Regional Watershed Monitoring Program Review

2001 - 2008

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Watershed Monitoring and Reporting Section
Ecology Division

TORONTO AND REGION Conservation
for The Living City

Acknowledgments

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This report may be referenced as:

"Well designed programmes, supported by sustained funding, provide the best conditions for studying processes whose effects can only be identified over long periods of time and for revealing new questions which could not have been anticipated at the time the monitoring began" (Burt 1994).

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1. Introduction

On the global scale, the value of long-term observational records has recently been acknowledged, particularly in relation to climate change and the impacts of pollution. Without consistent monitoring, these phenomena may not have been recognized. On the local scale, long-term environmental monitoring is essential to identify physical and biological changes taking place in the Toronto region. Establishing consistent baseline data is necessary to identify and assess trends over time and to distinguish between natural trends and human-caused changes in the environment. Monitoring can serve as the "canary-in-the-coal-mine" for the natural environment, whereby one small incident may not seem especially noteworthy, but it may offer the first tangible warning of a larger problem developing. In addition, inventory and monitoring are key elements for effective implementation of management programs, policies, legislation and agreements. Quite simply, "*Without measurement, you can't tell if you've achieved your goals*" (TCSA 2008).

In the past, several organizations monitored various aspects of the natural environment in the Toronto region for their own purposes. This lead to monitoring overlap while some environmental features were overlooked; data gaps were also developing due to funding cutbacks to various organizations. Often, data were not shared between agencies because groups were not aware of what was being monitored by others or the data collected was not compatible due to differences in sampling methods. The Toronto and Region Conservation Authority (TRCA) held several workshops in the late 1990s involving a variety of agencies and the public to discuss topics such as various approaches to watershed monitoring, areas where coordination of activities could take place and the roles and responsibilities of various stakeholders. Following these workshops, the TRCA prepared "*Development of a Regional Watershed Monitoring Network*" (hereinafter referred to as the '*development document*') (TRCA 2000a) which summarized the discussions from the workshops and outlined a comprehensive, integrated and coordinated approach to environmental monitoring for the Toronto region. This "network approach" brings together cooperative

TRCA's Regional Watershed Monitoring Program (RWMP) began in 2001 and monitors:

- Aquatic Habitat & Species
- Surface Water Quality

organizations to collect, store, distribute and report on environmental monitoring data in an organized fashion. The aim of the network is to draw on the strengths on individual partners, allowing each to focus on its specific areas of expertise. Data can be shared by the participating parties making a more effective use of resources, time and funding and eliminating overlaps in the information gathered. The resulting data could then be used by the network partners to help guide environmental management decisions for the Toronto region.

Because of the large scale of the TRCA's jurisdiction (9 watersheds, 3467 km^2 comprised of 2506 km^2 on land and 961 km^2 water-based) and the number of agencies involved in managing the environment in the Toronto region, the level of cooperation necessary to coordinate a monitoring network of this magnitude is quite significant. The TRCA undertook a lead role in monitoring several aspects of the natural environment under the Regional Watershed Monitoring Program (RWMP) which addressed several gaps identified in the development document. In 2001, the RWMP was launched as a mechanism to update "state and condition" information for the region's watersheds and to bring much of TRCA's watershed monitoring work under a single program. This included monitoring activities which were already in place as well as some of the additional monitoring suggested in the development document. The RWMP was developed to focus on long-term monitoring of aquatic and terrestrial ecosystems at the sub-watershed and watershed scale and across the region as a whole. This helped to provide better planning and coordination, protocol standardization, consistency, filling of data gaps, effective data management, and cost effectiveness. It also facilitated the communication of data available and data sharing both internally and with external agencies. The RWMP currently monitors the following components: aquatic habitat and fish community (includes fluvial geomorphology and West Nile virus monitoring), terrestrial ecosystems (habitats, vegetation communities and species), surface water quality and quantity, and groundwater quantity and quality. The information collected by the RWMP provides the underlying scientific data that informs the key planning and reporting mechanisms of the TRCA and other agencies in the Toronto region. A series of individual discussion papers (TRCA 2000b, 2000c, 2000d, 2000e) presents detailed background information for four components (Aquatic Habitat and Species, Terrestrial Natural Heritage,

Surface Water Quality and Flow and Precipitation) of the monitoring program.

As a means of ensuring continuous improvement, this report reviews the first seven years (2001-2008) of operation of the TRCA's Regional Watershed Monitoring Program with respect to the original goals and objectives outlined in the development document. This report briefly touches on network operation as a whole as well as some of the work being done by other agencies participating in the network. Excerpts from the original development and discussion papers are presented in italics for easy reference. In addition, a gap analysis (e.g. review of other reports such as Watershed Report Cards) was conducted, emerging issues are discussed, and recommendations are provided to help guide monitoring in the Toronto region.

1.1 Network Goals and Objectives

The overall aim of the monitoring network is to complete the monitoring necessary to fulfill the environmental reporting

The original goal of the watershed monitoring network was to "*develop a comprehensive, integrated and coordinated approach to environmental monitoring that fulfills the watershed monitoring and reporting needs of the Toronto Remedial Action Plan (RAP), the TRCA and those of the individual watershed and waterfront councils and alliances while furthering the interests of municipal, provincial and federal partners*" (TRCA 2000a). In other words, the aim was to facilitate an integrated network approach to monitor surface water, groundwater, aquatic biology, and terrestrial natural heritage features in an efficient, systematic and scientifically defensible manner. This data, independent of which party collected it, would be available for all network participants to use for their individual reporting needs. Access to various data sources would help improve environmental management decisions.

Specific objectives of the monitoring network and the RWMP are:

A. The development of a program that provides the necessary information to assess the health of the RAP area, watersheds, sub-watersheds and waterfront ecosystems, both spatially and temporally;
B. To identify a set of indicators that reflect ecosystem condition, integrate the monitoring requirements of the RAP with report cards for individual watersheds, and are compatible with the indicators being developed through State of the Lake Ecosystem Conference (SOLEC) for the Great Lakes basin as well as indicators being developed for municipal State of the Environment Reports;
C. To develop an efficient program that builds upon existing monitoring activities and avoids duplication between agencies, municipalities, and organizations and is cost effective in allocating the best use of resources and informs management decisions;
D. To identify ways to engage and involve the public, interest groups, and school groups in meaningful monitoring activities;
E. To develop and obtain agreement from stakeholders on a set of monitoring protocols for the collection, analysis, storage and distribution of data on the indicators that are identified (TRCA 2000a).

A summary of the program to date with respect to the original goals and objectives listed above is provided in Section 8.1.

2. The Monitoring Program

2.1 Background

The following information provides some of the background rationale which was considered when developing the monitoring program as well as some of the changes which have been implemented as the monitoring network has evolved. For further background information, please refer to the development document (TRCA, 2000a).

2.1.1 Scale

> *"The spatial and temporal assessment of condition and causes of change in condition at the scales of the RAP area, watersheds, the waterfront and subwatersheds in the TRCA's jurisdiction are the focus of this program...It is not the intent of this program to be a substitute from monitoring associated with implementation projects or reach specific sampling...It is the intent of the program to be able to track the overall cumulative impacts of both positive and negative changes at the broad RAP, watershed and subwatershed scales."* (TRCA 2000a)

> "An important concept in the proposed monitoring program is Tier 1 and Tier 2 monitoring to deal with the scale...The monitoring program is focused primarily on answering the questions for heath and tracking change at a watershed and subwatershed scale. The density of data proposed to be collected could be summarized for a regional, municipality, or combined with other data for larger basins, but could not be summarized at a more local scale. At the local scale, the site data is intended to be used as a flag or early warning of problems. Where impacts are detected at a sampling site, more detailed studies are recommended to localize, diagnose and trace the source of the problem. These activities fall under Tier 2 monitoring. Tier 2 monitoring is an important extension of the proposed monitoring program..." (TRCA 2000a)

The RWMP was designed to monitor environmental variables at the

The TRCA manages a large area (3467 km^2) consisting of nine main watersheds (Etobicoke Creek, Mimico Creek, Humber River, Don Diver, Highland Creek, Rouge River, Petticoat Creek, Duffins Creek and Carruthers Creek) ranging in size from 38 to 903 km^2. Because watersheds are separate entities in a hydrological sense, it has become common to manage environmental resources on the basis of individual basins. Watersheds can be broken down into smaller sub-units known as subwatersheds. The major watersheds and subwatersheds used during the development of the RWMP are presented in Figure 1.

Currently, the RWMP monitors over 1800 individual stations (all components of the monitoring program, not monitored every year) with the number of sites in each watershed proportional to the size of the watershed (Table 1). Figure 1 displays the sites monitored as part of the RWMP. Individual maps for each component of the monitoring program are provided in Appendix A.

On the watershed scale, there appears to be adequate spatial coverage for most components of the monitoring program. Most components have at least one sampling site per component per watershed and in watersheds with multiple sites, they tend to be spread out throughout the watershed. Noticeable

In general, the RWMP covers the TRCA's

exceptions include the smaller watersheds of Mimico, Carruthers and Petticoat Creeks. The Mimico Creek watershed does not have precipitation monitoring, the Carruthers Creek watershed is lacking groundwater and precipitation monitoring and the Petticoat Creek watershed does not have any surface water quality or groundwater monitoring. The aquatic monitoring components of the program appear to be lacking monitoring sites in the headwaters (first order) of each watershed but, the aquatic monitoring program was initially designed to focus on second order or larger streams (TRCA 2000a).

Figure 1. Regional Watershed Monitoring Program Sites

Table 1. Number of Sites Monitored as Part of the Regional Watershed Monitoring Program[1]

	Etobicoke Creek	Mimico Creek	Humber River	Don River	Highland Creek	Rouge River	Duffins Creek	Carruthers Creek	Petticoat Creek	Other[2]	Total
Aquatic Habitat & Species											
Fish & Aquatic Habitat	14	5	38	23	11	26	21	3	4	4	149
Benthic Invertebrates	14	5	38	23	11	26	21	3	4	4	149
Fluvial Geomorphology	10	5	35	17	7	26	31	10	9	-	150
West Nile Virus Monitoring	3	-	16	4	2	3	7	2	1	7	45
Surface Water Quality											
Surface Water Quality	3	2	10	4	1	7	6	1	-	-	34
Stream Flow and Precipitation											
Baseflow	163	22	424	123	49	184	94	19	15	11	1104
Streamflow	2	1	2	3	1	2	7	1	1	2	22
Snow	1	-	3	1	-	2	3	-	-	-	10
Precipitation	4	-	10	5	2	4	4	-	1	2	32
Groundwater Quality & Quantity											
Groundwater Quality & Quantity	2	-	9	1	-	3	6	-	-	-	21
Terrestrial Natural Heritage											
Ecological Land Classification[3]	2319	200	16072	2023	540	3149	9083	458	860	1331	3604
Total Fixed Plots[4]	8	-	49	14	3	12	3	23	2	4	118
Forest Fixed Plots											
Vegetation	2	-	9	2	1	1	4	1	1	1	22
Breeding Birds	1	-	9	2	1	1	3	1	1	1	20
Salamanders	2	-	7	2	1	2	4	-	1	1	20
Wetland Fixed Plots											
Vegetation	2	-	5	2	-	3	3	-	-	-	15
Breeding Birds	1	-	6	2	-	2	3	-	-	-	14
Frogs & Toads	1	-	6	2	-	2	3	-	-	-	14
Meadow											
Breeding Birds	-	-	5	2	-	2	3	-	-	1	13
Terrestrial Volunteer Monitoring[5]	5	2	22	11	3	8	8	2	1	3	65

[1] Not all sites monitored annually, sites are often monitored in rotation (e.g. 3-year cycle)

[2] Includes minor watersheds flowing such as Frenchman's Bay

[3] Area in hectares

[4] Program initiated in 2008

[5] Actual number of sites monitored yearly can fluctuate depending on volunteers

Monitoring headwater streams would have substantially increased the number of monitoring sites required and was cost prohibitive during the inception of the RWMP. Since that time, a study was initiated in 2007 by TRCA to characterize conditions and examine urban impacts to headwater streams. The results of this study will help guide future decisions as to if headwater streams should be added to the regular monitoring of the RWMP.

Additional monitoring may be required on the subwatershed scale, particularly in subwatersheds

Based on the subwatersheds presented in Figure 1, most (but not all) subwatersheds are being monitored with at least one site for each component of the RWMP. Exceptions include groundwater and precipitation monitoring which were not intended to be conducted on a subwatershed scale. Currently, there is at least one subwatershed in each watershed that is lacking at least one RWMP monitoring component. This is particularly evident in the Duffins Creek watershed which has had its subwatershed mapping refined since the inception of the RWMP (e.g. the RWMP was developed based on 6 subwatersheds in Duffins Creek but current mapping includes 15 subwaterheds). Of the subwatersheds that are not currently being monitored, these subwatersheds tend to be smaller subwatersheds in headwaters which may not be suitable for monitoring the particular component that is lacking or, nearby subwatersheds may serve as a suitable surrogate.

Although RWMP data is not intended for site-specific studies, RWMP stations can act as baseline/anchors for comparison. Site specific studies which require pre- and post-activity monitoring can be supplemented using RWMP data to help determine if changes are due to site specific issues or because of larger, regional trends and changes.

2.1.2 Indicators

Environmental indicators can be tracked to help show

The concept of an indicator is fundamental to the monitoring framework. Environmental indicators are simple measures that can help to explain what is happening in the environment. Environmental indicators can include physical, biological and chemical

measures. Tracked over time, indicators can provide information on trends in environment and often has significance extending beyond what is being directly measured. Since the environment is very complex, indicators provide a more practical and economical way to track the state of the environment as it is impossible to record every variable in the environment. There are three general types of indicators (condition, stress, response) and the following definitions were adapted from SOLEC (1999):

> State or Condition: These indicators address the quality of the environment, the quality and quantity of natural resources, and the state of human and ecological health. These indicators directly reflect the state of environmental and human health and they are chosen by considering biological, chemical and physical variables and ecological functions.
>
> Pressure or Stress: These indicators describe natural processes and human activities that impact, stress or pose a threat to environmental quality. Three categories of pressure indicators include: Direct Pressure – stresses that act immediately upon environmental quality, such as pollutant loadings and concentrations; Indirect Pressure – human activities that lead to direct pressures, such as agricultural practices, spills, cross connections; Underlying Pressure – societal, economic or cultural conditions that drive human activities, such as population growth and new technologies.
>
> Management Activities (Response): These indicators include individual and collective actions to halt, mitigate, adapt to, or prevent damage to the environment. They also include actions for the preservation and the conservation of the environment and natural resources. Examples of actions include education, regulation, market incentives, technology changes, implementation projects, etc.

A variety of indicators have been chosen for several components of the monitoring network. Examples are shown in Figure 2. Indicators were selected based on the following criteria (TRCA 2000a):

- Relevant to RAP beneficial use impairments, watershed report cards, SOLEC and municipal state of the environment reports
- Appropriate to the regional, watershed and subwatershed scale

- Based on data already available or requires collection but is essential to the condition-stress-response monitoring framework
- Comparable over time
- Quantifiable
- Scientifically valid
- Understandable
- Cost effective

Currently, the RWMP focuses on condition/state type indicators. Condition/state indicators for each component of the monitoring program are outlined in the background discussion papers (TRCA 2000b, 2000c, 2000d, 2000e). The condition/state indicators are monitored on a regular basis ranging from annually to every ten years, depending on the indicator. Some indicators have been modified from those listed in the discussion papers, others have been added or dropped from the program. Some broad-based indicators (stress/pressure, response/management) are monitored as part of other TRCA programs or by other organizations but have not been the focus of the RWMP. For example, watershed urbanization is calculated by the TRCA's GIS department (usually on a watershed by watershed basis for the completion of individual projects such as Watershed Report Cards), water taking is monitored by the Ontario Ministry of the Environment (MOE) through their Permit to Take Water program and spill response is monitored by the MOE's Spills Action Centre.

