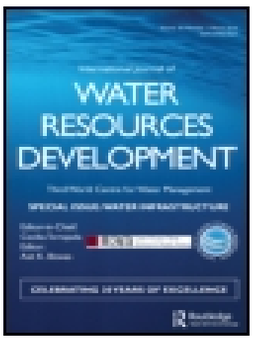

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Implementing integrated water management: illustrations from the Grand River watershed

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ABSTRACT

The Grand River watershed is the largest in southern Ontario. Poor water quality, floods and drought experienced in the 1930s prompted the formation of the Grand River Conservation Authority. While significant water improvements have been achieved, the Grand River faces chronic stress from the impacts of rapid population growth, land use intensification and changing climate. There is renewed commitment to address evolving water issues through integrated watershed management. This article summarizes the lessons learnt in the Grand River watershed and contends that integrated watershed management, although difficult to implement, provides a useful framework for practical application and positive results.

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Introduction

The Global Water Partnership (2000, p. 22) defines integrated water resource management (IWRM) as 'a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare, paving the way towards sustainable development, in an equitable manner without compromising the sustainability of vital ecosystems'. The watershed as a management unit for water and related land resources underpins IWRM (Cortner & Moote, 2000; Goldstein & Huber-Lee, 2004; Heathcote, 2009; Saravanan, McDonald, & Mollinga, 2009; Mitchell, 2015). According to Shaver, Horner, Skupien, May, and Ridley (2007), addressing natural resource problems at a watershed scale rather than a single location or portion within it allows all relevant factors contributing to the problem to be included in the planning process, increasing the number of potential solutions to the problem or threat.

However, there are mixed views on the value of implementing IWRM. The application of IWRM for the day-to-day management of natural resources remains problematic, with significant gaps between theory and practice (Biswas, 2004; Blomquist & Schlager, 2005; Butterworth, Warner, Moriarity, Smits, & Batchelor, 2010; Mitchell, 2009; Molle, 2008). Some refer to IWRM as a 'nirvana concept' that promises more than it can deliver (Molle, 2008; see also Biswas, 2008). Others acknowledge that while IWRM has challenges, it is unreasonable to view it as a remedy for all environmental, social and economic woes. Rather, the principles

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inherent in the concept should be applied and the problems scoped based on context-specific factors. A watershed governance structure that allows inclusiveness, collaboration and accountability is one factor that will influence the success of IWRM (Plummer, Spiers, FitzGibbon, & Imhof, 2005). Another is the willingness of agencies to embrace an adaptive management approach, where lessons learnt are applied to future watershed planning initiatives (Veale, 2010).

The aim of this article is to describe the evolution and implementation of IWRM in the Grand River watershed in Ontario, Canada. A case study of these efforts will illustrate the successes, challenges and lessons learnt from experiences implementing IWRM. This remainder of the article is in four sections. First, the history and formation of the Grand River Conservation Authority (GRCA) are described. Second, the evolution of efforts to implement IWRM in the Grand River is illustrated by reviewing watershed planning initiatives. Third, the lessons learnt from implementing IWRM are considered: sustained collaboration; celebrating success; scoping the plan; and continuous improvement. These principles provide a useful framework to evaluate watershed and water management. The article concludes with a summary of the experiences implementing IWRM in the Grand River watershed.

Context

The Grand River watershed, the largest in southern Ontario, is located west of the Greater Toronto Area (Figure 1). The river emerges about 8 kilometres north-east of Dundalk and stretches almost 300 kilometres to the outlet at Lake Erie. Combined with its major tributaries, the Conestogo, Nith, Speed and Eramosa Rivers, the Grand River drains an area of 6800 km^2. The watershed is the largest of Ontario's drainage basins discharging into Lake Erie. Thirty-nine municipalities are wholly or partly within the Grand River watershed, as well as two First Nations reserves, formed under the federal Indian Act(1985).[1]

History of water management in the Grand River watershed

Water management has long been practised in the Grand River watershed. Key events over the course of the past century are summarized in Figure 2. In the 1800s, Europeans settled here, drawn by its abundant natural resources and fertile soils. The Grand River and its tributaries offered water supply, water power, transportation, and disposal for human and livestock waste. Over time, deforestation, agricultural drainage and urban settlement combined to intensify fluctuating river flows and contribute to poor water quality.

