated with alternative methods.

The program objectives and organizational structure described in the following sections are based on these general principles.

4.2 Program Objectives

The overall goal of the water component of STEP is to advance the knowledge and practice of wet weather flow management through monitoring and applied research into the effectiveness and environmental impact of stormwater management practices. Specific objectives include the following:

- monitor and evaluate the effectiveness of new and innovative stormwater management technologies, or functional attributes of conventional stormwater technologies not currently well understood;
- assess potential barriers to technology innovation and implementation;
- provide recommendations for guideline and policy development; and
- disseminate study results and recommendations, and promote the use of effective technologies at a broader scale through education and advocacy.

As suggested by participants in the CWRA workshop, there will be considerable flexibility in the interpretation of these objectives. The word 'technology' will be broadly interpreted to include individual stormwater controls as well as preventative measures, restoration, controls during the construction phase, maintenance measures, alternative urban site designs, and various stormwater controls implemented in series. Similarly, technology evaluations may involve various study components, including performance assessments (influent/effluent monitoring), environmental effects monitoring, assessment of specific functional processes, cost-benefit analyses, and various types of modelling. Monitoring may occur at the scale of a single site, multiple sites in series, or an entire subwatershed.

The focus of the program will be on new technologies or on certain aspects of conventional technologies about which little or no information exists. For example, stormwater ponds have been well researched, but little is know about their potential as breeding grounds for mosquitoes carrying the West Nile Virus, or their effects on benthic communities in receiving waters. A set of criteria will be developed to guide the selection of technologies to be evaluated under the program.

The second objective of technology transfer will remain a central part of the program. In this context, the term 'stormwater management community' is meant to include technology users, designers, planners, consultants, developers, approvals agencies and anyone else that may have an interest in stormwater management. The general public is included as part of the target audience in recognition that public acceptance and knowledge of these technologies is an important aspect of the process of technology adoption. The study results will be disseminated through reports, the STEP web site (hosted by Seneca College), workshops, conferences, a user database, and individual conference presentations. Articles may also be published in peer review journals or as conference proceedings.

The initial geographic focus of the program will be the TRCA jurisdiction, which roughly corresponds to the Remedial Action Plan's Toronto Area of Concern (AOC). However, this limited focus does not preclude partnership projects outside of the Toronto AOC, especially if better opportunities for study of a particular technology exist elsewhere, and transfer of study results to areas within the TRCA jurisdiction is possible.

4.3 Organizational Structure

Figure 1 shows the proposed organizational structure of the water component of STEP. In broad terms, this structure allows for high level planning and decision making by core funders and program management through a Steering Committee, which represents the interests of the broader stormwater management community. The technical advisory committee (TAC) reports to and receives instructions from the Steering Committee, and is comprised of representatives with relevant technical expertise from the various levels of government, universities/colleges and private industry. The function of the TAC is to determine the broad scope and design of studies selected for implementation, develop generic monitoring and data analysis protocols, and advise on specific technical issues related to the projects. Project study teams selected by the TAC would further refine the project scope and study design, but would be primarily responsible for study implementation in terms of monitoring, data analysis, modelling and report writing. As mentioned earlier, the wide range of expertise required to fulfill the monitoring needs identified by the stormwater community will require drawing upon skill sets outside of the core group through an open tender process. Hence, the study team may consist of representatives from a number of organizations.

Details on program funding and the function of the various groups identified in Figure 1 is described in more detail in the following sections.

4.4 Financial Support

It is proposed that core funding for the program be provided through a 5 year Memorandum of Understanding (MOU) among the three levels of government. The partnership would help to fulfill agency commitments relating to stormwater under the Remedial Action Plan and other initiatives, depending on the specific mandate of each contributing agency. The MOU would set annual agency contributions to the program, outline agency roles and responsibilities, and lay out a work plan for the five year period. The proposed core partner agencies are as follows:

- Environment Canada on behalf of other federal departments through the Great Lakes Sustainability Fund and the Great Lakes Remedial Action Plan (RAP)
- Ontario Ministry of the Environment
- RAP Steering Committee, representing TRCA, MOE and Environment Canada
- Regional Municipalities in the Greater Toronto Area - York, Peel, Durham, Toronto
- TRCA