The RWMP is focused on monitoring condition/state type indicators which directly reflect the

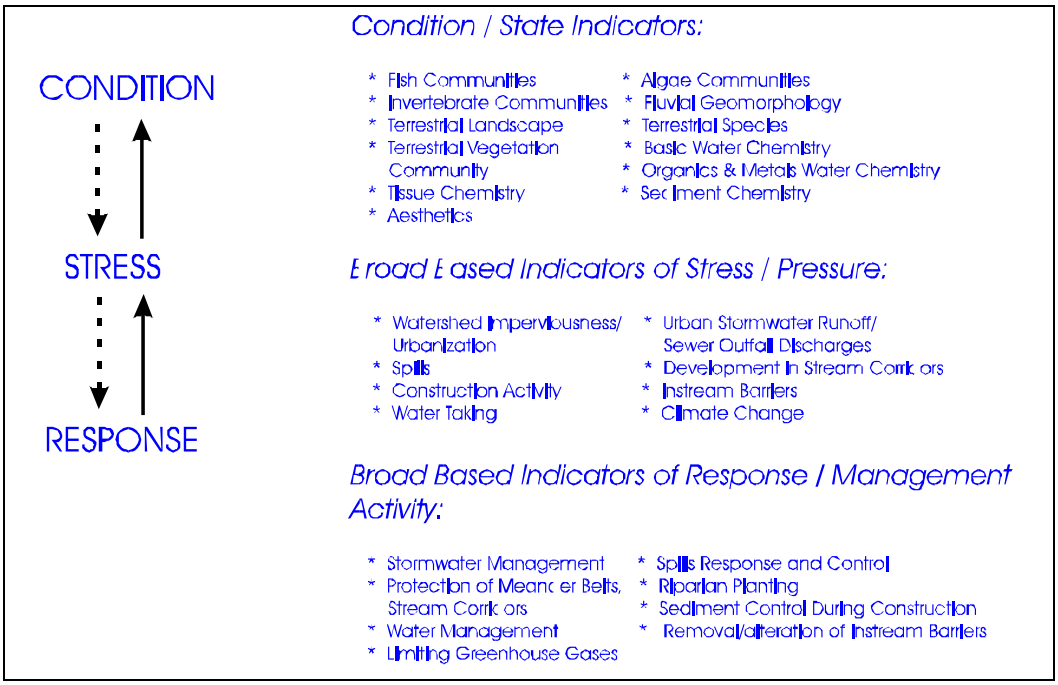

Figure 2. Schematic presentation of the condition-stress-response framework (TRCA 2000a)

> *"The three types of indicators mentioned above provide different information but they are linked through a condition-stress-response causal relationship. This relationship is a feedback loop that describes the way in which management activities can alter environmental stresses that impact environmental condition."* (TRCA 2000a)

The RWMP has been effective in streamlining the monitoring of condition/state type environmental indicators in the Toronto region to reduce duplication and allow easier sharing of data between agencies. The streamlining of broad-based monitoring indicators (stress/pressure, response/management) has not gone through the same process as of yet. Further effort to integrate broad-based indicators into the monitoring network along with efforts to streamline the monitoring is required. Monitoring all aspects of the "condition-stress-response" relationships will help make informed management decisions and to evaluate the results of these decisions on a long-term, large-scale basis. Several broad-based indicators are sometimes used to assess environmental change in the Toronto region but the full utility of this data has not yet been achieved.

2.1.3 Monitoring Network Approach

> "The concept of a monitoring network is central to achieving the project objectives and successful implementation of the monitoring program...Each participant in the network would be responsible for some aspects of collecting, storing, analysing, distributing and reporting...By cooperating in a monitoring network, participants would make more efficient use of resources by focusing their efforts on their expertise, and eliminating overlap by relying on other partners...Contributions to the network will vary by partner but would include such things as data collection, data analysis, reporting or funding." (TRCA 2000a)

The monitoring network currently has several participants whose roles and responsibilities are varied and have changed over the duration of the program (Figure 3; Table 2). The original development document suggests that "operation of the network would need to be coordinated by one partner with roles and responsibilities of each partner outline in management agreements" (TRCA 2000a). To date, no organization has formally stepped forward to manage the network as a whole (i.e. not the RWMP specifically, rather the monitoring network comprised of multiple participants/organizations). Rather, the network operates as a fluid entity, where data is shared freely amongst the members but there is no official network structure. In most cases, there are no formal management agreements with regards to monitoring, due to the "binding" nature of an agreement with respect to funding and resource commitments. Rather, participants cooperate with each other to gain access to the data and to make data collection more efficient. These external groups often have separate reporting agreements, although their data is often used for TRCA reporting.

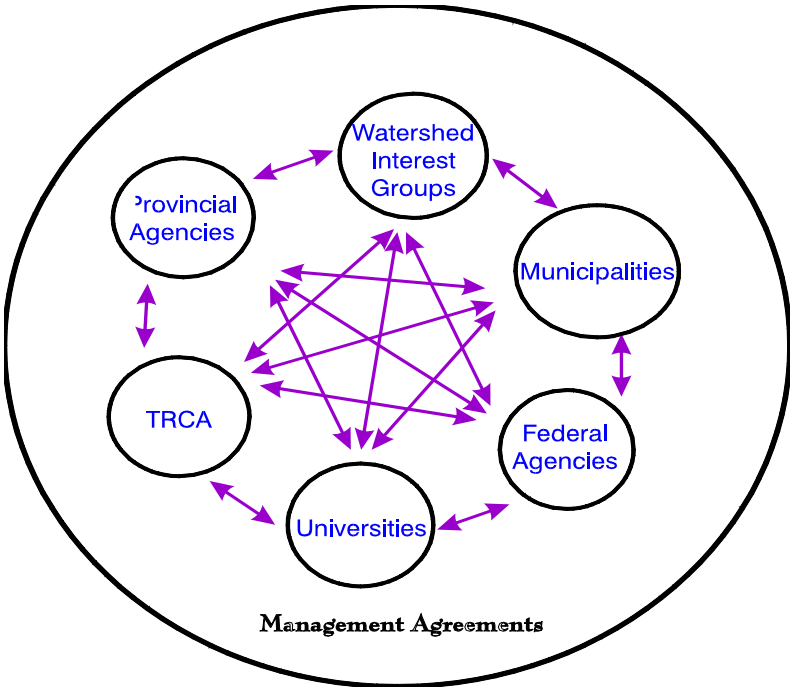

Figure 3. Schematic representation of the monitoring network (TRCA 2000a)

Table 2. Regional Watershed Monitoring Network participants

Data Collection	Data Analysis	Reporting	Funding[1]
• Toronto and Region Conservation	• Toronto and Region Conservation	• Toronto and Region Conservation	• Toronto Remedial Action Plan (MOE/ Environment Canada)
• Ontario Ministry of the Environment	• Durham Region	• Toronto Remedial Action Plan	• Durham Region
• Ontario Ministry of Natural Resources	• City of Toronto	• Ontario Ministry of the Environment	• City of Toronto
• University of Toronto	• Peel Region	• Ontario Ministry of Natural Resources	• Peel Region
• City of Toronto	• York Region	• Fisheries and Oceans Canada	• York Region
• Fisheries and Oceans Canada	• Ontario Ministry of the Environment	• Durham Region	• Ontario Ministry of the Environment
• University of Guelph	• Ontario Ministry of Natural Resources	• City of Toronto	• York University
• York University	• York University	• Peel Region	• University of Toronto
• Environment Canada		• York Region	• Guelph University
		• Environment Canada	

[1]Monetary or in-kind

2.1.4 Process

Five process components were followed in the development of the monitoring network (Figure 4):

- Setting the context for the project;
- Development of indicators and protocols;
- Compilation of regional water monitoring program;

- Watershed monitoring network; and
- Consultation

In general, the development of the RWMP followed the process outlined in Figure 4. Several workshops were held in 1999 with interested parties from other Conservation Authorities, various levels of government, academia, non-profit environmental groups and the public. The first workshop was to exchange ideas on approaches to watershed monitoring and to identify areas where Conservation Authorities might benefit from coordination of ongoing monitoring activities. The two other workshops assisted with setting the contest of the monitoring program (RWMP) as well as provided input to the development of the discussion papers. Participants commented on the proposed framework and draft discussion papers as well as provided input on the roles and responsibilities in the proposed monitoring network. The first few components were completed and are summarized in the development document and the associated discussion papers. This included the development of indicator measures and sampling protocols for four components of the monitoring program (aquatic habitat and species/fluvial geomorphology, terrestrial natural heritage, surface water quality and flow and precipitation).

Comprehensive discussion documents (analyzing the current monitoring status in the Toronto area) have not yet been produced for

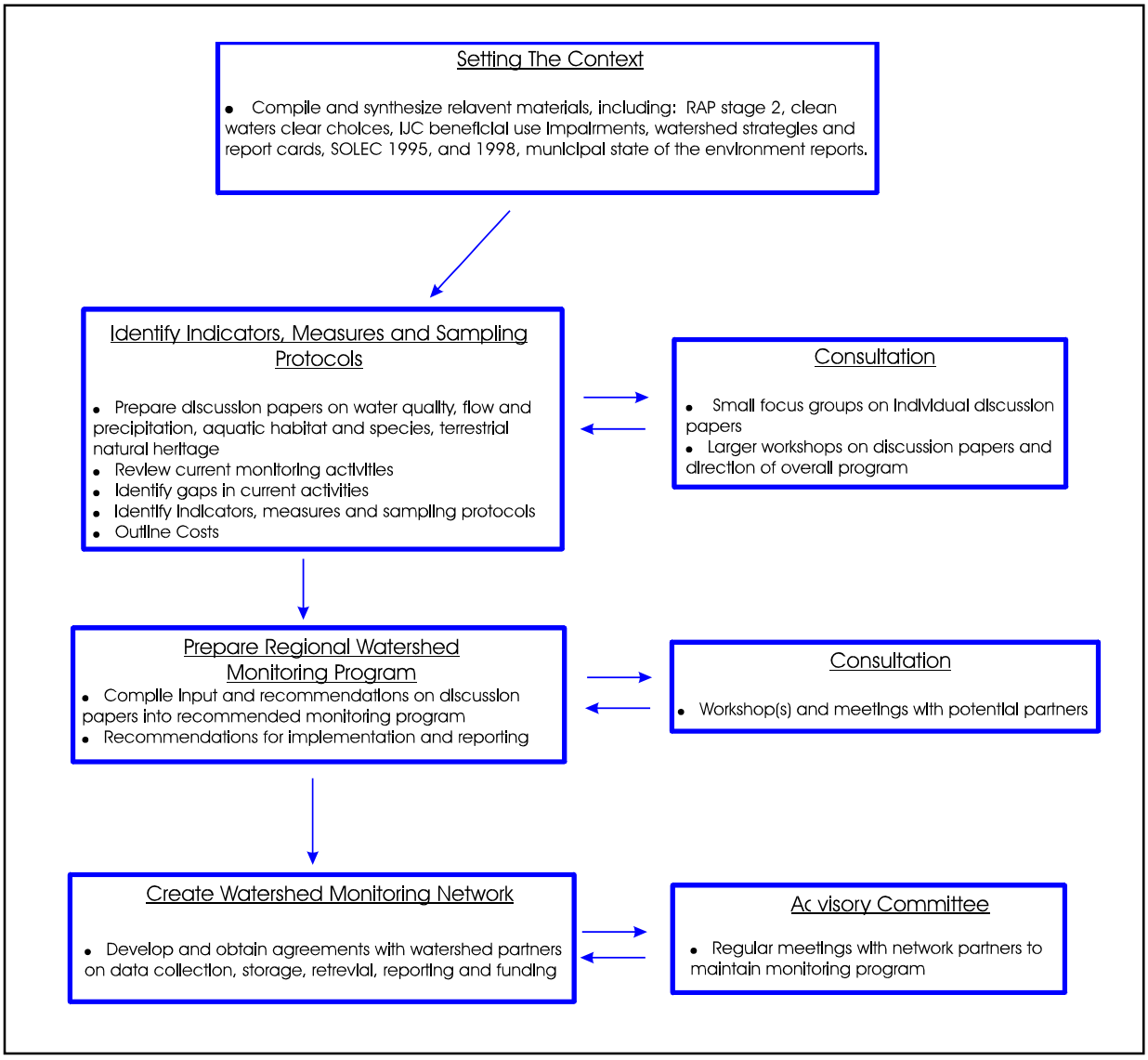

Figure 4. The process suggested for the development of the Regional Watershed Monitoring Program

The development of the network deviated from the suggested process in the final two process components. In most cases, formal agreements have not been signed between network participants. As mentioned earlier, the network currently functions cooperatively rather than with formal agreements. Although a formal network advisory committee was not formed, the majority of the network participants are involved with the Lake Ontario Modelling Team (LOMT). The LOMT is a coalition of partners from along the north shore of Lake Ontario that includes Fisheries and Oceans Canada (DFO), the Ministry of Natural Resources (MNR), Environment Canada, the City of Toronto and conservation authorities (TRCA, Central Lake Ontario

Conservation Authority, Ganaraska Region Conservation Authority and Conservation Halton), to assist in the development of a set of models to aid in characterizing streams and aquatic communities (fish and benthic invertebrates) in southern Ontario, and to assess changes in the aquatic community due to land use change. The LOMT meets semi-annually to discuss the characterization of aquatic communities in southern Ontario, identify research opportunities and facilitate information exchange and data sharing. The principle outcome of this group includes models that determine the biophysical condition of a stream relative to expected/reference conditions, and predict the impact of future land use change on biophysical properties of streams. Although the geographical context of this project is the streams flowing from the Oak Ridges Moraine to Lake Ontario, the resulting models are expected to have wide application. The LOMT serves a similar function to the suggested network advisory committee, except on a larger scale rather than focusing on the Toronto area.

Background

Current Status

- State/condition indicators have been established for aquatic habitat and species, terrestrial ecosystems, stream flow and precipitation, and surface water quality and quantity
- The RWMP was designed to monitor environmental variables at the subwatershed, watershed, and regional scales
- The RWMP covers the TRCAs jurisdiction spatially on a watershed scale but not completely on the subwatershed scale
- There is no official structure to the overall monitoring network (e.g. in most cases, there are no formal monitoring agreements)

Gaps/Opportunities

- Additional monitoring may be required on the subwatershed scale, particularly in subwatersheds where mapping has been refined since the inception of the RWMP
- Pressure/stress indicators and management/response indicators need to be developed
- Discussion documents were not completed for the groundwater and air quality monitoring components of the monitoring program
- No formal network advisory committee

Recommendations

- TRCA should take a larger role in managing the overall network
- Establish a network advisory committee and annual workshop with both active participants in the network and potential new participants to discuss current monitoring activities which are part of the network, activities outside the network, potential for collaboration/ streamlining and discussions of new, innovative or potential future monitoring techniques
- Further define stress/pressure and response/management indicators in conjunction with future watershed report cards and develop monitoring protocols to measure/monitor these indicators

2.2 Monitoring Program Components

> "Biological communities are able to integrate a wide variety of impacts and thus can provide a good barometer of overall

A series of indicators and sampling protocols were proposed which fit into the condition-stress-response framework outlined in the development document as well as in Section 2.1.2 of this report. The following sections review the indicators and protocols proposed initially, those currently in use and the statistics recommended for analyzing the data collected. It is important to keep in mind the scale at which RWMP was designed - The monitoring program is focused primarily on answering the question of health and tracking change at a watershed and subwatershed scale (TRCA 2000a). The monitoring activities for each component of the RWMP are outlined in individual tables with further details provided in the text following the tables.

2.2.1 Aquatic Habitat and Species

As part of the aquatic habitat and species component of the monitoring network, a variety of indicators are monitored including fish and invertebrate communities and aquatic habitat. Monitoring is biologically focused, providing important "front line" type information which can is used for assessing watershed condition and assessing watershed management targets. There are four main components (fish, benthic invertebrates, algae and aquatic habitat) monitored as part of the RWMP. An overview of the current status of the aquatic habitat and species monitoring is provided in Table 3. Further detail regarding the individual components is provided in the text following the table.

2.2.1.1 Fish Community Monitoring

Stream fish community sampling is conducted by the RWMP on a 3-year watershed rotation (Table 4) and follows the Ontario Stream Assessment Protocol (OSAP). The OSAP protocol is endorsed by the provincial (MNR, MOE) and federal (DFO) governments as the preferred protocol for conducting long-term stream monitoring. The fish community is monitored using single-

pass electrofishing at 149 sites across the TRCA's jurisdiction, mainly on second to third order watercourses.