By the 1930s, floods, drought and pollution directly affected public health and economic development and prompted local business leaders to lobby the provincial government for action (Adams, 1937). The provincial government responded by authorizing a study, with clerical and financial support from municipalities (Mitchell & Shrubsole, 1992; Ontario Department of Lands and Forests, 1962). The study considered the problem of low river flow and its relationship to public health, water supply, sewage disposal, flood control and the provision of hydroelectric power. It recommended the construction of five dams and reservoirs, reforestation, wildlife management and the general improvement of the scenic features of the river valley (Ontario Department of Lands and Forests, 1932).

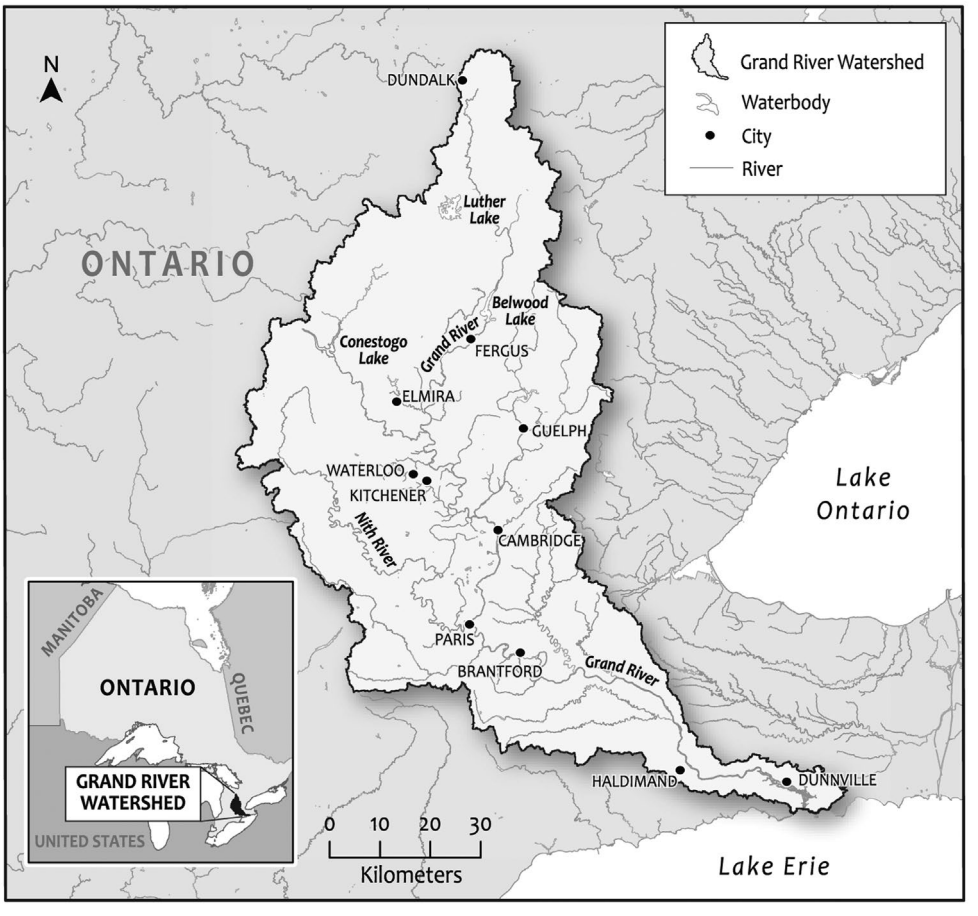

Figure 1. The Grand River Watershed, the largest watershed in southern Ontario, Canada.