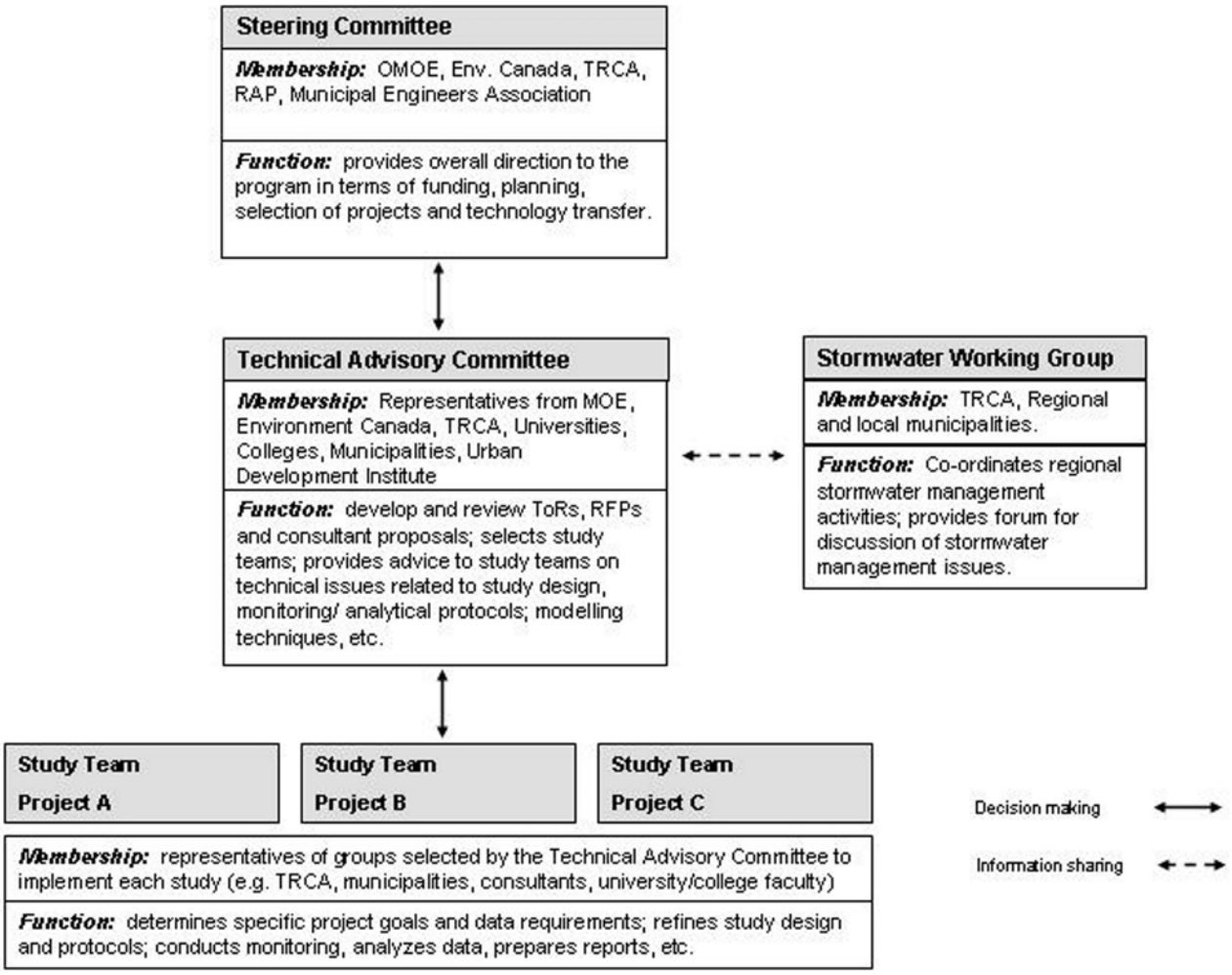

Figure 1: Proposed organizational structure of the water component of STEP

Other potential partners on a project by project basis may include:

- Federal Department of Fisheries and Oceans
- Ontario Ministry of Natural Resources
- Local municipalities in the GTA, such as Markham, Richmond Hill, Vaughan, etc.
- Universities/colleges (matching funds through research grants)
- Private sector businesses
- Foundations and other institutions

4.5 Steering Committee

The core funding agencies will provide overall program direction through a Steering Committee that meets once or twice a year. The Steering Committee will select projects against pre-determined selection criteria, assess budget requirements and identify funding partners for specific projects.