Table 3. Overview of Indicators and Measures of Condition for Aquatic Habitat and Species with respect to the Regional Watershed Monitoring Program

	Recommended Parameters (TRCA 2000b)		Current Status
Indicator	**Parameters/Measures**	**Statistics**	
Fish Communities	Target species Self-sustaining populations Index of Biotic Integrity (IBI)	Presence/absence of life history stages IBI scores and metric scores Biomass estimation (waterfront) In future, comparisons to regional reference sites	Stream fish communities (149 sites) are sampled once every 3-years via single pass electrofishing. Target species have been outlined in Fisheries Management Plans for individual watersheds. Proposed statistics have been calculated on a watershed by watershed basis but not for the Toronto region as a whole. Regional reference sites have not been established.
Invertebrate Communities	Indices of community composition, eg. taxa richness, number of EPT, biotic index, Hilsenhoff	Mean and median scores, range in score, deviation from expected, trend through time, etc. In future, comparisons to regional reference sites	The invertebrate community is sampled at 149 sites on an annual basis. The proposed statistics have been calculated on a watershed by watershed basis. In addition, the Benthic Aggregate Assessment (BAA) has been established as a summary statistic for benthos data which determines is a site is unimpaired or potentially impaired with regards to urbanization. Regional reference sites have not been established.
	West Nile Virus Vector Species[1]	Presence/absence, abundance of vector species	Presence/absence West Nile virus vector mosquito larval monitoring is carried out in selected TRCA natural wetlands and municipal stormwater management ponds on a monthly basis during the summer
Algae (Periphyton)	Indices of community composition	Examples of statistics suggested include: species composition, correspondence analysis, diversity indices, saprobic index, trophic diatom index, etc. A specific diatom index for the GTA based on correspondence may also be developed in the future.	Algae monitoring is a new biomonitoring technique for the Toronto area and is currently being developed by the University of Toronto/MOE/TRCA.
Habitat	Woody riparian vegetation	Percent of stream length with woody riparian vegetation, aerial photo interpretation every 5 years to document	Riparian habitat immediately alongside fish community sites is measured using the OSAP, once every 3-years in conjunction with the fish community monitoring. Aerial photo interpretation has not yet been

	Recommended Parameters (TRCA 2000b)		Current Status
Indicator	Parameters/Measures	Statistics	
	Baseflow	primarily loses Baseflow yield	conducted. Baseflow is monitored at a minimum of every once every 3-years and is further discussed in the flow and precipitation section. Thermal stability is monitored using temperature loggers once every 3-years. Substrate is monitored as using the OSAP once every 3-years. The statistics listed have not yet been calculated and regional reference sites have not been established.
	Temperature & Thermal stability Habitat homogeneity Substrate	Comparison to suitability index (SI) curves and overall habitat suitability index (HSI) values	
	Fluvial Geomorphology	Long section, cross section, pebble counts	150 monitoring sites have been established throughout the TRCA's jurisdiction. Sites are monitored on a 3-year rotation by watershed. Because fluvial geomorphologic processes usually take long periods of time to show detectable results, data has not yet been analyzed.

[1]West Nile Virus vector species monitoring was not part of the original discussion document. West Nile Virus was discovered in Ontario in 2002 and added to the RWMP in 2004.

Table 4. Stream Fish Community and Aquatic Habitat Sampling Rotation

2001, 2004, 2007	2002, 2005, 2008	2003, 2006, (2009)
Humber River	Don River	Duffins Creek
Etobicoke Creek	Highland Creek	Rouge River
Petticoat Creek	Mimico Creek	Carruthers Creek

The data collected allows for the determination of what species are present at different life cycles. In general, the Index of Biotic Integrity (IBI), which is a multi-metric index used to determine the health of a fish community, has been the main statistic used to analyse the fish community data collected. The Weighted Species Association Tolerance Index with Respect to Water Quality (WSATI-WQ; Wichert 1994) is being considered for future analysis. The WSATI-WQ was specifically developed to compare changes through time in ecological conditions based on fish communities present in the Toronto area. The WSATI-WQ was developed using published information on a fish species' degree of tolerance to reductions in water quality according to four habitat categories: chlorine concentration, low dissolved oxygen concentration, increased turbidity and physical habitat destruction. Multivariate statistics, a collection of procedures which involve observation and analysis of more than one statistical variable at a time may also be used to analyze data in the future.

The RWMP was designed to look at fish communities in second or third order watercourses, rather than headwater streams. As mentioned earlier, a headwater stream study is currently underway to help understand the importance of headwater streams in TRCA's jurisdiction. Recommendations from the headwater stream study should be considered for application to the RWMP. As Fisheries Management Plans are updated and finalized, several recommendations have been made to add sites to the RWMP to ensure data is collected for each Fisheries Management Zone. These zones, although often similar to subwatersheds, are based on slightly different characteristics. Fisheries Management Zones are "a geographic area that has relatively homogenous hydrogeological characteristics and ecological functions, and supports a characteristic fish community" (TRCA 2007e). Because of this difference, sometimes there is limited data within a Fisheries Management Zone but sufficient data on a subwatershed scale. For example, the Rouge Watershed Plan Implementation Guide (TRCA 2008d) suggests the addition of

sites in three Fisheries Management Zones yet, there is already at least one site per subwatershed in these areas. The RWMP was set up to detect long-term changes over time, rather than studies about individual fish communities. Additional sites based on Fisheries Management Zones are a project-specific need rather than a gap in the RWMP.

2.2.1.2 Benthic Invertebrate Community Monitoring

Benthic invertebrate community sampling has been a core activity for the RWMP since 2001 and is conducted annually at 149 stream stations across all of the TRCA watersheds. Stream invertebrate samples are collected using a modified kick and sweep technique across several transects at a site. During the time period when the RWMP was being developed, there was no standard sampling protocol for benthic invertebrates in the Province of Ontario. The TRCA adopted a protocol whereby benthic invertebrates were collected at each of the transects set out by the Ontario Stream Assessment Protocol (OSAP; Stanfield 2001) habitat module (10-20 transects depending on stream width). Samples are collected using a 500 micron mesh D-net, with the samples from all transects combined into a single composite sample and preserved. In 2004, the MOE's Ontario Benthos Biomonitoring Network (OBBN; Jones *et al.*, 2004) introduced a standard protocol for the Province (which has recently been incorporated into the OSAP). Although the mesh size of the net and the method by which invertebrates are collected (travelling kick and sweep) are similar, the recommended OBBN protocol differs from the method that TRCA had already been using for four years before the introduction of the OBBN. The OBBN method collects invertebrates from only three transects while the RWMP collects benthos from 10-20 transects depending on the width of the stream. TRCA was faced with the decision of continuing with the sampling method that had been used for the first four years of the RWMP or adopt the new provincial protocol. Rather than making an arbitrary choice, the two protocols were compared. Staff collected data in 2003 and 2004 and determined that the two methods were interchangeable using coarse identification (27-group with mix of phylum, order, family as outlined in the OBBN protocol) within the context of large geographic scales or for the detection of major impacts (Borisko *et al.*, 2007). With these findings, it was decided to maintain the initial sampling protocol, ensuring repeatability and the ability to compare data.

Standardized random sub-sampling is carried out (100+ individuals). Samples are initially identified to the 27-group (mix of phylum, order and family) taxonomic level outlined in the OSAP and OBBN protocols and then further identified to the lowest practical level (usually family/genus) by the TRCA's entomology technician. From 2001-2004, samples were identified to species by contract taxonomists. Species identification was quite costly and in 2005, the decision was made to identify samples to the family/genus level. Many authors suggest that biotic-assemblage patterns occurring in large geographic scales can be adequately represented with coarse level taxonomy, whereas studies conducted in smaller areas (e.g. within a single river reach) require more detailed taxonomy (see Jones 2008) suggesting that higher level taxonomy should be able to detect large-scale processes (e.g. climate, historical colonization, speciation processes). Annual sampling of benthic invertebrates is recommended by Conservation Ontario (2003) but the RWMP should consider reduced sampling effort with further emphasis on lower (more precise) taxonomic detail. This may provide additional information which may allow for the detection of more subtle changes, particularly on the subwatershed level. A cost-benefit analysis should be conducted to determine how the RWMP sampling program should proceed.

To date, the main method of data analysis has been the Benthic Aggregate Assessment (BAA) (based on WSA, 1999) which is used to determine if sites conditions are "unimpaired" or "potentially impaired" with respect to criteria which are deemed characteristic of a healthy stream condition. The BAA is a decision rule system based on measured values for a series of ten benthic invertebrate indices. If five or more of the index values fall outside the expected limits for an unimpaired community, then the site is considered potentially impaired. Otherwise, the site is considered unimpaired. The organisms found at potentially impaired sites are looked at in detail to determine if the site is truly impaired. This includes determining the presence of sensitive organisms using the RWMP's Bioindicator Database (Golder Associates, 2004). Further work is required to refine the BAA to tease out "impaired" sites from the "potentially impaired" sites.

As noted above, most benthic invertebrate data used by the TRCA is analyzed using a multi-metric approach (i.e. BAA) which combines metrics (indicators) into a single index value. Multi-metric data analysis is useful because it

produces a single score that is comparable to a target value and includes ecological information. However, not all information collected is used, metrics are often redundant in a combination index and errors can be compounded (Reynoldson et al. 1997). The individual metrics can also provide useful information about different environmental stresses. Currently, most research in Canada is using multivariate data models to analyze benthic invertebrate data rather than multivariate methods. Multivariate statistics have shown a higher level of sensitivity to detect changes from reference condition than multi-metric indexes. Multivariate methods are attractive because they require no prior assumptions either in creating groups out of reference sites or in comparing test sites with reference groups. However, multivariate methods are complex and can be difficult to understand (Reynoldson et al. 1997). Multivatiate statistical analysis (e.g. correspondance analysis) has been used for some RWMP benthos data (e.g. TRCA 2005) and should be considered for future analysis.

Despite using a different field protocol, TRCA staff are participants in the Ontario Benthos Biomonitoring Network (OBBN). One of the mandates of the OBBN is to develop reference sites for Ontario. "Minimally impacted" reference sites are used to define the normal range of biological condition for a given habitat type. Currently, the OBBN is collecting data on a number of factors (natural riparian vegetation, catchment forest cover, land-use (development/urban, agriculture) in catchment, and water chemistry) to help determine quantitative criteria for minimally impacted sites. Once quantitative critera has been established for reference sites by the OBBN, TRCA will proceed to determine if any sites exist within the TRCA's jurisdiction or if surrogate sites in other areas will have to be used as reference sites.

Recently, several mussel species were designated under the Canadian Species at Risk Act (SARA). Freshwater mussels are now the most endangered organisms in North America with "nearly 70% of species at risk of extinction" (Metcalfe-Smith & Cudmore-Vokey 2004). Although mussels are considered a fish species under the Fisheries Act, they are part of the benthos of water bodies. Mussels have been looked at in specific areas (e.g. Humber River) but little is known about the mussel populations in the Toronto region as a whole. Further consideration should be given to monitoring mussel species in the TRCA jurisdiction.

West Nile virus (WNv) vector species monitoring is a new program under the RWMP. It is an important part of the monitoring program particularly because the West Nile virus pathogen can transfer from birds to humans via mosquitoes. West Nile virus was first detected in the United States in 1999 (Kilpatrick et al. 2006) but was not detected in Canada until 2002 (Health Canada 2005). The objectives of the program are to monitor larval mosquito populations for the evidence of WNv vector species, characterize the abundance of the two key vector species, Culex pipiens and Culex restuans, identify vector hot spots and participate in public outreach and education activities in conjunction with the Regions of Peel, Durham, York and City of Toronto. Monitoring is conducted monthly at TRCA natural wetlands and selected municipal stormwater management ponds during the summer months. TRCA wetlands are monitored as part of due diligence to protect both TRCA staff and the public and selected municipal stormwater management ponds are monitored for comparison with the natural wetlands.

2.2.1.3 Algae Monitoring

In the development document, algae were suggested as a possible indicator for watershed health. Because of their strong connection to basic water chemistry and their short life cycles, algae are often the first group of organisms to be impacted by shifts in physical and chemical conditions in a watercourse, including the introduction of pollutants at relatively low concentrations. This makes algae an excellent early warning system of change in a watershed. The algae (particularly diatoms) monitoring component of the RWMP was developed in conjunction with Dr. Marianne Douglas from the University of Toronto and her graduate student Natasa Drakulic-Zugic. Algae samples were collected from RWMP sites in 2002 and used by Drakulic-Zugic for her Ph.D. thesis (2006). In her thesis, Drakulic-Zugic developed an initial sampling protocol for collecting algae samples as well as some models describing the algae community in the Toronto area. In the summer of 2008, the TRCA and the MOE initiated a study to test the use of the algae protocol by field staff and to determine if the results are repeatable by field crews with limited algae collection experience. The data will be analyzed to determine if algae are a cost-effective, informative bioassesment method which should be permanently added to the RWMP.

2.2.1.4 Aquatic Habitat Monitoring

The aquatic habitat component of the RWMP is monitored at the site level every 3-years in conjunction with the fish community monitoring according to the OSAP. The OSAP monitors habitat characteristics such as instream cover (percentage available, type), channel morphology (riffle/run/pool), substrate type and bank stability. The aquatic habitat component also includes water temperature monitoring using data loggers which record water temperature at set time intervals from spring to fall at fish community sites. The water temperature data is used to calculate the thermal stability of watercourses (e.g. warm water, cool water, cold water) and characterize stream temperatures on a seasonal basis. In addition, 150 fluvial geomorphology sites have been established throughout the TRCA's jurisdiction to monitor physical changes to watercourses and the processes that shape them (e.g. erosion, stream bed migration, channel stability, etc). The discussion document recommended that habitat be monitored at two scales: locally at each monitoring station and broadly at a watershed and subwatershed scale. The OSAP protocol along with the fluvial geomorphology monitoring is used to monitor aquatic habitat at the detailed site level. On the larger sub-watershed/watershed scale, riparian vegetation communities are monitored as part of the terrestrial ecosystem component of the RWMP. Detailed riparian vegetation monitoring (e.g. aerial photo interpretation to document gains/losses over time) needs to be developed more thoroughly based on new digital imagery. The discussion document also mentioned that baseflow "*is an important site level component of aquatic habitat*" and it was "*recommended that baseflow estimates be made at each monitoring station and used to help compare results at each site, between sampling years*". Baseflow monitoring is a part of the RWMP and is further discussed under the under the water quantity - flow and precipitation component (Section 2.2.4).

2.2.1.5 Summary

Aquatic Habitat and Species

Current Status

- 149 fixed sites monitored for fish and benthic invertebrate communities and aquatic habitat monitoring
- 150 fixed sites monitored for fluvial geomorphology
- 45 fixed sites monitored for West Nile Virus vector mosquito species

Gaps/Opportunities

- Headwater streams are not monitored for fish and benthic invertebrate communities and aquatic habitat monitoring
- Some benthic invertebrates are currently identified to family/genus level rather than the species level
- Algae monitoring is being further developed as this indicator is expected to be the first aquatic community to respond to environmental change
- Information on freshwater mussels in Toronto Region streams is lacking

Recommendations

- Recommendations from the headwater stream study should be considered for implementation to the RWMP
- Conduct a cost-benefit analysis with regards to benthic invertebrate sampling (i.e. should sampling be conducted annually? what level of taxonomy is appropriate?)
- Further development of algae monitoring protocols, statistics and indices

2.2.2 Terrestrial Natural Heritage

The Terrestrial Natural Heritage component of the RWMP was established in 2000 and builds on data collected over the preceding 15 years first under the Environmentally Significant Areas (ESA) project work and the Terrestrial Natural Heritage Program. A large activity of the program has been to document a baseline condition across the TRCA's jurisdiction through the systematic inventories of vegetation communities and species. TRCA staff collected a large database of flora and fauna species (field collected) and land

cover (remote-sensed) from across the region. The distribution of species was studied in relation to the "quality" of habitats they were found in: what size, shape and matrix influence (from surrounding lands) supported what species. Every habitat patch was given a rank of very poor, poor, fair, good or excellent. The resulting computerized landscape analysis model was used to evaluate the entire system quality (the Quality Indicator). The distribution and amount of natural cover measures would complement the quality indicator (Distribution and Quantity Indicators). A projection of urbanization in the region was mapped digitally and evaluated to predict the response of the region's biodiversity to urbanization should it proceed following the current practices in natural system protection. Much of the system would fall from a poor-fair to a poor quality, implying dramatic reductions in species distribution regionally. Those species became species of concern.

The thresholds of habitat quality (from very poor to excellent) were used to set system targets for quality, distribution and quantity of natural cover across the TRCA jurisdiction. Aiming for a "good" quality natural system, a second model was developed to assist in designing the target natural system that would achieve the target. The model selected the areas of highest value to the region's natural system based on a variety of criteria, both ecological and planning. The result was a target system that includes much of the existing forests, wetlands and meadows plus additional areas to be restored. This target system was evaluated using the landscape analysis model. It was determined that at least 30% of the region should be natural cover in order to sustain the existing distribution and populations of species of concern. That target system would also help to sustain the environmental and social benefits of the existing system.