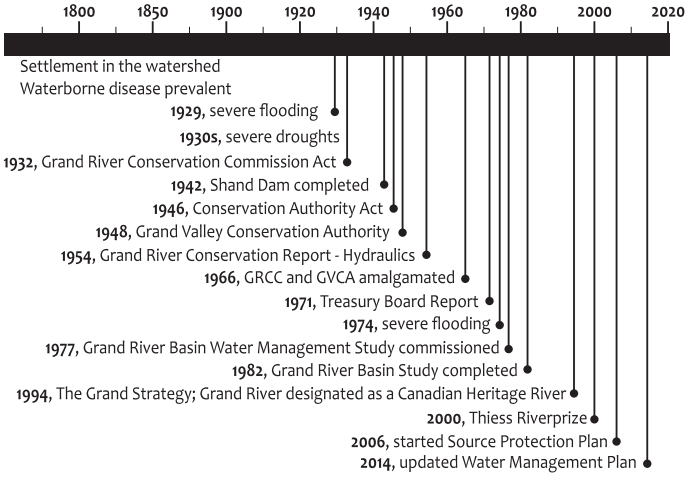

Figure 2. History of watershed management in the Grand River watershed.

The first watershed agency in Canada: the Grand River Conservation Commission

In 1932, the province established the Grand River Conservation Commission (GRCC) to undertake surveys; it was the first watershed agency in Canada. In 1938, after experiencing severe droughts, the province empowered the GRCC to investigate, construct and operate reservoirs. Members included the municipalities of Brantford, Elora, Fergus, Kitchener, Paris, Preston, Galt and Waterloo.[2]

The GRCC built three multi-purpose water control structures between 1942 and 1958, including the Shand, Conestogo and Luther Dams (Figure 1). The GRCC contributed 25% of the cost, and the remainder was shared equally between the federal and provincial governments. The GRCC also planted trees on lands adjacent to the newly created reservoirs.

In Ontario, natural resource concerns were not confined to the Grand River watershed. In 1946, the province passed the Conservation Authorities Act (1990), which enabled municipalities to collaboratively manage land and water resources on a watershed basis (Ontario Department of Lands and Forests, 1962). The Grand Valley Conservation Authority was formed in 1948. Activities were guided by a watershed-wide management plan. The plan focused on land acquisition, reforestation, local erosion and flood control, extension programmes for rural landowners, and recreational areas. It also encouraged all watershed municipalities to work together to address a broad range of resource management issues (Ontario Department of Lands and Forests, 1962).

Formation of the Grand River Conservation Authority

The practicality of two conservation organizations operating in the same watershed was assessed in the 1960s. As a result, the GRCC and the Grand Valley Conservation Authority amalgamated in 1966 to form the Grand River Conservation Authority (GRCA). The GRCA continued to carry out a wide range of conservation programmes and operate the multi-purpose dams and reservoirs.

In 1971, the efficacy of building more dams for water supply and effluent dilution to accommodate a growing population, versus the development of a pipeline to one of the Great Lakes, was debated and assessed (Ontario Treasury Board, 1971). As a result, the Grand River Implementation Committee was formed in 1972 to develop a comprehensive plan for the Grand River watershed.

In May 1974, a destructive flood caused an estimated CAD 7–10 million in damage (excluding business losses and clean-up costs) in the watershed (Grand River Disaster Relief Committee, 1975). The province established a Royal Commission to investigate the circumstances during and after the flood and offer advice to mitigate future damages. Improvements to the water control system, including a new dam and reservoir downstream from Fergus, were recommended (Leach, 1975). In 1979, a comprehensive environmental assessment of water control structures was completed by the GRCA. This study reinforced the call for an additional multi-purpose reservoir, together with river channel and waste disposal improvements (Grand River Conservation Authority, 1979).

Towards IWRM in the Grand River watershed

In 1977, the province initiated the Grand River Basin Water Management Study (Basin Study) to examine the interrelated issues of water quality, water supply and flooding. Directed by

the Grand River Implementation Committee, this CAD 1.6 million study was led by five provincial ministries and the GRCA. The technical work was managed by a coordinator and undertaken by five multi-agency subcommittees. The study generated and examined 26 scenarios to deal with water issues over a 50-year horizon. Public input was sought throughout the process. Four public consultation groups, representing a wide range of interests and geographical areas of the watershed, helped form, screen and evaluate the scenarios.

The Basin Study was released in 1982. It offered 22 recommendations, calling for mix of structural and non-structural approaches to be undertaken by municipal and provincial governments and the GRCA. The anticipated cost of implementing the recommendations was more than CAD 180 million (Grand River Implementation Committee, 1982). Through the determined efforts of the partners, many of the recommendations were implemented, such as diking and the construction of sewage treatment plants. One key recommendation was to establish a coordinating committee to monitor implementation and consider periodic updates to the plan; however, this was never fulfilled (Project Team, Water Management Plan, 2014).