Stormwater practitioners, industry interests and the public are represented through Steering Committee member agency relationships with one or more of these groups. For instance, TRCA meets and receives regular input from watershed groups, consultants and developers through the watershed planning and stormwater management plan review/approvals processes. Similarly, MOE issues stormwater facility approvals and receives input from a range of stakeholders in the process of updating the Stormwater Management Planning and Design manual. It is through these agency activities and relationships that concerns or issues can be brought to the table at the program planning and project selection level of decision making.

4.6 Stormwater Working Group

The TRCA and various municipalities have expressed interest in forming a stormwater working group, which the TRCA has committed to form in parallel with STEP. The proposed group would be comprised of representatives of the various GTA local and regional municipalities and the TRCA. Other representatives of associations or agencies interested or actively involved in stormwater management, such as the Urban Development Institute, Ministry of the Environment and Environment Canada, would be circulated with an agenda and meeting minutes, and be invited to attend meetings when meeting topics are of interest to them.

The group would meet 2 or 3 times a year to share knowledge and experiences in stormwater management, identify priorities in stormwater monitoring and research, establish common monitoring and technology evaluation protocols, and co-ordinate joint initiatives. It is expected that the group will help to save costs by avoiding duplication of effort among municipalities, enhance the collective utility of monitoring and research and serve as a vehicle through which resources can be pooled to maximum effect. Although the working group will not participate directly in STEP decision making (represented by the dotted line in Figure 1), it is expected to provide a valuable source of advice and information on proposed projects, and will help to disseminate study results and recommendations to groups outside of the partnership.

4.7 Technical Advisory Committee

Membership of the program technical advisory committee (TAC) would have broad representation from the three levels of government, universities/colleges and the urban development institute. Members from each of these groups would be selected based on their expertise and ability to provide technical input and direction to the program. Since the TAC is closely involved with all of the various studies, meetings would be scheduled more frequently than the Steering Committee - perhaps every 3 to 4 months, depending on the number of on-going projects.

A primary function of the TAC would be ensure that study methods with respect to monitoring, analytical protocols and modelling are scientifically defensible and meet standards set by other stormwater research agencies (*e.g.* American Society of Civil Engineers). Once the technical issues of the study design have been determined, the TAC would work with program staff to develop and review project Terms of References, Request for Proposals (as needed) and consultant/university/college submissions, ultimately leading to the selection of project specific study teams. As the study progresses, TAC members would provide on-going input to study teams on technical issues relevant to specific projects.

4.8 Study Teams

As mentioned earlier, a diverse range of expertise will be required to undertake the various types of studies and evaluations identified by workshop participants. Field experience needs may include aquatic biomonitoring, water quality and sediment sampling, flow and hydraulic assessments, geomorphology evaluations, and surveying of bathymetry, topography and vegetation. Skills will also be needed in modelling, statistical analysis, database management, project management, cost benefit analysis, and report writing. Thus the study teams will often include expertise drawn from a number of organizations, including TRCA , universities/colleges, consultants, research groups within the three levels of government, and/or the Regional Watershed Monitoring Network (RWMN).

The study teams would be primarily responsible for project implementation (i.e monitoring, data analysis, modelling, report writing etc.). However, since study team members are selected base on their expertise, they would also be expected to participate in refining study protocols and determining specific project goals and data requirements. Review of interim and final reports, in advance of the reports being sent out to external peer reviewers, would be another function of both TAC members and the study teams.

4.9 Core Program Staff

A core group of full-time staff based out of the TRCA will be devoted to co-ordinating program activities, providing support to the various committees and study teams, maintaining a central database, managing budgets, assisting with conference/workshop organization and participating in study implementation activities.