In order to promote the target system a public document, the *Terrestrial Natural Heritage Systems Strategy* (TNHSS; TRCA 2007b) was written and reviewed by stakeholders. The TNHSS was thus developed as part of the Terrestrial Natural Heritage Program to retain and recover terrestrial natural heritage within the TRCA's jurisdiction; it incorporates target-setting at the regional level to assist in decision-making at smaller scales. The Terrestrial Natural Heritage Program approach and models behind the TNHSS provide a powerful tool to direct land use policy, strategic planning and environmental decision-making at multiple scales. The TNHSS was developed between 2001

and 2006 by TRCA staff in collaboration with municipalities, the private sector, academia and community groups, and was approved in principle by the TRCA Board in 2007. Although the objectives of the strategy are based on making positive changes at all scales, the evaluation models were developed at the landscape scale using a combination of digital land cover mapping and field-collected data. Based on the TNHSS, the greatest gains to regional biodiversity will be expected to follow from changes to the existing system:

- An increase regionally in terrestrial natural cover quality from "fair to good" and quantity from 25 to 30 %;
- Increases to terrestrial natural cover quantity and quality in the Greenbelt Area;
- Increases in terrestrial natural cover quantity in the Agricultural and Rural Area;
- Increases in terrestrial natural cover quality in the Designated Greenfield Area; and
- The protection of much of the existing terrestrial natural cover in the Built-up Area.

The RWMP provides the main mechanism for tracking progress in improving the natural system from baseline conditions toward achieving the target system in the TRCA jurisdiction as the TNHSS is implemented. TRCA standards for data collection and systems evaluation were set up in the Terrestrial Natural Heritage Program, and the resulting indicators and protocols were adopted in both the TNHSS and the RWMP Terrestrial Natural Heritage Monitoring discussion paper (TRCA 2000e). There are three types of data collected: 1. remote-sensed; 2. systematic inventory; and, 3. fixed plot monitoring. An overview of the program is provided in Table 5.

The TNHSS relied heavily on the data collected through remote-sensing and the systematic inventory to determine the baseline. The remote-sensing can lend itself well to long-term monitoring but the systematic inventory is too labour intensive and expensive to sustain in the long-term. Fixed monitoring plots will document temporal changes as the TNHSS is implemented. These plots are set up to monitor vegetation, breeding birds, frogs and salamanders across forest, wetland and meadow habitat. As part of the development of the fixed plot monitoring program, a "priori" power analysis was conducted to determine the number of plots required (Zorn 2008). The sampling program

is one of the most comprehensive ecological monitoring programs in Ontario. "If the TRCA is able to successfully implement these monitoring measures with the sampling effort recommended here then its long term ecological monitoring program would be comparable to some of the most comprehensive and effective monitoring programs in Ontario. Few agencies are currently implementing area-based, multiple parameter, multiple ecosystem monitoring in the province (e.g. monitoring programs that assess trends in biodiversity, ecological processes and stressors across a range of dominant ecosystem types with the same landscape)." (Zorn 2008).

Table 5. Overview of Indicators and Measures of Condition for Terrestrial Natural Heritage Program

Monitoring Parameters			
Indicator	**Parameters/Measures**	**Statistics**	**Current Status**
Quality Distribution	Landscape level assessment (habitat patch)	Habitat Patch Size, Shape, and Matrix Influence, total score	Entire TRCA jurisdiction has been mapped based on 2002 aerial orthophotos
Quantity	Landscape level assessment (habitat patch) Forest and wetland cover	% cover of site vs. watershed	Entire TRCA jurisdiction has been mapped based on 2002 aerial orthophotos
Vegetation Community	Site level assessment Ecological Land Classification (ELC) inventory to vegetation type detail.	Vegetation Communities of Regional Concern and representation (L Ranks)	Approximately 36,000 ha surveyed (60% of Regional Natural Cover)
Species Flora/Fauna	Site level assessment Floral, breeding bird and amphibian surveys	Flora and Fauna Species of Regional Concern and Representation (L Ranks)	Approximately 36,000 ha surveyed (60% of Regional Natural Cover)

	Incidental mammal observations		
Monitoring Parameters (Fixed Plot)			
Indicator	**Parameters/Measures**	**Statistics**	**Current Status**
Forest Health	Fixed plots (quadrants and transects) to assess Tree Mortality, Crown Vigor, Floristic Quality Index, Forest Birds, Salamanders	Overall temporal trends and differences in 3 land-use zones for: tree mortality, crown vigor, mean FQI, species abundance and richness, invasive species	Fixed Plots set-up in 2008 to assess overall Regional system Future set-up of additional plots in 3 land use zones
Wetland Health	Fixed plots (quadrants and transects) to assess wetland birds, frogs/toad calls, aquatic vegetation.	Overall temporal trends and differences in 3 land-use zones for: Frog Chorus call intensity, species abundance and richness, mean FQI, invasive species	Fixed Plots set-up in 2008 to assess overall Regional system Future set-up of additional plots in 3 land use zones
Meadow Health	Fixed plots (transects) to assess meadow birds	Overall temporal trends and differences in 3 land-use zones for: Species abundance and richness	Fixed Plots set-up in 2008 to assess overall Regional system Future set-up of additional plots in 3 land use zones

In addition to the TRCA staff fixed plot monitoring activities in support of the terrestrial natural heritage component of the RWMP, a volunteer monitoring program, developed in 2001 will continue to provide data on the condition of the natural system over time. The *Terrestrial Volunteer Monitoring Program* (TVMP) is an extremely successful initiative where

Terrestrial Natural Heritage

Current Status

- 100% of natural cover inventoried using remote-sensing
- Over 36000 hectares documented through the systematic inventory
- 118 fixed plots sites set-up in 2008
- Approximately 55 sites monitored through the Terrestrial Natural Heritage Volunteer Monitoring Program

Gaps/Opportunities

- Currently implementing fixed plot monitoring throughout the TRCA's jurisdiction in order to detect regional trends in species and vegetation communities over tiem
- Lacking information on soils

Recommendations

- Maintain fixed plot monitoring to ensure long-term changes (such as

volunteers monitor the presence/absence of indicator flora and fauna species at fixed sites throughout the TRCA's jurisdiction. The TVMP is further discussed in Section 4.1.

2.2.3 Surface Water Quality

Water quality testing in Toronto area streams is conducted by a variety of organizations in order to achieve the goals outlined in the monitoring network development document. An overview of the current status of the Water Quality monitoring component of the RWMP is provided in Table 6.

Table 6. Overview of the Indicators and Measures of Condition for Water Quality

	Recommended Parameters (TRCA 2000d)		Current Status
Indicator	**Parameters/Measures**	**Statistics**	
Water Chemistry - Basic	BOD or dissolved oxygen, chlorides or conductivity, E. coli bacteria, nitrogen compounds (NO2, NO3, un-ionized Ammonia, TKN), pH, total phosphorus, suspended solids, turbidity, water temperature; in addition, for lakes only - Chlorophyll a[1]	Minimum, maximum, mean and median concentrations over a five year period.	Basic water chemistry is sampled monthly at 34 stream sites by TRCA staff and analyzed by MOE, City of Toronto and/or private laboratories. The water quality data collected by the RWMP allows for the calculation of the statistics proposed in the original discussion document. To date, the CCME Water Quality Index has not been calculated but is being considered for future reporting. Regional Health Units collect water quality samples for Lake Ontario and inland beaches.
		CCME[3] Water Quality Index.	
		Trend over entire period of sampling.	
		For beaches: Number of days per swimming season the beach is closed, due to unacceptable E.coli levels.	
Water Chemistry - organics/metals	Priority Pollutants identified in the Canada-Ontario Agreement: Tier 1 - e.g. aldrin/dieldrin, chlordane, DDT, PCBs, mercury, etc.; Tier 2 -	Percent of samples above the minimum detection limit.	Tier 1 and Tier 2 Priority Pollutants are collected by the MOE periodically. Metal samples are collected monthly under the RWMP at 34 stream sites as well as by the MOE. The data collected under the RWMP
		Minimum, maximum, mean and median concentrations over a five year period.	

	Recommended Parameters (TRCA 2000d)		Current Status
	PAHs, cadmium, etc.		allows for the calculation of the statistics suggested in the original discussion document.
	Metal parameters that exceeded PWQO or other Guidelines in MOE's Tributary Toxics Discharge Program: Aluminum, Cadmium, Copper, Iron, Lead, Silver, Zinc	Percent of samples that exceed target (e.g. PWQO).	
		Trend over entire period of sampling.	
Tissue Chemistry - Contaminants in Young of the Year (YOY)Fish Flesh	Parameters as determined by MOE, with reference to past studies (Aldrin/Dieldrin, BHC, Chlordane, DDT, Heptachlor, Hexachlorobenzene, Mirex, Photomirex, Octachlorostyrene, PCB, Toxaphene, Mercury).	Number of parameters detected annually.	YOY fish tissue chemistry data is collected and analyzed annually by the MOE. On occasion, the RWMP has collected fish samples for submission to this program.
		Minimum, maximum, mean and median concentration of contaminants in forage fish per site, based on data availability.	
		Percent of sites with samples that exceed target for a given parameter.	
		Trend over entire period of sampling.	
Tissue Chemistry - Contaminants in Sport Fish	Parameters as determined by MOE, with reference to past studies (Aldrin/Dieldrin, BHC, Chlordane, DDT, Heptachlor, Hexachlorobenzene, Mirex, Photomirex, Octachlorostyrene, PCB, Toxaphene, Mercury).	Minimum, maximum, mean and median concentration of contaminants in sport fish per site, based on data availability.	Sport fish tissue chemistry data is collected and analyzed annually by the MOE. On occasion, The RWMP has collected fish samples for submission to this program.
		Percent of samples that exceed target (e.g. specified restriction levels for human consumption).	

	Recommended Parameters (TRCA 2000d)		Current Status
		Number of allowable meals per month.	
Tissue chemistry – Contaminants in Herring Gull Eggs	Parameters as determined by the Canadian Wildlife Services branch with reference to past studies (Hg, DDT and metabolites, dieldrin, mirex, chlorinated organics (e.g. PCBs and its congeners), HCB, dioxins (e.g. 2,3,7,8 TCDD), furans)	Mean annual concentration of specific contaminants per site plotted over time for the period of record.	The Great Lakes Herring Gull Egg Monitoring Program is the world's longest-running annual monitoring program for contaminants in wildlife. The longevity of the egg database makes it possible to examine changes in contaminant concentrations in wildlife over time. Contaminant levels in eggs have improved (decreased) over the last 30 years of sampling (SOLEC 2007)
Sediment Quality – chemistry	Organics: PCBs, organochlorine pesticides Metals:Al, As,Cd,Cu,Cr, Fe, Mn, Ni,Pb,Zn	Percent of samples that exceed target (e.g. Provincial Sediment Quality Guideline (PSQG)).	Concentrations of contaminants in sediment cores is improving (SOLEC 2007)
Aesthetics	Incidence of debris, litter, nuisance algal blooms or weed growth, poor water clarity.	Comparison of the number of complaints recorded in a given year, with previous years. Measure of "incidence" and degree of problem to be defined and measured on a specified frequency, using survey techniques (further discussion required)	Aesthetics monitoring was conducted under the RWMP in 2001. Data was completed by volunteers and analyzed by RWMP staff. The data was not scientifically repeatable therefore aesthetics monitoring was discontinued.

[1]The above-noted parameters have been recommended as key parameters of concern, however we recommend that an ambient water quality monitoring program should include a broader range of basic water chemistry parameters to assist in data interpretation and ensure a data record for presently unforeseen problems.

[2]PWQO: Provincial Water Quality Objective

[3]CCME: Canadian Council of Ministers of the Environment

TRCA's RWMP collects monthly grab samples for water quality at 34 stream sites across 8 watersheds (Table 7). There are no water quality sampling sites in the Petticoat Creek or Frenchman's Bay watersheds. Eleven sites are collected as part of the MOE's Provincial Water Quality Monitoring Network (see below), and the remaining 23 sites are collected via a partnership with the City of Toronto who provide in-kind laboratory analysis. The development document and associated discussion paper recommended that 21 sites should be established throughout the TRCA's jurisdiction. Through these partnerships, the RWMP has been able to establish 13 additional water quality sampling sites above and beyond the number of stations recommended in the development document.

Table 7. Number of Surface Water Quality Sampling Sites by Watershed

Etobicoke Creek	Mimico Creek	Humber River	Don River	Highland Creek	Rouge River	Duffins Creek	Carruthers Creek	Petticoat Creek	Other[1]	Total
3	2	10	4	1	7	6	1	-	-	34

[1] Includes minor watersheds flowing such as Frenchman's Bay

Samples are submitted either to the City of Toronto, MOE or private laboratories for analysis of general chemistry, metals, nutrients and microbiological (e.g. E. Coli) analysis. Water sampling follows the MOE Provincial Water Quality Monitoring Network (PWQMN) protocols (MOE 2003) and include field water chemistry measurements (e.g. water temperature, conductivity, dissolved oxygen) using handheld meters (e.g. Hydrolab, YSI). Sampling occurs year round and is independent of precipitation but the majority of samples are taken during dry weather events.

The Provincial Water Quality Monitoring Network (PWQMN) collects surface water quality information from streams and rivers at strategic locations throughout Ontario. Over 390 locations are currently being monitored and historical data exists for over 2000 locations dating back to 1964. A standard suite of water quality parameters is monitored at each station including chloride, metals, nutrients, suspended solids and other general chemistry parameters. Two PWQMN stations (06008301902 near the mouth of the Humber River, 06008501402 near the mouth of the Don River) are sampled by the MOE for an enhanced group of parameters including mercury

and microbial indicators. PWQMN samples are collected at monthly intervals during the ice-free season.

The RWMP enhances the PWQMN sampling by collecting water quality during the four winter months and submits the samples to the City of Toronto for analysis. The RWMP also collects microbial samples at every water quality site in the network, including the PWQMN sites. Sampling for bacteria at all RWMP stations began in 2003. In the spring of 2006, it was discovered that the private laboratory that was analyzing the microbial data had incorrectly labelled the E. coli samples rendering this data unusable (fecal coliform data was determined to be acceptable). Upon discovery of this issue, the private laboratory was immediately changed and recent results have been favourable.

Several laboratories analyze the RWMP data and there have been some issues meshing the various datasets together due to differing laboratory techniques and detection limits. A split sample quality assurance/quality control (QA/QC) program was implemented in the fall of 2008 to evaluate inter-laboratory performance from different laboratories on identical parameters. The results from this program will allow the RWMP to determine the comparability of the four laboratories that are currently analyzing water quality samples. The samples have been collected and submitted to the various laboratories and results are expected in late 2008/early 2009.

The RWMP water quality sampling program is based on grab samples at preset monthly intervals which results in a diversity of flow conditions. Because flow measurements are not taken in conjunction with the water quality sampling and in most cases, there are no continuous flow stations nearby; it is difficult to separate wet (precipitation) and dry (baseflow) samples. Water quality is significantly influenced by wet weather conditions because as runoff flows along the ground, it can pick up contaminants (e.g. petroleum, pesticides, fertilizers, sediment, etc) which eventually make their way into local streams. The current monitoring program does not easily allow for modifications to the sampling regime to incorporate targetted wet weather sampling. The protocol for the PWQMN is to collect random samples rather than targetted samples. Approximately one-third of the water quality sites are collected as part of the PWMQN and the majority of the remaining sites are historic PWQMN station. In order to maintain consistency in the datasets

and to allow for comparison with historical data, the RWMP should continue collecting samples according to the PWQMN protocol and a specific wet weather sampling program should be initiated. A review of current (e.g. municipal) and historical wet weather sampling in the Toronto area should be conducted to determine the need and appropriate locations/timeing for wet weather sampling and to develop partnerships with other organizations. If necessary, additional samples targetting precipitation events should be collected and where possible, these samples whould be integrated with flow montirong to help document the wide range of water quality conditions in the Toronto Region.

Degraded aesthetics are discussed in the original development document. Degraded aesthetics can be caused by undesirable algae growth, litter and debris, cloudy waters from sediment erosion, unpleasant odours and unnatural alterations to the watercourse that have occurred over time. To help quantify the extent of the problem, the RWMP initiated a community-based visual survey in October 2001 and 2002 where members of the community conducted visuals surveys over a section of stream or the waterfront in their neighbourhood (TRCA 2003b). The results of this program were found to be biased and not repeatable; therefore the program was discontinued. Further details regarding this program are available in Section 4.3.

The MOE conducts several water quality monitoring programs including the Toronto Tributary Toxics Assessment, Young-of-the-Year Fish (YOY) Contaminant Monitoring, Sport Fish Contaminant Monitoring and the Lake Partner Program (volunteer program). The MOE has been conducting the *Toronto Tributary Toxics Assessment* as part of the RAP process periodically since 2003. This sampling is intended to identify those tributaries with significant concentrations and loadings of persistent bioaccumulative substances. A combination of flow monitoring, and event based large-volume sampling for trace organics (PCB congeners and PAHs), physical parameters, nutrients, and metals is employed. Samples are collected year round during storm events and base flow conditions. From 2003-2004, the program collected organochlorines and chlorobenzenes but stopped in 2005 because of data quality concerns. The YOY and Sport Fish Contaminant Monitoring Programs are conducted in the Toronto area at various times. Staff at the MNR and MOE collect fish which are analyzed at the MOE's laboratory in

Toronto. The fish are analyzed for a variety of substances, including mercury, PCBs, mirex, DDT and dioxins. The data provided by this monitoring program are used to produce the Guide to Eating Ontario Sport Fish which is published every other year by the MOE in co-operation with the MNR. The results are used to develop the tables in the guide, which give size-specific consumption advice for each species tested from each location. This advice is based on health protection guidelines developed by Health Canada.