In 1987, another multi-agency initiative began which reinforced cooperative and coordinated management in the watershed. Several municipalities in the watershed were interested in pursuing Canadian Heritage River designation for the Grand River. A multi-agency steering committee, with representatives from Parks Canada, the Ontario Ministry of Natural Resources and the GRCA, was formed to explore whether the Grand River was a suitable candidate. After background studies (Nelson & O'Neill, 1989), the Canadian Heritage Rivers Board accepted the nomination of the Grand River in 1990, based on the watershed's rich diversity of cultural resources of national stature and the excellence of recreational opportunities provided by the river system.

Formal designation was contingent upon the tabling of a management plan with the board. A management plan called the Grand Strategy was produced after extensive public participation (Grand River Conservation Authority, 1994). A shared vision was debated, modified, and accepted early in the planning process. The principles of consensus, community involvement, cooperation and commitment underpinned the plan. Building on the philosophy that everyone sharing the resources of the watershed should be part of a cooperative effort to conserve, interpret and enhance river-related heritage resources, the motto 'Share the resources – share the responsibility' was adopted. The plan provided a framework for stakeholders to volunteer for specific actions (e.g. collecting and exchanging information, or assisting in implementing some projects) and was accepted by the Canadian Heritage Rivers Board in 1994, after which the Grand River and its major tributaries were formally designated.

In keeping with the vision and principles adopted for the Grand Strategy, several watershed-scale strategies and initiatives were promoted to address key aspects of watershed health and sustainability in the 1990s. An example is the Fisheries Management Plan.

Following the Canadian Heritage River designation in 1994, growing appreciation of the Grand River as a significant fishery resource and rising public interest in water quality and the environment led to the formation of a Grand River Fisheries Working Group. The purpose of the group was to investigate how angling interests and expectations could be met throughout the watershed. Representatives from angling groups, universities, provincial and federal agencies and the GRCA joined together to identify issues and potential solutions, advance stewardship and community sponsorship, interject fishery matters into land use

and watershed planning decisions, and recommend management actions. Following extensive public input, the Grand River Fisheries Management Plan was published in September 1998 (Grand River Fisheries Management Plan Implementation Committee, 2005). Since that time, a multi-agency implementation committee has met regularly to carry out the recommendations of the report. In recognition of their continued work, the committee received the National Recreational Fishery Award from the federal Department of Fisheries and Oceans in May 2009 (Grand River Conservation Authority, 2009).

A significant event that influenced how water was managed in Ontario occurred in 1997. The province enacted the Water and Sewage Services Improvement Act (1997), which transferred ownership of wastewater treatment plants to municipalities (Ontario Sewer and Watermain Construction Association, 2001). This prompted some municipal water and wastewater managers to ask the GRCA to convene a working group to facilitate cross-municipal boundary discussions on water issues, including wastewater discharges to the river, non-point source pollution, water supply, and spill notifications. An early outcome of the discussions was the initiation of a Rural Water Quality Program, fashioned after a former provincial programme called Clean Up Rural Beaches (Project Team, Water Management Plan, 2014). Participating municipalities provided financial assistance to farmers to adopt best management practices, such as fencing near waterways and no-till farming, to protect and improve water quality. The Rural Water Quality Program continues today. The GRCA provides technical assistance and administers the programme. Over 4000 projects have been completed since the programme began (Project Team, Water Management Plan, 2014).

The long-term efforts of the GRCA and its partners have resulted in visible improvements to the river system. The multi-purpose reservoirs have successfully mitigated flooding and augmented low river flows, improving downstream water quality and ensuring more consistent flows for municipal water supplies. Upgrades to wastewater treatment and rural landowner stewardship projects have contributed to improvements in water quality and aquatic health, validated by the return of sport fish to several river reaches (Grand River Conservation Authority, 1997). The merits of this ongoing integrated and collaborative approach for managing water and related land resources were acknowledged in 2000, when the GRCA received the Thiess International Riverprize honouring excellence in river management (Krause, Smith, Veale, & Murray, 2001).