The group would consist of a program co-ordinator, a field monitoring co-ordinator, two experienced field technologists, and a database/web support technician. The manager of TRCA's Resource Science Section would be part of the Stormwater Working Group and help to identify stormwater research needs, assist in setting up new projects, develop partnerships, identify funding sources, help co-ordinate workshops and seminars, and work with municipalities and the development community on the implementation of study recommendations. The TRCA's Regional Watershed Monitoring Network staff would advise on the availability of watershed data and provide training and assistance on project specific environmental effects monitoring. The TRCA's GIS and communication departments would also provide services on an as needed basis.

4.10 Integration with TRCA's Regional Watershed Monitoring Network

Although the objectives of the proposed monitoring program and the RWMN are distinct, integration could clearly provide mutual benefits, both in terms of the use to the program of in-stream data collected through the Network, as well as the potential opportunity in some projects for expanding the number of monitoring locations within the Network. For example, event sampling using auto-samplers for water quality would help to enhance the Network's wet weather water quality data set, which consists primarily of samples collected at a single point in time (i.e. grab samples) during low flow conditions. Conversely, in stream data on benthic invertebrates and channel geomorphology collected by the Network could be of value to receiving water assessments conducted under the program.

Data collected through the RWMN is entered into a central database that facilitates data searches, cross referencing, and statistical analysis. Integrating the project specific STEP data into the RWMN database will further strengthen the overall utility of the existing database.

4.11 The Project Cycle

Figure 2 shows the various stages of study planning and implementation at the scale of an individual project. The process starts with a consultation period during which input on proposed projects is sought from the various stakeholders through groups represented on the Steering Committee. Selection of projects will consider RAP objectives, watershed/ subwatershed goals, existing research on similar topics, municipal initiatives, public concerns, cost and overall relevance to resolving specific issues. General project budgets would be determined at this stage.

During the project planning phase, general goals and objectives are developed within the context of the subwatershed. These goals in conjunction with a literature review help to inform data requirements, costs and selection of an appropriate site. The project planning stage is primarily a TAC function because it is at this time that the study scope and monitoring/analysis protocols are determined and project Terms of References/Request for Proposals are developed, all of which requires technical input. Based on specific project needs and a review of proposal submissions, the TAC selects members of the study team.

Once the study team has been established, the general study framework outlined in the Terms of Reference is reviewed and refined, and the specific details of where to monitor and how are defined. TAC input may be requested as part of this process. Further refinement may occur through the early part of the study implementation phase as conceptual plans are tested against practical field experience.

Analysis and interpretation of results is typically done as the monitoring study progresses to detect potential problems or issues. Modelling may only begin at this stage if monitoring data are required for calibration. Final analysis will include a summary of all data collected for all study components. These will be formatted for input to the program database. Interpretation and presentation of the results is done with reference to the original objectives of the project.