The Lake Partner Program is a province-wide, volunteer-based, water-quality monitoring program. Volunteers collect total phosphorus samples and make water clarity observations about their lakes. Participation in the Toronto region has been at limited locations and results are often sporadic. Effort to encourage Toronto residents to participate in this program is needed. Further details regarding this program are presented in Section 4.3.

The City of Toronto and Durham Region continue to undertake bacterial monitoring for beaches along Lake Ontario. Throughout the summer, the

Water Quality

Current Status

- 34 stream water quality monitoring sites including 11 under the Provincial Water Quality Monitoring Network
- Partnerships with the Ministry of the Environment and the City of Toronto for laboratory analysis of water quality samples

Gaps/Opportunities

- No water quality monitoring in the Petticoat Creek and Frenchman's Bay watersheds
- Consistent laboratory analysis (e.g. methods, detection limits) is required
- Improved laboratory resolution (e.g. lower detection limits for certain parameters) is required
- Emerging contaminants (e.g. pharmaceuticals)
- Water quality samples are not currently integrate with flow monitoring
- Updated and improved monitoring of inland lakes/ponds in partnership with the Ministry of the Environment

Recommendations

- Initiate water quality monitoring program in the Petticoat Creek and Frenchman's Bay watersheds
- Continue participating in the Provincial Water Quality Monitoring Network

health departments conduct bacteriological tests to determine if these beaches are safe for swimming. In addition, the City of Toronto has been participated in the Blue Flag program which is a highly respected and recognized international eco-label. Blue Flags are awarded to beaches that meet strict criteria that cover everything from water quality to environmental programs. Six beaches in the Toronto area are participating in the program: Centre Island Beach, Cherry/Clarke Beach, Gibralter Point Beach, Hanlan's Point Beach, Ward's Island Beach, and the Woodbine Beaches.

2.2.4 Stream Flow and Precipitation

The flow and precipitation monitoring program provides both direct information about the state/condition of the water quantity in the Region's streams as well as supportive information to aid in the understanding of the biological conditions of aquatic habitat and species. Stream flow is also linked to water quality as there is a correlation between flow and contaminant levels associated with storm runoff. Although baseflow is outlined in the Aquatic Habitat development document (TRCA 2000b), it is discussed in detail in this section. An overview of the current status of the Stream Flow and Precipitation monitoring component of the RWMP is provided in Table 8.

Table 8. Overview of Indicators and Measures of Condition for Stream Flow and Precipitation

	Recommended Parameters (TRCA 2000e)		Current Status
Indicator	Parameters/Measures	Statistics	
Stream flow	Base flow, total flow, daily flow, monthly flow, annual flow, peak flow, instantaneous flow, duration, flow frequency	Baseflow/average annual, total annual flow, trends through time	Flow and water level data is collected is 54 stream gauges. Data is recorded using continuous data loggers. Data is also available from provincially and federally operated monitoring stations.
Snow course	Water equivalent (depth), crust condition, soil condition	Trend through time	Snow is monitored at ten sites throughout the TRCA jurisdiction.
Precipitation	Rainfall amount	Frequency, duration, trend through time	Precipitation is monitored at 32 stations throughout the TRCA jurisdiction. Data is also available from municipal, provincial and federal monitoring stations.

Climate[1,2]	Wind speed and direction, air and soil temperature, soil heat flux/moisture/water content, barometric pressure, net radiation, solar irradiance, photosynthetic active radiation, evaporation, evapotranspiration, leaf wetness, relative humidity, snow depth, precipitation	Frequency, duration, trend through time	Five climate stations were installed in 2008 and four additional stations have been purchased and will be installed in the spring of 2009.

[1] Program initiated in 2008

[2] Not all parameters measured at each station

Stream flow data has been collected within TRCA watersheds for over 50 years by various agencies. Compiling and archiving flow data was originally implemented by the federal government to meet its international obligations related to the Great Lakes. The TRCA has installed stream gauges since the start of the RWMN program for several reasons including stormwater management projects, water budgets, design and flood control purposes, drainage area modeling and to track changes to the watercourse due to development. There are 54 active stream gauges used by the TRCA flood warning network. Thirty-two gauges are owned by Water Survey Canada (WSC) but TRCA has a cost-sharing agreement with WSC which allows TRCA to use the data and operate the gauges. The remaining 22 gauges are owned and operated by the TRCA. The development document and associated discussion paper recommended the continuation of the 32 existing stream flow sites plus and additional 22 temporary sites which would monitored on a 3-year rotational basis. Rather than adding the sites temporarily, the additional 22 sites were added permanently to the stream monitoring program. Previous reports (e.g. TRCA 2008d) have suggested the need for increased flow monitoring stations to help establish baseflow regime in streams that will be affected by future urban development, to evaluate the success of innovative stormwater management technologies and to improve model calibration. These types of recommendations meet project-specific needs, rather than improving the RWMP on a regional basis (Tier 1). At a local scale (Tier 2), RWMP data is intended to be used as a flag or early

warning of problems. Where impacts are detected at a sampling site, more detailed studies are recommended to localize, diagnose and trace the source of the problem (TRCA 2000a).

A specific Baseflow Monitoring Program was established in 2000 and brought under the RWMP umbrella in 2004. The Baseflow Monitoring Program conducts monitoring of low stream flow during the summer season. The Baseflow Program consists of more than 1100 individual monitoring sites, with ongoing summer monthly monitoring occurring at an average of 80 stations per year. These 80 stations are called Indicator Stations and are strategically located throughout the watersheds including the outflow of each major subwatershed. The other stations are more intensely distributed within each watershed and are measured systematically during a specific summer in order to obtain baseline data for upcoming watershed plans. The main purpose of the Basefow Program is to develop data that allows for a better understanding of the interconnections between the groundwater and surface water systems. The long term goal of the TRCA Baseflow Program is to guide the management and protection of baseflow levels to protect aquatic life and ensure sustainable human use of surface water.

Precipitation gauges are the most widely used water quantity indicator and there are several government agencies and municipalities involved in collecting rain data in the GTA for flood purposes. Rainfall data determines individual flow events, annual flow measurements, weather forecasting, and flood forecasting. Rainfall data also helps to define road and sewer design standards, stormwater management standards, and bridge/culvert design standards. Rainfall measurements are mainly recorded using tipping bucket gauges, with a few exceptions as conical, cylinder and weighting gauges existing within the network. There are 26 precipitation gauges which are telemetered to provide real-time access to the data. Reports have suggested the addition of extra precipitation gauges within watersheds that already have gauges as well as in the Mimico and Carruthers Creek watersheds which do not have precipitation gauges. The network has been designed to provide coverage of 1 gauge per 10 km (or less). Although the Mimico and Carruthers watersheds are not monitored directly, adding stations in these watersheds would be redundant as these watersheds are quite narrow and there are several climate stations nearby. It is important to remember the scale that precipitation component of the RWMP was designed. The program was

designed on the watershed scale and additional gauges for the calibration of hydraulic models is a project specific need, rather than a regional monitoring need.

Currently, there are five climate monitoring stations installed and four additional stations have been purchased for installation in the spring of 2009. Climate stations monitor the following attributes: wind speed and direction, air and soil temperature, relative humidity, barometric pressure, solar irradiance, snow depth and precipitation. Some stations also have the ability to monitor additional attributes such as: soil heat flux/moisture/water content, photosynthetic active radiation, evaporation, evapotranspiration, and leaf wetness. The data collected by the newly implemented network will be used by many government and non-government organizations for the purposes of flood warning, stormwater management modelling, climate documentation, judicial evidence (e.g. municipal infrastructure failure modelling), and public education.

One of the climate stations already installed is a Bowen Ratio Energy Balance (BREB) system. The BREB station is installed at the Kortright Conservation Area in collaboration with York University. The BREB station allows for hourly micro-meteorological assessment of evaporation, a critical component of water budgets which has not yet been refined specifically for TRCA watersheds. This will provide a better understanding of the factors generating floods, the factors contributing to plant stress and will provide a means of measuring photosynthesis and respiration and thus the net contribution of the local environment to the regional carbon budget.

One of the new climate stations to be installed in the spring will be equipped an anemometer (wind sensor) capable of measuring wind eddy covariance (vertical turbulent fluxes within atmospheric boundary layers). This new station is owned by the University of Guelph and operated by the TRCA. The station will be located in Richmond Hill and will provide eddy covariance data for a two-storey residential area which will help improve TRCA's modelling activities (e.g. climate).

The TRCA currently monitors snow at ten sites under the RWMP. The sites were originally selected to give a representative assessment of the snow

characteristics across the GTA. Data collected at these sites includes snow depth, water equivalent, snow density, snow crust, and underlying soil condition. The data is submitted to the Ministry of Natural Resources (MNR) where it is archived and published bi-weekly during the winter months.

The data collected by the water quantity component of the RWMP is used for TRCA's flood warning system (separate program but supported by RWMP data). This is a scaleable flood warning system that includes web-based data and video. Data is delivered via a cellular communication-based network to a base station computer at the TRCA's main office. The system integrates automated remote water level measuring equipment with the rain gauge system. There is a real-time, web-based decision support system including a warning or call-out system based on sensor and station attributes. This system is an integral part of the TRCA's flood warning program.

For each component of the flow and precipitation monitoring program, the network has achieved or exceeded the targeted number of monitoring sites.

Flow and Precipitation

Current Status

- 54 stream flow stations throughout the TRCA's jurisdiction, 32 of which are operated in partnership with Water Survey Canada
- 10 snow pack monitoring sites
- 32 precipitation monitoring gauges
- 5 climate stations added in 2008

Gaps/Opportunities

- Improved climate monitoring including evaporation, soil moisture/temperature, solar radiation, etc.

2.2.5 Groundwater Monitoring

To date, the TRCA has not completed a discussion paper for groundwater monitoring specific to the RWMP. Currently, the RWMP is collecting groundwater data in the Toronto area as part of the Provincial Groundwater

Monitoring Network (PGMN) established by the MOE. The PGMN is a partnership program between the MOE and Conservation Authorities to collect and manage ambient (baseline) groundwater level and quality information from key aquifers located across Ontario. In general, the MOE is responsible for establishing the monitoring network and the associated information system, program coordination, data analysis and reporting, maintaining the information system and technology transfer and training. TRCA, through the RWMP, is responsible for the field operations including maintaining field equipment, collecting water level data and water quality samples, and data analysis and reporting on a local level. Information generated by the PGMN provides vital baseline data for the development and implementation of water management programs and activities such as source protection plans, nutrient management plans, assessing applications for water takings, drought response decisions, and resolving groundwater interference complaints.

Groundwater monitoring is not typically conducted on a watershed basis, rather, it is based of the aquifer system which is typically composed of multiple water-bearing units that underlie the ground surface, often extending outside watershed boundaries. There are 22 wells in 14 locations in the TRCA's jurisdiction with at least six wells in each of the three regional aquifers (Oak Ridges, Thorncliffe and Scarborough). Manual water level data is collected at least twice per year. Each well is installed with a continuous water level logger which measures the water level on an hourly basis. Telemetry equipment has been installed at 18 of these sites, which allows for remote downloading of data. The remaining sites were deemed unsuitable for telemetry installation and as a result data from these wells are downloaded manually.

Water quality samples are collected once per year, in the autumn. The water quality sampling program was initiated in a limited number of wells in 2003 but was discontinued in 2004 due to changes in Regulation 903 under the Ontario Water Resources Act that limited access to wells to licensed water well technicians. The installation of dedicated pumps and changes to Regulation 903 allowed the water quality sampling program to be reinstated in 2006. When well water quality sampling reveals a health-related risk, a protocol for follow-up action must be followed.

The *Interim Watershed Characterization Report* (TRCA 2007d) was completed as part of the Source Water Protection program. This report identified the physical and human characteristics of TRCA's watersheds, summarized the current understanding of groundwater and surface water flows, provided a summary of the current knowledge of groundwater and surface water quality, identified potential threats to water quality and identified data gaps with respect to Source Water Protection. The report states that the current groundwater monitoring network is inadequate. "Although there is not a scientific formula to deduce the optimal number of wells, with eight hydrogeological layers and three regional aquifer systems in the groundwater model, the existing network is clearly insufficient to assess groundwater flow paths and trends. Even having one well per layer per watershed would require over 70 wells, which would require tripling of the size of the network." As the Source Water Protection work continues, the RWMP will consider the recommendations made to improve monitoring of groundwater in the Toronto Region.

Groundwater

Current Status

- Groundwater quality and quantity is monitored at 22 wells across 5 watersheds (Provincial Groundwater Monitoring Network)

Gaps/Opportunities

- Mimico Creek, Highland Creek, Carruthers Creek, and Petticoat Creek watersheds do not have any groundwater monitoring
- Current monitoring program is inadequate for assessing groundwater flow paths and trends in the Toronto Region

Recommendations:

2.2.6 Air Quality Monitoring

To date, the TRCA has not completed a discussion paper with regards to air quality monitoring nor has an air quality monitoring program been initiated. The MOE, a participant in the Toronto monitoring network, conducts an air quality monitoring program. Six key air pollutants are monitored by the MOE as part of the program: sulphur dioxide, ozone,

nitrogen dioxide, total reduced sulphur compounds, carbon monoxide and fine particulate matter. These six pollutants were chosen because, at high levels, they have an adverse effect on humans and the environment. The air monitoring data are sent to a computer centre at the MOE. Data are compared to ambient air quality standards for each of the six air pollutants. These scientifically-based standards, which are updated from time to time, indicate the maximum safe level for a pollutant. Above this level, the pollutant begins to have an undesirable impact on people and the environment. The monitoring data are converted into the Air Quality Index (AQI) scale which is a rating system for outdoor air in Ontario. The AQI scale ranges from 0-15 (very good) to 100+ (very poor). An AQI is calculated for each of the six pollutants. The pollutant with the highest AQI number has the greatest impact. It becomes the "overall" AQI for a particular location. For example, the AQI for ozone is 20, and this happens to be the highest out of the six pollutants. It is therefore reported as the overall AQI (e.g. "AQI of 20, reason: ozone"). Air quality is monitored in at least six locations in the Toronto region surrounding area including: Toronto East, Toronto North, Toronto West, Toronto Downtown, Brampton and Mississauga. To date, the MOE's air quality monitoring program is sufficient for TRCA's reporting purposes.

Air Quality Monitoring

Current Status

- RWMP does not have an air quality monitoring component
- Air quality monitored by the Ministry of the Environment

Recommendations

3. Stress/Pressure Monitoring and Response/Management Indicators and Protocols

Stress/pressure indicators describe human activities and natural processes that impact, stress or pose a threat to environmental quality. Monitoring stress/pressure indicators can help make management decisions such as actions to

Stress/pressure indicators describe human activities and natural processes that impact,

halt impacts or remediate degraded conditions. The challenge is to identify fundamental stresses that could act as indicators in the condition-stress-response framework.

Examples of stress/pressure indicators were listed in the original development document and include:

Land use:

- Percent impervious surface
- Upstream and/or surrounding (matrix influence) land use
- Trail density
- Traffic density/extent of automobile usage
- Percent impervious surface

Urban Stormwater Runoff/ Sewer Outfall Discharges:

- Number/ volume of Combined Sewer Overflows (CSOs)
- Outfall water quality
- Landfill leachate quality
- Sewage treatment plant effluent quality
- Number, substance, distribution of permitted discharges

Agriculture Runoff:

- Area
- Crop Type
- Presence of livestock

Spills:

- Substance, location, frequency

Water Taking:

- Volume withdrawn and as a percent of available water
- Distribution of permitted water taking permit holders

Climate Change:

- Trend over time in precipitation
- Mean annual water temperature
- Extreme storm events

Response/management indicators include individual and collective actions to halt, mitigate, adapt to, or prevent damage to the environment. They also include actions for the preservation and conservation of the environment and natural resources. Examples include education, regulation, technology changes, etc. It is important to link the response/management indicators back

to the stress/response indicators within the condition-stress-response framework. The original discussion document listed the following management activities which are linked to the stress indicators listed above:

Response/management indicators include actions to stop, mitigate, adapt to, or prevent damage to the environment as well as actions for the

- Stormwater management, both quality and flow
- Sewer bylaw enforcement
- Spills response and spills control
- Agricultural/environmental farm plans
- Protection of stream corridors and adjacent lands
- Planting woody riparian vegetation
- Removal or alteration of in-stream barriers
- Limiting greenhouse gas emissions
- Education

TRCA along with various network participants are currently monitoring or are involved with many of the stress/response and response/management indicator activities listed above. Standard sampling protocols for both stress/pressure indicators and response/management indicators were not outlined in the original development document and have not yet been developed. It is recommended that the list of indicators and protocols be developed to complete the condition-stress-response monitoring framework.