Updating the Basin Study: a renewed approach

Today, close to one million people reside in the watershed, most in urban areas. There are 45 municipal and one First Nation drinking water systems in the watershed.[3] Over 70% of the drinking water supplies come from groundwater sources; surface water sources account for the rest. There are four surface water intakes in the Grand River system. The region of Waterloo and the city of Guelph supplement groundwater drinking water supplies with surface water withdrawals, whereas the city of Brantford and the Six Nations of the Grand River depend solely on surface water withdrawals from the Grand River for their water supply. The Grand River receives treated effluent from 30 wastewater treatment plants. Also, non-point pollution sources, such as farms and urban development, contribute contaminants to the river (Project Team, Water Management Plan, 2014). The river also provides excellent opportunities for recreational fishing and paddling.

Despite continuing management efforts, the river system remains sensitive to stresses from rapid population growth, agricultural and urban intensification, and changing climate. The Grand River and most of its larger tributaries are highly eutrophic. Surface water quality is deteriorating in the middle and lower reaches of the river (Cooke, 2006; Loomer & Cooke, 2011). The capacity of the river system to receive additional wastewater and runoff from non-point sources is uncertain. The cumulative effects of nutrient and groundwater inputs are not well characterized or understood. There is increasing concern that the cumulative impact of progressive urbanization may negatively influence the water budget and disrupt fundamental hydrological processes, particularly in the central moraines area (Veale, Cooke, Zwiers, & Neumann, 2014). Without careful planning, the mounting demands on the river system could reduce the availability of water, increase water demand, and boost contaminant loads in surface and groundwater.

In 2008, the GRCA initiated dialogue with potential partners on the need to revisit the 1982 Basin Study to deal with existing and emerging water problems in the watershed. Since water management activities are undertaken by multiple agencies at three government levels, a business case was developed. There were two central messages. First, the resolution of water issues requires a collaborative approach that recognizes the complexity and interrelatedness of hydrological, ecological and social systems. Second, solutions to address the impacts of multiple inputs and sources throughout the river system must be watershed based.

In 2009, the Grand River Water Management Plan (WMP) was launched to update the Basin Study. The approach was crafted based on previous experience with watershed-scale plans. Partners included municipalities,[4] provincial ministries, federal departments, First Nations and the GRCA (GRCA, 2014). The goals of the plan were to: ensure water supplies for communities, economies and ecosystems; improve water quality to improve river health and reduce the river's impact on Lake Erie; reduce flood damage potential; and increase resiliency to deal with climate change. These goals are broader than those of the Basin Study. While water quality, water supply and flooding were still considered top management priorities, a broader ecosystem-based philosophy was adopted, which acknowledged the impact of human activities on the health and functioning of natural systems. The influences of water quality and quantity on the ecological and hydrological health of the Grand River and Lake Erie, and the implications of climate change, were not considered in the Basin Study.

A Project Charter outlining the purpose, scope and partner roles was crafted and voluntarily signed by the partners, committing them to work together towards meeting the stated goals (Grand River Conservation Authority, 2010). The Project Charter stressed that the updated WMP would represent a 'joint call to action' by aligning the efforts of all partners and galvanizing them to achieve mutually supported targets for water management. The WMP was to be a collective and concerted effort to stretch limited dollars in support of 'best value' actions to maintain river health and resilience.[5] The plan was to build on past and current information, knowledge and modelling, planned and proposed projects and activities, and commitments to meet shared goals. It was not to be a prescriptive plan, offering recommendations for projects and programmes that ought to be undertaken. Rather, it was to represent the collective commitment of all partners to determined action, with each agreeing to implement specific actions.

The Project Charter outlined factors for success that helped guide the planning process. Some key factors included: (1) there is sustained collaboration among partners; (2) there are early wins to celebrate and share; (3) the plan is scoped to reflect available time, funding, resources, data and science; and (4) monitoring and performance measures are created to ensure adaptive management and continuity.