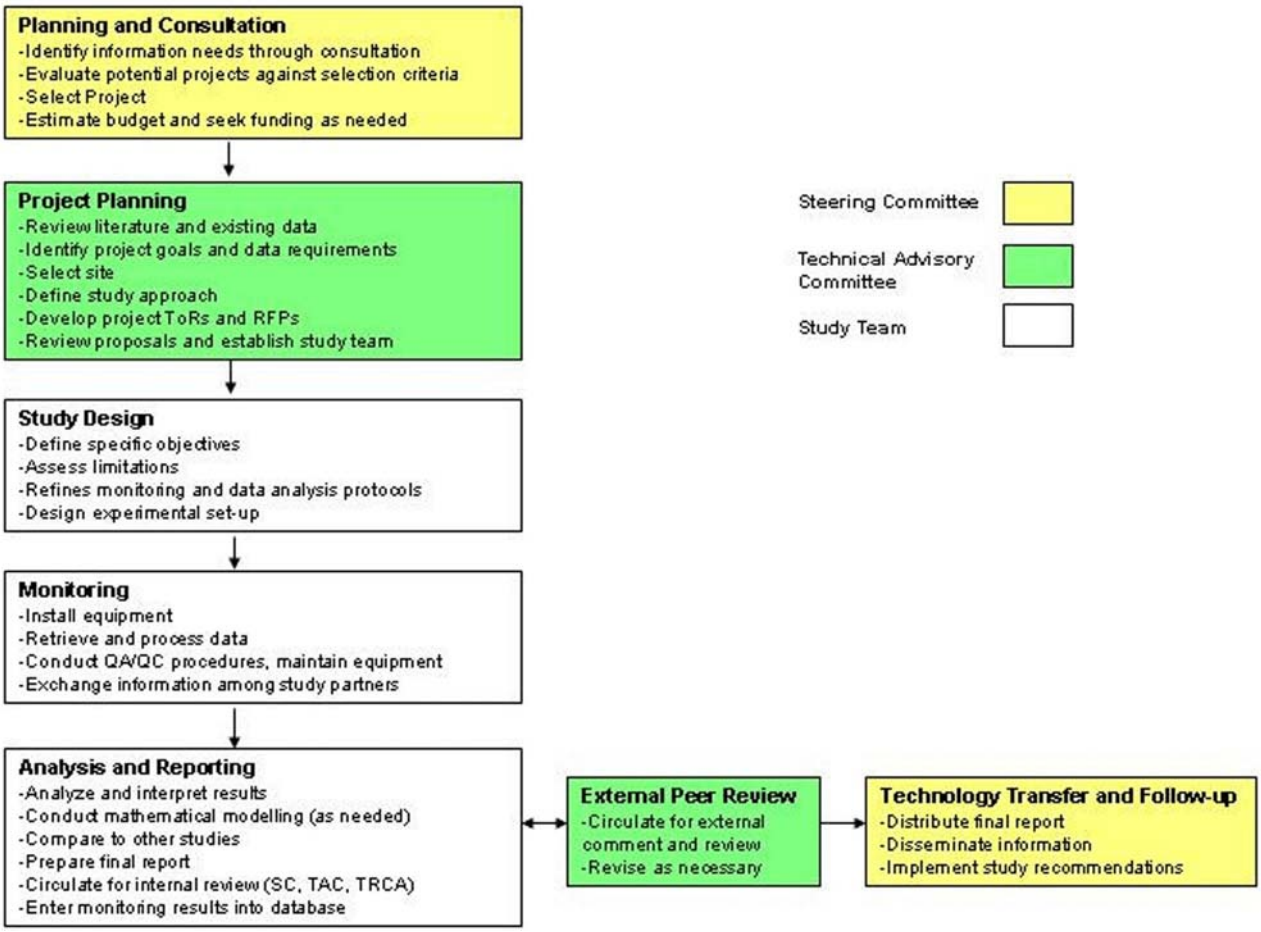

Figure 2: Flow chart for a typical monitoring project

Reports will be reviewed internally, revised as necessary and circulated for external peer review by the TAC. Final reports will be posted on the sustainable technologies web site, hosted by Seneca College, and distributed in hard copy form to study partners. Results will be presented at seminars/workshops held once every two years, and at external conferences. Publication of study results in a suitable journal will be considered as part of the technology transfer process.

Each study will include a series of recommendations and next steps. In the follow-up stage, the Steering Committee would be responsible for working with outside groups to ensure that these recommendations and next steps are realized, and that the project has practical influence at a wider scale.

4.12 Proposed and On-going Projects

As discussed earlier, new projects will be screened against selection criteria developed through consultation with funding partners. Selection criteria would likely consider RAP objectives and

watershed/ subwatershed goals, the originality or innovative nature of proposed studies, municipal initiatives/objectives, public concerns, cost and overall relevance to resolving specific issues. The following list of sample projects would likely meet these criteria and fit within the mandate of the program outlined in this paper. Some of these projects are currently being conducted by TRCA staff and project partners with financial support from agencies listed in the previous section. As such, they provide working examples of how the proposed program would function in practice, and could easily be adopted by a newly formed program.

Green Roof

Roofs with vegetation cover are attracting increasing interest as a method of controlling stormwater runoff, reducing the urban heat island effect, fighting smog, saving on building energy costs and providing aesthetic benefits to an otherwise concrete jungle. Dark impervious roofs absorb the suns rays causing higher air temperature and increased use of air conditioning. Replacing natural areas with roof tops also increase stream peak flows and runoff volumes. By contrast, green roofs detain flow and reduce runoff though soil storage and evapotranspiration. The soil and plant layer also provide building insulation and absorb atmospheric pollutants that contribute to smog.