4. Opportunities for Public Involvement

The original development paper discussed various opportunities for the public to help monitor their local environment. This approach has the advantage of empowering the people directly connected to their local environment to act as stewards within their neighbourhood. The monitoring data collected by volunteers is intended to be used to detect or highlight potential problems that may require further study.

4.1 Terrestrial Natural Heritage

The *Terrestrial Volunteer Monitoring Program* (TVMP) is an extremely successful initiative where volunteers monitor the presence/absence of indicator flora and fauna species at fixed sites throughout the TRCA jurisdiction. Citizens volunteer their time for training and data collection, while private landowners participate by allowing surveys to occur on their properties.

The present program varies from the discussion document that suggested monitoring twice every five years. Currently, 66 ten hectare sites located in natural cover areas on both public and private lands are monitored annually. Monitoring data are collected during ten site visits distributed throughout all four seasons each year. Volunteers work in pairs, with each survey visit's protocol focusing on a subset of the total indicator species list. The TRCA facilitates training and discussion of natural history and conservation within local watersheds, and coordinates field trips focusing on indicator species and habitats.

As a citizen science based project, the TVMP was designed to allow a high level of confidence in the validity of the data collected. Key elements include:

- required seasonal training for all volunteers, specific to the species and protocol for that season;
- the degree of ease with which volunteers could find and identify species included as a consideration in the indicator selection process
- a set of characteristics for each species (primary, secondary, tertiary) to be checked on data sheets as volunteers record each observation, to inhibit erroneous recording of similar looking or sounding species
- standardized observation protocols, visual and audio aids
- rigorous data quality assurance

Key accomplishments include the development of a web-based data entry system for volunteers, the creation of automated data validation matrices to assist in both the standardization and processing of data and completion of a report on the first 5-years of data (TRCA 2008). Results were compiled from all sites to evaluate overall indicator species richness (the number or percent of indicator species found) as well as species richness for subgroups within

The Terrestrial Volunteer Monitoring Program completed a 5-year review of the data collected from 2002-2007. Results include:

- Indicator species data collected at fixed plots since 2002
- Urban areas had lower species diversity than rural and urbanizing areas
- Indicator Species of Conservation Concern

the indicator species list (e.g. jurisdictional Species of Conservation Concern, amphibians (frogs/toad), breeding birds, flora, and lichens). The data for sites were grouped by land-use zone (urban, urbanizing and rural) and by major habitat type (forest, wetland, meadow). Not surprisingly for an urban and urbanizing region, the terrestrial ecosystem showed a considerable difference from the rural areas. The indicator species richness mean (average) for the region was 39%. In a fully functional system comprised of native forest, wetland and meadow habitat, this number would be much higher. The indicator Species of Conservation Concern group demonstrated a low species richness averaging 6 of a possible 28 species. The indicator amphibian group mean was 3 of a possible 8 species found. Breeding birds averaged 4 of a possible 14 species, and the porcupine was found on just 6% of sites. In the past, this species would have been widespread in the region's forests. Analysis of change over time and investigation of temporal trends will be conducted once 10 years of data has been collected. Recommendations from the report include monitoring populations of northern leopard frog and developing a simple invasive species monitoring protocol element to be incorporated into the volunteer monitoring program.

The Terrestrial Volunteer Monitoring Program continues to be an extremely valuable contributor to the TRCA's data collection efforts. The quality of the data is evident both during the quality assurance process and through the analysis (TRCA 2008b). The quantity of data collected is clearly much higher than could be achieved at reasonable cost using staff field teams. The opportunity for interested community members to participate and build their knowledge of the terrestrial ecosystem and biodiversity issues is an added benefit. Multiple volunteers, particularly students and recent immigrants with an environmental background, have progressed from participating in

the terrestrial monitoring program to employment within the environmental sector, some of them with TRCA.

4.2 Aquatic Habitat and Species

The development document suggests three areas where volunteers may be able to help monitor aquatic habitat and species: collection and identification of benthic invertebrates, stream temperature monitoring and identification of spawning trout/salmon locations. Although these parameters can be relatively easy to monitor by volunteers, the detail of the data collected by volunteer monitoring programs is often not enough to decipher small changes. It is the smaller changes that may indicate that an area is starting to decline, allowing water resource managers the opportunity to attempt to address the issues before dramatic changes occur. Most benthos volunteer monitoring programs use stream surveys whereby benthic invertebrates are collected and then identified in the field. Stream surveys usually lump together large groups of organisms (e.g. whole orders) into a single pollution-sensitivity category. While this compromise may be necessary for a simple field method that volunteers with relatively little training can complete, it reduces the reliability of the assessment. For example, pollution sensitivities among mayflies, for example, vary from very sensitive to very tolerant. Further identification of benthos (i.e. to family level) requires a lab and microscope, extensive training and a large investment of time. Therefore, stream surveys are useful to identify high-quality sites and very degraded sites, but their resolution is generally too low to distinguish among sites of intermediate quality. Therefore, the RWMP has elected to use staff to collect and identify benthic macroinvertebrates.

The RWMP works with volunteer organizations to introduce monitoring techniques such as:

- Invertebrate collections
- Basic water chemistry

The RWMP has helped several volunteer groups with aquatic monitoring activities in the past. In 2008, the RWMP began developing the Aquatic Volunteer Monitoring Program (AVMP) with the intent to start the program to the community in the spring/summer of 2009. The goal is to develop formal reference materials which can be used by individuals or groups to monitor

local streams. The details of the program have not yet been finalized but may include water temperature monitoring and trout/salmon spawning monitoring. Water temperature is also a relatively easy parameter for volunteers to monitor. Volunteers can conduct synoptic surveys with simple, inexpensive thermometers (e.g. stream temperature recorded at a particular time). In recent years, the cost of continuous temperature loggers has reduced significantly. These devices can be placed in the water and record water temperature at set intervals (e.g. hourly) for long-periods of time. In addition, trout/salmon spawning is relatively easy for volunteers to monitor. There are several trout/salmon spawning monitoring programs in the United States (e.g. South Fork Boise River (Idaho), Mill Valley Stream Watch (California)) that use volunteers to monitor redds (fish nests). Volunteers are instructed on redd identification and are provided with a GPS unit, thermometer, metre stick and field sheets. Volunteers usually provide their own digital camera, boots/waders and polarized sunglasses. Volunteers walk streams and record possible redds locations. Additional information including water clarity, weather, temperature, stream flow conditions are recorded. The redds are measured for approximate width and depth. This data is sent to the managing biologist over the internet (e.g. email, dedicated website) who has the opportunity to verify the redds using the photographs or in the field using the GPS coordinates provided by the volunteers. This type of monitoring could expand the knowledge of trout/salmon spawning in the Toronto area, especially in areas such as private property which are not regularly accessed by TRCA staff. This type of monitoring may be particularly helpful in the efforts to restore Atlantic salmon to the Greater Toronto Area.

4.3 Water Quality

The discussion document outlines the use of supplementary water quality monitoring such as university research, golf course water testing, special project monitoring by consultants or municipalities and school/classroom monitoring activities. Since supplementary monitoring activities tend to focus on a sub-watershed scale or a smaller site-specific scale, it could help to address localized data gaps. In order for this data to be useful, a comprehensive database would need to be created to house not just the data but detailed information about why the data was collected. To date, the

TRCA continues to upgrade the water quality database that it uses to house the RWMP data. The database does not house any supplemental water quality information but changes to this database should be explored to determine if the database is feasible for the housing of additional water quality data.

The RAP identified the aesthetic conditions in Toronto's streams and on its waterfront as one of the "impaired beneficial uses". In October 2001 and 2002, the RWMP used volunteers to conduct an aesthetics survey (TRCA 2003b). Drawing upon a method developed for the Rouge River Area of Concern in Michigan, the survey evaluated aesthetic conditions based on four indicators: water colour, water clarity, water odour and the presence of visible debris and litter. Each of the indicators was scored separately (out of 10) and the average of the four indicator scores provided the overall site score. Although useful in determining areas that needed further investigation, the results between the two years were highly variable. It was recommended that TRCA staff participate in the subsequent aesthetic surveys to improve the geographic distribution of surveys, reduce variations associated with sampler bias and inconsistent application of survey methods, and permit observation and measurement of a larger range of variables influencing aesthetics ratings. To this end, aquatic RWMP staff note aesthetic problems while they are conducing their regular field work. A standardized data sheet has not been created but should be considered for incorporation into the regular field program.

The MOE continues to run the *Lake Partner Program*. The Lake Partner Program is a province-wide, volunteer-based, water-quality monitoring program. The goal of the Lake Partner Program is to protect the quality of Ontario's inland lakes by involving citizens in a volunteer-based water quality monitoring program. Volunteers collect total phosphorus samples and make monthly water clarity observations on their lakes. This information will allow the early detection of changes in the nutrient status and/or the water clarity of the lake due to the impacts of shoreline development, climate change and other stresses. A number of inland lakes in the Toronto region have been monitored sporadically by this program including Claireville Reservoir, Heart Lake, Palgrave Mill Pond, G. Lord Ross Reservoir, Lake Wilcox and Grenadier Pond. Further efforts should be made to encourage

volunteers to participate in this program as many ponds in the Toronto Region are not routinely monitored.

5. Implementation and Reporting

> "In order to implement the proposed monitoring program, a watershed monitoring network has been recommended. A monitoring network relies on the strengths and expertise of the network partners. By participating in a monitoring network, partners would make more efficient use of resources by focusing their efforts, eliminating overlap, and relying on other partners in the network to provide information for which they have expertise.
>
> To implement the proposed monitoring network, three key issues will need to be addressed:
> - commitments to continue existing monitoring activities and undertake new proposed activities
> - funding support for the recommended monitoring activities that extend beyond existing activities
> - agreements on data storage, data sharing and reporting
> - coordination of monitoring network." (TRCA 2000a)

Most of these issues have been touched upon throughout this review but are summarized briefly discussed in the following sections.

5.1 Monitoring Commitments

> "A key objective of this project is to develop an efficient monitoring program by building on existing monitoring activities." (TRCA 2000a)

To date, all monitoring activities that were discussed in the initial development papers continue to function as intended. Subtle changes, such as the agency responsible for collecting the data in the field, may have changed but the overall program continues. New programs, including the

TRCA's West Nile Monitoring Program, have been added to the network since its inception.

5.2 Funding Sources

Funding for the RWMP comes from a variety of sources. Monetary funding is or has been received in the past from the following contributors:

- City of Toronto
- York Region
- Peel Region
- Durham Region
- Ontario Ministry of the Environment
- Toronto Remedial Action Plan
- York University

In-kind funding has been provided by:

- Ontario Ministry of the Environment (e.g. laboratory analysis)
- City of Toronto (e.g. laboratory analysis)
- University of Toronto (e.g. taxonomic identification of algae)
- Guelph University (e.g. climate monitoring equipment)

Support (e.g. technical advice, equipment, data, etc.) for the RWMP program has been provided by:

- Ontario Ministry of Natural Resources
- Ontario Ministry of the Environment
- Fisheries and Oceans Canada
- University of Toronto
- York University
- Guelph University

5.3 Reporting

RWMP data has been used for:

- Remedial Action Plan (RAP) reports
- Municipal State of the Environment Reports

The RWMP program provides the underlying scientific data that informs the key planning and reporting mechanisms of the TRCA. The data collected by the RWMP also helps TRCA planners and ecologists make informed decisions. RWMP data has been used to complete or to help with the review of the projects listed (non-exhaustive) in Table 9.

The original discussion document suggests that "annual reports on the status of the network and monitoring activities would be prepared for review and input by a larger audience including the public". A report was completed to document the first year of the RWMP (TRCA 2001) monitoring network but reports were not competed for subsequent years (2002-2006). A report on 2007 RWMP activities (TRCA 2008a) was recently finalized. Annual reports on what is being monitored by other members of the network as well as the RWMP would be beneficial to all network participants. Analysis of ten years of data from the RWMP is scheduled for 2010. Results will be reported in conjunction with the Living City Report Card scheduled for release in 2011.

In addition to the reporting outlined in the development document, Conservation Ontario has also suggested that a State of the Watershed Report (also known as a Watershed Report Card) be completed every five years. Watershed Report Cards summarize the health of the watershed based on key environmental features such as surface water quality, natural cover (e.g. forest

cover), etc. The data collected by the RWMP is essential to the completion of these reports.

Table 9. Representative TRCA Programs, Projects and Reports Supported by RWMP data

Watershed Report Cards & Implementation Guides	
· Humber River (TRCA 2007a, 2008c)	· Duffins & Carruthers Creeks (TRCA 2003c)
· Etobicoke & Mimico Creeks (TRCA 2006a)	· Rouge River (TRCA 2007c, 2007e, 2008d)
· Don River (2007f)	
Fisheries Management Plans	
· Humber River (MNR & TRCA 2005)	· Duffins & Carruthers Creeks (TRCA 2004)
Remedial Action Plan	
· RAP Progress Report 2001-2006 (TRRAP 2008)	· Toronto and Region RAP Progress Report 2006 – Degradation of Benthos (internal)*
Water Quality	**West Nile Virus**
· Water Quality Summary Report for the Toronto Region 1996-2002 (TRCA 2003a)	· Annual Report on West Nile virus Vector Status in Toronto and Region Conservation Wetlands & Stormwater Management Ponds (TRCA 2006b, 2006c, 2007f)*
Land Management	
· Cold Creek Conservation Area Management Plan	· Claireville Management Plan
Source Water Protection	
· Drinking Water Source Protection Plans	· Interim Watershed Characterization Report
Terrestrial Inventories	
· West Gormley Lands Study Area: Terrestrial Biological Inventory and Assessment*	· Centennial Park Study Area: Terrestrial Biological Inventory and Assessment*
Project Review	
· Restoration project review	· Land development review
Regional Reports	
· Regional Watershed Monitoring Program Progress Report (TRCA 2001, 2008a)*	· Dog-strangling Vine -*Cyanchum rossicum* (Kleopow) Borhidi: A Review of Distribution, Ecology and Control of this Invasive Exotic Plant (TRCA 2008e)*
Benthic Invertebrates	
· Report on the condition and changes in the benthic invertebrate community for the Humber watershed 2002-2004 (TRCA 2005)*	· Report on the condition and changes in the benthic invertebrate community for the Etobicoke-Mimico watersheds (TRCA 2006a)*

· An evaluation of rapid bioassessment protocols for stream benthic invertebrates in Southern Ontario, Canada* (Borisko et al. 2007)	
Other	
· The Visual Aesthetic Condition of Watercourses in the Toronto Region based on the Results of Two Pilot Community-based Visual Aesthetics Surveys (TRCA2003b)*	· Effects of a Chemical Spill on the Fish Community within the Rouge River, Markham Road Tributary*
· Etobicoke Headwaters Subwatershed Study	· Terrestrial Volunteer Monitoring Program Results 2002-2007 (TRCA 2008b)*

*Reports produced by the Watershed Monitoring and Reporting Section

The RWMP has also commissioned several reports from various consulting firms to help plan the monitoring program and/or analyze some of the data. Examples of these reports include:

- Benthic Community Monitoring Program: Toronto Area Watersheds 2001 (Golder Associates 2001)
- Regional Monitoring Program – Fluvial Geomorphology Component (Parish Geomorphic 2002, 2003, 2004)
- A Priori Power Analysis for Toronto and Region Conservation Authority's Regional Watershed Monitoring Program (Zorn 2008)

5.4 Utility of the RWMP to Other Initiatives and Partners

RWMP data is used by a variety of organizations, such as those listed in Table 9. Additional information about specific programs such as the Toronto Remedial Action Plan (RAP) is provided in the following sections.