Initiated in 2003, the TRCA monitoring program evaluates the benefits of a green roof at York University in terms of thermal and runoff quality and quantity control. Results are currently being used to model benefits of multiple green roofs at watershed and subwatershed scales.

Funding support for this project is provided through the Great Lakes Sustainability Fund, the RAP MOU, City of Toronto, regional municipalities of York, Peel, and Durham (proposed), Ministry of the Environment (laboratory services), and TRCA (in-kind). TRCA staff conduct the monitoring, data analysis and report writing for this project.

Construction Sediment Control Pond

Sediment runoff from construction sites has been shown to have detrimental impacts on receiving waters and aquatic habitat. Although sediment control practices have been mandatory at construction sites for over two decades, these have failed to protect aquatic life, and water quality and stream habitat guidelines continue to be exceeded.

Stormwater ponds are commonly used to control construction sediment runoff. It is has been suggested that the ultimate pond, designed to MOE's 'enhanced level protection' (Level 1) requirements, would provide a suitable level of control during the construction period. However, initial monitoring of a Level 1 pond in Richmond Hill during the late construction phase indicated that effluent quality failed to meet sediment standards needed to protect downstream receiving waters.

This monitoring project, initiated in 2004, builds and expands on the earlier study by monitoring a Level I pond draining to the Little Rouge river in Markham from the top soil stripping and grading stage through to final construction. The study will determine whether increased storage and improved pond design will provide sufficient sediment control for the protection of downstream aquatic life. Two years of data collected from the study site will subsequently be

used in a hydrodynamic model to identify specific conditions under which ponds are an effective sediment control practice. The modelling and monitoring data will be used to develop sizing guidelines for construction sediment ponds.

Funding partners in the project include the Great Lakes Sustainability Fund, the RAP MOU, City of Markham, the City of Toronto, Department of Fisheries and Oceans (2005), regional municipalities of York, Peel and Durham (proposed), Ministry of the Environment (laboratory services), Guelph University (in-kind) and TRCA (in-kind). The study implementation partners include TRCA (quality/quantity monitoring), Guelph University (hydrodynamic modelling), and Ryerson University (topographic surveys).

Mitigation of Urban Development Impacts on Natural Wetlands

Natural wetlands are very sensitive to even small changes in hydrologic regime. As urban development expands, natural wetlands are one of the first ecosystem types to feel the impacts. In the Greater Toronto Area, urban areas are currently planned or under construction within the drainage basin of several provincially significant wetlands. This wetland monitoring/modelling project evaluates the feasibility of protecting natural wetlands from rural/urban land use change by managing catchment infiltration and runoff such that the pre-development wetland water budget is maintained. The site is well suited for the study because there are several years of pre-development baseline data from which the wetland hyrdoperiod can be simulated using a continuous hydrology model. Results of the study will be used to develop guidelines on techniques for maintaining pre-development wetland water budgets, and determining acceptable deviations from natural water level fluctuations.
Funding support for this project is provided by the developer. A consultant (Clarifica Inc.) Was retained in 2004 by the developer to do the monitoring/modelling. TRCA and the Town of Richmond Hill have and will continue to provide guidance on monitoring requirements, and will review the interim and final reports.

Backyard soak-away pit

Lot level stormwater controls such as rain barrels, backyard soakaway pits and rain gardens, are preferred methods of stormwater control because they treat rainwater as a resource by creating conditions to infiltrate water into the ground, and return it to the atmosphere through evapotranspiration, rather than exporting it as a waste product to storm sewers. Backyard soak-away pits have been used for on-site wastewater treatment for decades, but have only recently been recognized for their benefits as a stormwater control technology.