Table 10. Representative External Projects Supported by RWMP Data

Municipal State of the Environment Reports	
• York Region State of the Environment Report (York Region 2005)	• Peel Region State of the Environment Report (in progress)
Municipal Projects	
• Ajax/Durham Waterfront Water Quality Study	• Region of Peel Road Salt Management Plan
• York Region North Yonge Street Corridor Public Transit Improvement Project	• York-Durham Sanitary Sewer Dewatering and Environmental Monitoring
• City of Toronto Don River Combined Sewer Overflow Project	• City of Vaughan Black Creek Stormwater Optimization Study
• City of Toronto Highland Creek Geomorphic Master Plan	• City of Toronto Coronation Drive Natural Heritage Review
• Peel Natural Areas Inventory Project	• Toronto Wet Weather Flow Management Master Plan
• City of Toronto Highland Creek Trunk Sewer Repair Project	• York Region Caledon East Water Supply Class EA
• York Region Humber River Assimilative Capacity Study in support of the Kleinberg Water Pollution Control Plant Expansion Class EA	• York Region Nobleton Sewage Treatment Plant Design and Implementation
• Vaughan Official Plan	• Region of Peel Official Plan Update
Research	

• University of Toronto Ph.D. thesis: Use of diatom algae as biological indicators for assessing and monitoring water quality of rivers in the Greater Toronto Area, Canada (Zugic-Drakulic 2006) •	• York University M.Sc. thesis: Investigating the riffle-pool/meander link: a comparative analysis of horizontal and vertical undulations in stream channel morphology (Lofthouse 2007)
• University of Toronto research project to predict the fate of urban sourced contaminants in Toronto groundwater	• University of Toronto research project to develop new predicative models for Ontario's imperiled freshwater fishes
• Using a Landscape Approach to Identify the Distribution and Density Patterns of Salmonids in Lake Ontario Tributaries (Stanfield & Gibson 2006)	• Effects of Impervious Cover on Fish and Benthos Assemblages and Instream Habitats in Lake Ontario Tributaries (Stanfield & Kilgour 2006)
Other	
• Seaton Lands Aquatic Assessment	• Redside Dace Species at Risk Index Sites
• Area-Sensitive Forest Birds in Urban Areas (Environment Canada 2007)	• Greater Toronto Airport Authority Integrated Water Management Study Pickering Lands

5.4.1 Toronto RAP

The indicators and measures of the RWMP address many of the concerns outlined by the International Joint Commission (IJC) for the Toronto Region Area of Concern (AOC). Table 4.11 in the development document lists 14 indicators used to address the condition of the impaired uses outlined by the IJC. The data collected by the RWMP provides the data for 9 of the 14 indicators. Two of the indicators not covered by the routine monitoring of the RWMP involve tumours or other deformities of fish, birds and animals. In 2003-2004, TRCA conducted a specific study to investigate the occurrence of fish tumours which found that the incidence and frequency of tumours are reduced in the TRCA's jurisdiction over previous findings. In 2004, studies conducted by TRCA and Canadian Wildlife Service began for to look at the bird/animal deformities and reproduction issues. The remaining three indicators (restrictions of drinking water consumption, tainting of fish/wildlife flavour, and added costs to agriculture or industry) were deemed not impaired and therefore do not need to be monitored on a regular basis.

5.4.2 Conservation Ontario

Conservation Ontario is the umbrella organization that represents Ontario's 36 Conservation Authorities. Conservation Ontario developed "A Guide to Watershed Reporting" in 2002 which outlines methods for facilitating and standardizing the watershed reporting with the suggestion that State of the Watershed Reports should be completed every five years. The guide focuses on

the use of environmental indicators in measuring watershed health and attempts to balance the public's demand for understandable environmental information with the need to ensure scientific accuracy and confidence in data interpretation. Conservation Ontario suggests monitoring the following indicators: forest cover, forest interior, benthic invertebrates, phosphorus, bacteria (*E. coli*), chloride, and nitrates. Each of these indicators is currently monitored by the RWMP.

5.4.3 Municipalities

An Official Plan (OP) is a statutory document which sets out land use policy directions for long-term growth and development in a municipality. It reflects a community vision for future change and development. An OP contains policies governing various land use designations, such as Residential, Commercial, Industrial, Agricultural and Open Space and Recreation. OPs can also contain other policies which relate to environmental management. For example, the RWMP data collected is used to update OPs. For example, The City of Vaughan (city within York Region) is currently undertaking a three-year project to update their OP. Vaughan is quickly urbanizing and there is need to identify green spaces that will be part of the City.

Municipal State of the Environment (SOE) reports have also used or are currently using RWMP data to develop their SOE reports. SOE reports comment on the condition of the environment, the major environmental issues being faced in the municipality, identifies what the municipality is doing and what they should be doing to monitor and improve the environment. SOE reporting can provide early warning and analysis of potential problems for the environment, allows the public to monitor progress towards the achievement of the objectives, and provides baseline information for environmental planning, assessment and regulation. The first series of Peel Region's SOE reports were issued between 1995 and 1998 and are currently being updated. York Region recently completed an update to their original SOE report (York Region 2000, 2005). The York report is based on indicators for land, water and air. Under Section 7.5 "Better Able to Monitor and Measure Progress" (York 2005), it is noted that:

> "One of the greatest differences noticed while developing the SOE 2005 Report is the substantial improvement that has been made in the Region and elsewhere in information collection and analysis since 2000. This has resulted in a dramatic improvement in our ability to assess the status of the environment and to measure changes since the SOE 2000 Report...Examples of improved expertise include...TRCA's Monitoring Programs provide annual data on water quality, river flows and the health of aquatic systems...comparability of data from various sources (TRCA and LSRCA) has also improved..." (York Region 2005)

The Greening Greater Toronto Initiative by the Toronto City Summit Alliance (TCSA) is a new program with the objective is "to make the GTA the Greenest City Region in North America" (TCSA 2008). More than 100 partners from corporations, industry, government and the non-profit sector have joined forces to improve the environmental health and future of the Greater Toronto Area and make it the greenest city region in North America. Greening Greater Toronto was created in response to the 2007 TCSA's call for a regional environmental vision and plan that will build upon the existing efforts and leadership of environmental organizations, governments, research institutions and businesses. The Greening Greater Toronto Initiative sets out five environmental goals: 1. reduce carbon/greenhouse gas emmissions, 2. clean air, 3. clean water, 4. reduction and effective management of waste and 5. sustainable landuse and expanded greenspace. The TCSA "will partner with appropriate organizations in the region to ensure continuous measurement and monitoring of these indicators". The RWMP program will play an essential role in monitoring the "clean water" component of the program which includes water quality and baseflow monitoring.

In addition, the RWMP works closely with municipal governments in conjunction with the West Nile Virus monitoring program. Vector mosquito surveillance is undertaken by the Health Units from the Regions of Durham, Peel, York and the City of Toronto. TRCA has been playing an important role by conducting mosquito larval surveillance and monitoring of selected wetlands and stormwater management ponds on TRCA property complimenting work being completed by the Regional Health Departments.

For the past two years (2007, 2008), the RWMP's entomologist has conducted a larval mosquito identification workshop for Health Department staff.

5.4.4 Federal and Provincial Agencies

Data collected by the RWMP has been used by various federal and provincial agencies. Water quality data collected by the RWMP has been used by the Environment Canada to investigate pesticides in waterways. The RWMP continues to work closely the Ontario Ministry of the Environment (MOE). Currently, the RWMP collects water samples for both the Provincial Water Quality Monitoring Network and the Provincial Groundwater Monitoring Network operated by the MOE. The RWMP is currently conducting an algae sampling study in conjunction with the MOE to determine if algal sampling should be added to the suite of biomonitoring activities currently being monitored by the RWMP. For the past two years, RWMP staff has conducted the Ontario Stream Assessment Protocol workshop on behalf of the Ontario Ministry of Natural Resources (MNR) and work closely with the MNR District staff regarding yearly fish collections. RWMP continues to foster relationships with federal and provincial staff through the contributions to various committees such as the Redside Dace Recovery and the Lake Ontario Modelling Team. This includes data contributions to two recently published scientific journal articles (Stanfield & Kilgour 2006, Kilgour & Stanfield 2006).

5.4.5 Educational Institutions

The RWMP has facilitated mutually beneficial relationships with various educational institutions in the Toronto area. For example, RWMP staff worked closely with York University and Citizens' Environment Watch (a volunteer environmental organization) to develop "Juturna", an internet-based water quality reporting system (for additional details please refer to Section 6.1.2). RWMP staff have also worked closely with the University of Toronto and the Ontario Ministry of the Environment to develop algal biomonitoring for the Toronto area. In addition, RWMP has been supplied to students and researchers at local colleges and universities for several research projects.

6. Data Management and Network Coordination

6.1 Data Management

> "The monitoring network is based on the principle of cooperation between partners. Each partner in the monitoring network is responsible for carrying out their role in the proposed monitoring program...Some partners are actively involved in collecting, analysing and reporting on monitoring data while many rely on the availability of data and the interpretation provided by others. Since all partners require at least a subset of the pool of data provided by the monitoring network, agreements on data storage, and data sharing will be of paramount importance."

> "The level of cooperation necessary to make the monitoring network a success will require a significant level of coordination. To facilitate the development of the network it is recommended that an advisory committee be established, drawing membership from the potential partners. The activities of the advisory committee would be coordinated by the TRCA and its role would be to establish the necessary agreements to develop the network and oversee implementation. Annual reports on the status of the network and a meta database outlining the monitoring activities being carried out by each partner would be principle products of the advisory committee."

To date, the monitoring network has been based mainly on cooperation between agencies rather than formal agreements. This collaborative effort appears to be working thus far. In most cases, the agency that collects the data has been responsible for the data management. Information is shared freely between participating agencies on an as requested basis.

6.1.1 RWMP Databases and GIS

The TRCA has developed several database systems for storage of data from the RWMP. RWMP site locations are stored in a GIS database. Other data is stored in separate databases such as:

Envirobase

In 2001, the TRCA contracted a consultant to develop a relational database, Envirobase, to house all of the various environmental data collected through the RWMP (e.g. site location data, water quality results, etc.) as well as other programs of the TRCA. This relational database also has the ability to link various data sets that are currently available. In subsequent years, updates to the relational database have been completed to include the addition of a sediment quality and fluvial geomorphology component.

Currently, the water quality portion of the database is actively being used. By the end of 2008, the benthic invertebrate portion of the database will also be populated with data. Efforts are being made to populate the other components of Envirobase with data and to link stand-alone databases to the Envirobase (e.g. stream gauge database, West Nile Virus, etc.) by early 2009. TRCA's in-house database manager has made additional customizations to Envirobase including user-friendly interfaces, routine queries and easier data entry; making the database an invaluable resource to TRCA staff. Changes to the corporate network structure (e.g. upgrading to structured query language (SQL) which is a standard language for querying and modifying data and managing databases) in the near future will enable more effective sharing and use of the relational database by TRCA staff. Future plans include making the database web-based for easier access by network participants and other outside agencies.

Juturna

The Juturna project focused on the development a web-based data assessment and reporting system to support the TRCA's RWMP. The project evolved out of a partnership initiated in 2001 between TRCA, York University and Citizens' Environment Watch (an environmental non-government organization housed at the University of Toronto). At that time, a similar but smaller scale data

system called MapReflections was developed primarily for community monitoring data. The success of this initial project demonstrated the value of the partnership and the potential for expanding the work to more closely meet the objectives of the RWMP. For this pilot project, the geographic scope for this pilot project was the Humber watershed. The purpose of this pilot project was to demonstrate how biological monitoring and abiotic data can be presented in a geographic context to facilitate the sharing of watershed monitoring data with civic, scientific and political stakeholders. Four indicators of stream quality are provided to the users: Fish Index of Biotic Integrity, Benthic Invertebrate Aggregate Assessment, Thermal Stability and Basic Water Chemistry. These indications are based on the data collected under the Regional Watershed Monitoring Program. The monitoring data is "rolled-up" to provide an overall stream condition that can be readily understood by the general public. Data provided through this website is also available in a raw format where users can conduct their own analyses. Currently, the TRCA's involvement in the Juturna project is on hold as TRCA explores other larger scale initiatives with other partners (e.g. OSIS; see Section 6.1).

Terrestrial Volunteer Monitoring Program Database

A Microsoft Access database with web-entry capabilities was created specifically for the Terrestrial Volunteer Monitoring Program. The database allows for survey dates, times, environmental data, and species observation data via an internet portal. The database has built in data validation model which assists with quality assurance and quality control of the data entered by the volunteers. The data validation module compares data to a series of templates for survey protocol, habitat types present on sites, and species observation characteristics. Data that do not fully conform with template parameters are flagged for a manual staff review. The standardized manual process includes reviewing data comments, photos and/or samples, direct communication with the observer and, where necessary, a site visit to attempt to verify an observation.

6.1.2 Contributions to Other Databases

The RWMP also contributes data to several large-scale databases and models which extend outside the TRCA's boundaries.

Provincial Groundwater Monitoring Network (PGMN)/Provincial Groundwater Monitoring Information System (PGMIS)

The Provincial Groundwater Monitoring Information System (PGMIS) is a web-driven application operated by the MOE. As part of Ontario's Provincial Groundwater Monitoring Network (PGMN), PGMIS enables the MOE and its partners in the PGMN to monitor groundwater conditions in the province. The information from the PGMN will provide an early warning system for changes in water levels caused by climatic conditions or human activities as well as changes in water quality from natural or anthropogenic causes. The information is used to support informed decision-making on water-takings, drought management and land use planning. TRCA supplies the data collected in the field (e.g. water levels, insitu water quality) to the MOE for uploading into the PGMIS. The water levels recorded by the data loggers are accessed via telemetry by the MOE.

Provincial Water Quality Monitoring Network (PWQMN)

The Provincial Water Quality Monitoring Network (PWQMN) collects surface water quality information from rivers and streams at close to 400 locations across Ontario. TRCA collects 11 number of water quality samples on behalf of the MOE. Information generated by the PWQMN supports the development and implementation of water protection programs and activities such as source protection plans, nutrient management plans, assessing applications for water takings and setting water quality standards.

HABPROGS

HabProgs is an Access database that currently holds stream data collected using the Ontario Stream Assessment Protocol (OSAP; Stanfield 2005). The HabProgs database stores data on a variety of stream indicators such as fish species/biomass/density, benthic macroinvertebrates and local habitat features. TRCA supplies the aquatic RWMP data collected using the OSAP

protocol to the MNR for inclusion in the HabProgs database. Using this information, the database is designed to evaluate landscape conditions on the distribution and abundance of salmonids in Great Lakes tributaries.

Natural Heritage Information Centre (NHIC)

Data from the Terrestrial Monitoring Program is provided to the Natural Heritage Information Centre (NHIC) operated by the Ontario Ministry of Natural Resources. The NHIC compiles, maintains and distributes information on natural species, plant communities and spaces of conservation concern in Ontario. This information is stored in a spatial database used for tracking this information.

York-Peel-Durham-Toronto (YPDT) Model

The Oak Ridges Moraine (ORM) is a 160-km long ridge of sand, silt and gravel deposits that is oriented approximately east-west, and lies north of Lake Ontario. The ORM encompasses and, extends north, east and west from the City of Toronto. In order to understand and characterize the hydrogeology of ORM, the York-Peel-Durham-Toronto (YPDT) coalition and the Conservation Authorities Moraine Coalition (CAMC) have initiated regional and local-scale groundwater studies. The model is based on information provided by multiple agencies for the purposes of analyzing and disseminating water resource data as a basis for effective stewardship of water resources.

Ontario Stream Information System (OSIS)/Fish Web Collaborative

Many agencies and community-based monitoring groups are collecting stream information (e.g., fisheries, benthos, habitat) to monitor and report on the health of watersheds in the Great Lakes Basin. Data are currently being collected using different methods and stored on individual personal computers and agency network systems. As a result, it is difficult to access all of the available information on streams in Ontario and data are undiscoverable, uncoordinated and unstandardized. This makes it difficult to make comparisons across spatial and temporal scales. OSIS/Fish Web is being spearheaded by the Province of Ontario (Ministry of Natural Resources) with project working group members from Conservation Ontario and the

Department of Fisheries and Oceans Canada. A common information system is projected to Reduce costs, increase communication and data sharing, increase sample sizes and the power of statistical tests on the effects of regulations, habitat improvements or other management techniques, and permit comparisons to be made across spatial and temporal scales. The plan is to develop a multi-organizational collaborative model for the management of stream information in Ontario and establish a single standardized source accessible over the Internet. The ultimate goal of the project is to provide a website which allows access to the data maintained by multiple organizations (e.g. link to TRCA's corporate Envirobase database) and served via web mapping. TRCA is participating in the development of this system

6.2 Network Coordination

> "Continued review and verification of the recommended monitoring programs and protocols is recommended in the future. This will facilitate the review and possible inclusion of new monitoring activities as well as technological advancements or changes in existing monitoring activities." (TRCA 2000a)

An advisory committee was not established as suggested in the development documents. In most cases, agencies have been operating their own programs unless they have been approached by the TRCA in an attempt to streamline programs (e.g. water quality). Because there is still an individualistic approach to many aspects of environmental monitoring in the Toronto area, the network is lacking on the communication between participating agencies. For example, since the inception of the monitoring network, various agencies have started monitoring additional data which may be of use to other agencies. This information has not been formally communicated to other network participants. Further effort is required to enhance the communication amongst the network participants. Suggestions include creating a website to easily share information. Establishment of a monitoring network committee, which would meet on a regular basis along with the annual status reports suggested in the development paper, would greatly enhance the communication between the various parties involved in the network.

Subsequent to this review, a review of the monitoring network is scheduled for 2010, ten years after the inception of the program. The next review will include a review of the goals and objectives of the program as well as analysis of the data collected/coordinated by the TRCA. Analysis of the data will allow for the detection of change since the inception of the program as well as comparison to historical data sets to determine if large scale changes (e.g. implementation of RAP initiatives, improved stormwater management techniques) are having an effect on the watershed/subwatershed scale.

Data Management & Network Coordination

Current Status

- Several different databases (including spreadsheets) currently being used to store RWMP
- No formal advisory committee established for the RWMP
- No one organization responsible for network coordination

Gaps/Opportunities

- Complete database upgrade to SQL
- Develop user-friendly interfaces for data retrieval and data entry
- Ensure all RWMP data is entered into Envirobase (corporate database)
- Explore opportunities to improve data availability to network partners
- Continued effort to QA/QC data
- Data access to outside client groups

6.3 Summary

7. Emerging Issues, Gaps, Opportunities, and Recommendations

7.1 Emerging Issues

Since the start-up of the RWMP, several issues have come to the forefront of concern for the Toronto region.

7.1.1 Urban Issues

The majority of the TRCA's jurisdiction is considered urbanized or urbanizing. When the RWMP was developed, rapidly changing land use was not specifically considered. It is important to ensure that there are sufficient monitoring stations in rural, urbanizing and urban land use areas for comparison. As the populations continue to grow, urban areas will continue to expand which is almost invariably accompanied by loss and/or alteration of natural habitat. Two other issues associated with urbanization include wet weather runoff and the urban heat island effect.

When areas are urbanized, much of the vegetation and top soil is replaced by impervious surfaces such as roads, parking lots, and pavement. When natural land is altered, rainfall that used to be absorbed into the ground runs off into local streams. Flows during and after a precipitation event are usually higher and faster than under natural conditions. In addition, as the runoff travels across impervious surfaces, it can pick up contaminants such as oil and grease from cars, animal feces and pesticides from lawns.

Urban development also contributes to 'urban heat island' effect which causes an area to be significantly warmer than its surrounding rural areas. Changes in locale climate can affect vegetation communities, wildlife, the hydrologic cycle, and other components of the natural heritage system. In turn, these changes may influence air quality as well as the health of humans, vegetation communities and wildlife.

Consideration should be given to monitoring wet weather flow and water quality (see below) along with air temperature to help understand the effects of urbanization on our natural environment.

7.1.2 Wet Weather Flow & Water Quality

Wet-weather flow is any flow generated by precipitation (e.g. rain, snowmelt). Wet-weather flows have proven to generate a substantial amount of chemical, physical, and biological stress to receiving waters. Precipitation events can generate three types of "wet-weather" discharge: stormwater, combined Combined Sewer Overflow (CSO), and Sanitary-Sewer Overflow (SSO). Problem constituents in wet-weather flow include visible matter, pathogenic microorganisms, oxygen-demanding materials, solids, and nutrients. Pollutants in wet-weather flow discharges from many sources remain largely uncontrolled (e.g. stormwater runoff) in the TRCA's jurisdiction.

The RWMP's water quality component is currently set up to take monthly samples, independent of precipitation (see Section 2.2.3). Because flow measurements are not taken in conjunction with the water quality sampling and in most cases there are no continuous flow stations nearby, it is difficult to separate wet (precipitation) and dry (baseflow) samples. Changing the current water quality sampling regime would not be feasible due to funding agreements and comparisons with historical data sets.

The City of Toronto, in conjuction with the TRCA, is taking action to properly quantify water quality during precipition events. As part of the City of Toronto's Wet Weather Flow Master Plan, a series of automated water quality samplers with flow triggers have been installed along the northern City of Toronto border and near major tributary outlets to Lake Ontario. The purpose of these water sampling stations is to collect data on water quality of watercourses entering and leaving the City limits. By isolating the impact the City has on water quality, the City hopes to show that improvements to stormwater infrastructure are having a positive effect on the water draining into Lake Ontario. RWMP stations will augment this work by contributing dry weather data for comparison. The outcomes of this project should be reviewed to determine the feasibility of adding wet-weather flow stations to the RWMP.

7.1.3 Source Water Protection

Source water protection is simply protecting our water resources such as lakes, rivers and groundwater, from contamination or overuse. After the Walkerton tragedy, an inquiry was completed which concluded that source water protection is one of the most effective and efficient means of protecting the

safety of Ontario's drinking water. The Clean Water Act, 2006 was proclaimed on July 3, 2007 as part of the Ontario government's commitment to ensure the sustainability of clean, safe drinking water for all Ontarians and to implement the Walkerton Inquiry recommendations.

The Clean Water Act and associated regulations establishes source protection areas and regions across Ontario for which drinking water source protection plans will be created. Each source protection area represents a watershed. The best way to protect sources of water is on a watershed basis because water flows across traditional boundaries, such as towns and cities. Conservation authorities are watershed management agencies which are recognized for their watershed management knowledge, and connections to local communities. TRCA has completed the initial the technical watershed assessment component of the proposed source protection plan. The *Interim Watershed Characterization* Report (TRCA 2007d) outlines some data gaps (e.g. lack of groundwater monitoring wells) which may need to be added to the RWMP monitoring activities.

7.1.4 Invasive Species

Invasive species are one of the greatest threats to the biodiversity of TRCA's waters, wetlands and woodlands. In the absence of natural predators or controls, invasive species can have devastating effects on native species, habitats and ecosystems. Examples of invasive species include purple loosestrife, Asian long-horned beetle, emerald ash borer, zebra mussel, sea lamprey and round goby.

Routine monitoring at fixed sites allows for the tracking of invasive species both spatially and temporally. The aquatic monitoring program as well as the introduction of the terrestrial monitoring fixed plots in 2008 will allow for the tracking of invasive species in the Toronto region. The RWMP's volunteer monitoring programs should consider the development of educational materials for the identification of invasive species and with removal techniques, where appropriate.

7.1.5 Federal & Provincial Species at Risk Acts

The federal *Species at Risk Act* (SARA) and the provincial *Endangered Species Act* are key government commitments to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. These Acts may affect the RWMP because permits may be required by people conducting activities that may affect species on either Act. Permits will be issued for activities which will not jeopardize the survival or recovery of species at risk. This includes activities for scientific research relating to the conservation of the species conducted by qualified persons, activities that benefit the species or are required to enhance its chance of survival in the wild or affecting the species is incidental to carrying out the activity.

Recovery Strategies are detailed plans that outline short-term objectives and long-term goals for protecting and recovering species at risk. Recovery strategies along with the action plans and management plans associated with the recovery strategy have the potential to affect the RWMP because they can outline when and how species are monitored. This may include changes to the frequency of monitoring for certain species as well as different protocols for sampling these species.

7.1.6 Climate Change

Climate change is considered by many to be the one of the most serious threats facing the world today. Climate change is any long-term significant change in the "average weather" that a given region experiences. Climate change is a result of a build up of greenhouse gas emissions in the atmosphere, which have been markedly increasing since the dawn of the industrial revolution. Increased amounts of these green house gases trap reflected solar radiation leading to a general increase in overall global temperatures. While greenhouse gases occur naturally, the increases which are primarily from energy use, industry and transportation. The impacts of these increases in greenhouse gases are aggravated indirectly from deforestation and the general reduction in green spaces. Weather changes may include increases in average temperature and precipitation and changes to wind patterns. Changes in any aspect of the climate will impact the natural environment. For example, climate change may affect the temperature,

quantity and quality of water which in turn will affect fishes. Climate change is predicted to alter annual and seasonal precipitation paterns in North America (Bolin et al. 1986, Hengeveld 1990) which would affect lake levels and stream flows (Cohen 1986, Gleick 1987). If changes in water quantity occur with changes in water temperture, then changes in water quality will likely follow, owing to changes in concentration of ions, dissolved gases, and organic materials (Regier and Meisner 1990). Stream fishes are positively related to streamflow (Fausch et al. 1988) and are directly affected by both water temperature and quality.

On a watershed scale, some of the expected effects of climate change include:

- Overall increase in risk of extreme and erratic weather;
- Increased risk of heavy, rapid rainfalls;
- Increased risk of flooding and drought events;
- Increased risk of bank erosion;
- Increased risks for flooding and erosion;
- Increased water turbidity;
- Decrease in water quality;
- Increased stress on aquatic and terrestrial biodiversity; and
- Increased stress on water management structures.

TRCA understands that climate change will exacerbate the stresses already present in our watersheds, and therefore believes that a comprehensive approach which includes both mitigative and adaptive actions is needed to both reduce and cope with the effects of climate change. The various components of the RWMP will help monitor the effects of climate change over time. Additional monitoring components such as ozone monitors should be considered during the completion of this document.

7.2 Gaps, Opportunities and Recommendations

Gaps and opportunities have been discussed at the end of individual sections but are compiled together in this section for easy reference.

The following documents were reviewed as part of the RWMP gap analysis because they use RWMP data, they have reviewed the program and offered recommendations:

- Listen to Your River: A Report Card on the Health of the Humber River Watershed (TRCA 2007a)
- Humber River Fisheries Management Plan (OMNR & TRCA 2005)
- Humber Watershed Plan Draft Implementation Guide (TRCA 2008c)
- Rouge River State of the Watershed Report (TRCA 2007c)
- Rouge River Watershed Plan: Towards a Healthy and Sustainable Future (TRCA 2008d)
- Rouge River Watershed Plan: Towards a Healthy and Sustainable Future – Implementation Guide (TRCA 2008e)
- A Watershed Plan for Duffins Creek and Carruthers Creek (TRCA 2003c)
- Carruthers Creek State of the Watershed Report (TRCA 2002)
- Duffins Creek State of the Watershed Report (TRCA
- State of the Watershed Report: Highland Creek Watershed (TRCA 1999)
- Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watersheds Report Card 2006 (TRCA 2006a)
- Breathing New Life into the Don: 2003 Don Watershed Report Card (TRCA 2003)
- Interim Watershed Characterization Report (TRCA 2007d)

Over the years, a variety of suggestions have been made to improve the RWMP. Several of the recommendations have already been implemented including:

- Establish a long-term baseflow monitoring program
- Establish long term groundwater and stream flow discharge
- Expand the RWMP to include community volunteer-based monitoring
- Establish a system of fixed plots (terrestrial) to monitor species, vegetation communities and the factors that affect them to determine changes in biodiversity over time
- Establish and maintain a source water protection groundwater quality database
- Increased fluvial geomorphology monitoring
- Establish evaporation monitoring stations

Other recommendations have been made in various TRCA reports which warrant further consideration:

- Expand the RWMP to including monitoring during wet weather
- Develop, draft and adopt a Groundwater Management Policy
- Improve groundwater monitoring (water levels and water quality) by increasing the number of groundwater wells in the monitoring network
- Establish additional monitoring sites in first and second order streams

The following is a list of recommendations to help the RWMP and the monitoring network as it moves forward:

- TRCA should take a larger role in managing the overall monitoring network;
- Set up a yearly workshop with both active participants in the network and potential new participants to discuss current monitoring activities which are part of the network, activities outside the network, potential for collaboration/streamlining, roles and responsibilities, and discussions of new, innovative or potential future monitoring techniques;
- Undertake further efforts should be made to streamline programs which are conducted by more than one agency to improve efficiency and reduce cost;
- Continue to produce annual reports outlining the type of data collected by the RWMP as well as other programs participating in the monitoring network;
- Conduct a review of the RWMP data in 2010 (allows for a minimum of three years of data to be collected per program component) and report the findings to the Authority's partners and network participants;
- Further define stress/pressure and response/management indicators and monitoring protocols to measure/monitor these indicators;
- Develop a website or similar media to improve communication among network participants;
- Continue to improve databases and tools for the storage and retrieval of data collected through the program;
- Complete groundwater discussion papers (compile and synthesize relevant material to determine if current monitoring is sufficient for the Toronto region or if additional monitoring is required by the RWMP);
- Further develop the Benthic Aggregate Assessment to tease out impaired sites;

- Cost-benefit analysis of benthic invertebrate sampling and identification (i.e. is annual sampling necessary? Should invertebrates be identified to the species level?);
- Investigate the need for freshwater mussel monitoring in the Toronto area;
- Establish water quality monitoring sites in Petticoat Creek and Frenchman's Bay watersheds;
- Review water quality monitoring program with respect to flow monitoring program to improve integration of the two data sets;
- Continued support of citizen-science programs such as the Terrestrial Volunteer Monitoring Program; and
- Improve monitoring of inland waterbodies (lakes, ponds).

The above recommendations should be considered in detail, particularly with respect to subwatersheds as some components of the current RWMP are not monitored in every subwatershed.

8. Conclusions

8.1 Is the Network Achieving its Goals & Objectives?

Objective 1

The development of a program that provides the necessary information to assess the health of the RAP area, watersheds, sub-watersheds and [illegible]

Yes but needs improvement. The TRCA's RWMP along with additional information supplied by other agencies participating in the monitoring network provides the necessary information to assess the health of the TRCA's watersheds including the RAP area, both spatially and temporally. Some subwatersheds are not currently being monitored (and this situation needs to be rectified to ensure that all subwatersheds are being properly monitored. The current monitoring program is focused on condition type indicators which are necessary to ascertain the details to determine the health of the watershed. Future efforts incorporate stress/response and response/management type indicators into the program will ensure watershed managers have ready access to information/data in order to make informed decisions about management of natural resources

Objective 2

To identify a set of indicators that reflect ecosystem condition, integrate the monitoring requirements of the RAP with report cards for individual watersheds, and are compatible with the indicators being developed through State of the Lake Ecosystem Conference (SOLEC) for the Great Lakes

Yes. The condition/state indicators used by the RWMP provide comprehensive monitoring of the natural environment in the TRCA jurisdiction. As noted in Section 7, additional monitoring activities should be considered for the RWMP which will enhance the current monitoring program.

Objective 3

To develop an efficient program that builds upon existing monitoring activities and avoids duplication between agencies, municipalities, and organizations and is cost effective in allocating the best use of resources

Yes but needs improvement. Several components of the RWMP have undergone streamlining exercises with other agencies to avoid duplication and to make monitoring more efficient. Successful examples include the surface water quality monitoring program and the flow monitoring program. Other programs (e.g. groundwater monitoring) should undergo similar exercises to ensure that resources are being used effectively.

Objective 4

To identify ways to engage and involve the public, interest groups, and school groups in meaningful monitoring activities

Yes. The Terrestrial Volunteer Monitoring Program is a very successful project that has shown that volunteer data can be a valuable way to monitor data. New programs such as the Aquatic Volunteer Monitoring Program will add to the repertoire of public involvement projects.

Objective 5

To develop and obtain agreement from stakeholders on a set of monitoring protocols for the collection, analysis, storage and distribution of data as

Yes but needs improvement. Most sampling is conducted according to provincial protocols which have been approved by the appropriate government ministry (e.g. Ontario Ministry of Natural Resources, Ontario Ministry of the Environment). Improvements to the TRCA's internal database are needed (e.g. timely input of data and connections to other internal databases). The RWMP is working with the provincial government to help develop a provincial data management system for stream information (i.e. OSIS).

Objective 6

To develop a comprehensive, integrated and coordinated approach to environmental monitoring that fulfills the watershed monitoring and reporting needs of the Toronto Remedial Action Plan (RAP), the TRCA and

Yes but needs improvement. The TRCA's RWMP along with additional information supplied by other agencies participating in the monitoring network provides most of the necessary information to assess the health of the RAP area and watersheds, both spatially and temporally. A notable exception is the groundwater monitoring program which has been deemed inadequate for the current monitoring needs.

8.2 Summary

Both the RWMP and the monitoring network are generally performing as expected with respect to the original goals outlined in the *Development of a Regional Watershed Monitoring Network* document (TRCA 2000a). Monitoring of indicator variables has been achieved successfully and the program should continue monitoring these variables over the long-term. All elements of the program are designed to provide data sets that allow for interpretation at the subwatershed, watershed and regional scales. All program elements are strongly focussed on the collection of scientific data (e.g. standardized protocols), however, when possible, community outreach and education are incorporated. This is accomplished through the involvement of trained volunteers (e.g. Terrestrial Volunteer Monitoring Program), through partnerships with community groups and other non-governmental organizations, and through special events that demonstrate to or involve the community. The data collected is shared with partner municipalities and other agencies, and is used for planning, implementation and reporting activities such as State of the Environment Reporting, Source Water Protection, the Toronto Remedial Action Plan and to support major capital and infrastructure projects. Partnerships with academic institutions facilitate achievement of common research objectives as well as data sharing in support of academic study. The recommendations contained within this report should be considered for further action keeping in mind that any major modifications to the RWMP will have future budget implications.

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