This project monitors roof runoff drained through eaves troughs and downspouts to a backyard soak-away pit at a typical single family residence The system design attempts to minimize homeowner operation and maintenance requirements by, for instance, using simple debris filters that require cleaning only as often as do the eaves troughs. Monitoring will focus on the water quantity and quality control benefits of the system. Results will be used to: (I) make recommendations for technology improvements; (ii) define conditions (*e.g.* minimum lot size, soil types, etc) under which the technology can be applied; (iii) assess long term maintenance requirements, and (iv) provide a basis for quantitative modelling of the technology benefits at the catchment and subwatershed/watershed scales.

Like the wetland project, funding support for this project is provided by the developer. A consultant (Clarifica Inc.) was retained by the developer in 2004 to do the monitoring/modelling. TRCA and the Town of Richmond Hill have provided guidance on system design and monitoring requirements, and will review the interim and final reports.

Permeable Pavement and Bio-retention swale

Stormwater infiltration practices that help to reduce runoff volumes and peak flows, retain contaminants and reduce urban heat island effects are advocated as an effective means of maintaining pre-development water budgets. Permeable pavement and bio-retention swales are two such methods that have shown potential but have not been adopted because of uncertainties about performance, maintenance requirements, longevity and other factors.

This project evaluates the application and effectiveness of these technologies on a parking lot at Seneca College's King Campus. The installation will be specially designed for monitoring runoff water quality and quantity (overland and infiltrated through the soil), sediment chemistry, air temperature, infiltration rate changes and maintenance requirements. Monitoring is scheduled to begin in the spring of 2005.

The materials required for construction of the porous pavement, drainage network and monitoring vault was donated by various companies (Uni-lock, Hanson, EMCO Ltd., Layfield Plastics). These donations have been made with the understanding that the study is an independent, third party study that does not endorse or recommend the products donated. Confirmed funding sources include the RAP MOU, Great Lakes Sustainability Fund, Ministry of the Environment (lab services), the Mc Cutcheon Foundation, Walmart, the Oak Ridges Moraine Foundation, TRCA (in-kind), Seneca College (in-kind) and the Regions of York, Peel, Durham and Toronto. Study implementation partners have yet to be determined.

Other Projects

Other projects to be determined through a review of available literature and consultation with partners may include:

- an infiltration basin
- source control (e.g.: downspout disconnection, rain gardens, rainwater harvesting) benefits on receiving waters
- comparative assessment of selected conveyance controls designed for implementation in areas with tight soils
- cumulative environmental effects of stormwater controls on downstream aquatic habitat
- climate change impacts on design storms and stormwater BMP design criteria
- barrier assessment for improved site design technologies
- 'low impact development' technologies implemented in series as part of what has come to be known as 'sustainable urban form', and
- road salt management technologies

5.0 Conclusion

This paper proposes for discussion purposes a framework for the water/land component of STEP based on feedback expressed by representatives of government agencies, the private sector, conservation authorities, university faculty and other groups at a workshop hosted by CWRA in early 2003. The program structure, scope and function builds on experiences of the former SWAMP program with modifications designed to improve product delivery and better reflect the evolving needs of the stormwater management community. A set of guiding principles have been suggested to help further define the overall intent and philosophy of the program, and to serve as criteria for future evaluation of the program's success.

The proposed focus of monitoring activities will be on technology evaluation and receiving water assessments, with some effort expended on understanding specific functional mechanisms or processes, at least to the extent that this understanding contributes to satisfying specific project objectives (e.g. guideline development, maintenance requirements). It is proposed that studies be conducted mostly at the site scale, with some focus on the cumulative receiving water effects of multiple sites (e.g. several stormwater BMPs on a single stream), or on assessments of the entire treatment train from source to receiving waters. Studies must also consider the social, legal and economic dimensions of these technologies, in recognition that adoption at wider scales is strongly influenced by these factors.

As noted earlier, the range of technologies evaluated by STEP will extend beyond stormwater to those that also address air quality and energy use issues. This broad scope is a key step towards TRCA's Living City strategic vision, which emphasizes cross-disciplinary approaches and encourages consideration of issues from multiple perspectives and at a range of different scales. This emphasis recognizes that the social, economic and environmental benefits of technologies can best be exploited and demonstrated when the full range of technology impacts on all aspects of the environment are explicitly considered and evaluated.