A multi-agency Steering Committee was formed, supported by a technical Project Team with representation from all partners. Several multi-agency working groups were also formed to answer technical questions, synthesize information, share best practices and exchange perspectives. The GRCA provided administrative support and ensured that information was shared freely among and discussed by participants. Funding for the plan was shared by the GRCA and the Ministry of the Environment and Climate Change, which provided CAD 903,000 through the Showcasing Water Innovation Program under the Water Opportunities Act (2010). Environment Canada also provided funding to help facilitate the planning process and ensure that links between the WMP and the Lake Erie Lakewide Action and Management Plan were considered.[6]

Early in the planning process, the partners adopted the vision created in the Heritage River designation process and the guiding principles derived from the Project Charter (Table 1). Twenty-three broad water objectives, supporting human uses, ecological needs and social and cultural values for water, were developed with broad stakeholder input and accepted by the partners. Indicators and targets describing conditions when the broad objectives are met were also identified.

The GRCA facilitated workshops, surveys and meetings with participants to gain knowledge of their experiences or insights on innovative approaches to achieving the water objectives. A series of best practices were developed to support improving the performance of wastewater treatment plants, improving stormwater management and applying innovative decision support systems. Further, demand management strategies were established for water withdrawals, such as municipal and agricultural users. An arms-length Science Advisory Committee, made up of highly respected academics with expertise in various aspects of water management, provided the Steering Committee, Project Team and GRCA staff with scientific, technical and management advice.

The WMP was completed and endorsed by 15 plan partners in September 2014. It is an integrated action plan, containing 163 actions. These actions include existing and planned activities, strategies, best practices and innovative approaches, which the partners consider practical, achievable and cost-effective. In 2015, the partners transitioned into the implementation phase. A renewed Water Managers Working Group of municipal, provincial and federal agency representatives, First Nations, and the GRCA meets quarterly to evaluate the progress each partner has made towards implementing the plan and to discuss ongoing or emerging water management issues. The first report, released in 2015, concluded that partners were advancing 120 of the 163 actions listed in the WMP. Initiatives such as a Drought Contingency Plan and the Grand River Source Protection Plan, the commissioning of a new water treatment plant at the Six Nations reserve, and the naturalization of 1.3 kilometres of Schneider Creek to improve urban stream water quality in Kitchener were highlighted, while other actions were noted as pending (Grand River Conservation Authority, 2015).

The WMP is one component of the integrated watershed management plan for the Grand River watershed, as illustrated in Figure 3. A planning process to tie all the individual watershed-based plans together to create an integrated watershed plan is slated to begin in 2016.

Table 1. Guiding principles for partners to the update of the Grand River Water Management Plan.

Healthy communities and a healthy ecosystem
• A healthy river system is crucial for sustaining prosperity, growth and well-being in the Grand River watershed
• The Water Management Plan is guided by an ecosystem approach. We will strive to maintain and restore critical natural system interactions, functions and resiliency
• Ecosystem services (those services provided by natural processes, e.g. waste assimilation, water retention) are acknowledged, maintained and enhanced
Managing water resources is a shared responsibility
• Managing water requires common goals, collaborative decision making and co-operation
• Implementation is shared by all levels of government, landowners, businesses and residents
• Implementers are committed to joint action and own their piece of the Plan
• Stakeholder participation is essential
Water is best managed on a watershed basis
• The watershed is the most appropriate unit for managing water and the linkages between water and other natural resources
• The Water Management Plan is a critical component of a broader watershed management plan
Decision making must be transparent and responsive
• Water management decisions are integrated and transparent, taking into consideration the broad range of uses, needs and values for water and the needs of a healthy ecosystem
• Water management strategies are designed to be responsive to changing conditions, priorities, vulnerabilities and pressures; adaptation is supported by monitoring and progress reporting
Management of water resources must be effective and efficient
• The concepts of sustainability, adaptive management and continuous improvement guide decision making and implementation
• Best value solutions are sought
• Best available science, expert advice and local knowledge are inherent to the Plan

Discussion

There is no doubt that implementing IWRM presents challenges, yet it is worth pursuing. Experiences from the Grand River watershed illustrate that an integrated approach, which considers a multi-disciplinary, multi-agency approach to concurrently address a range of resource issues, goals and outcomes is possible and can be put into practice, yielding successful outcomes. However, integration takes time, tenacity, perseverance and a commitment to continuous learning and improvement. A key tool for encouraging integration and commitment was the Project Charter and recognition of the factors for success embedded in it. The following discussion illustrates the influence of these factors on the outcomes of the WMP.

Sustaining collaboration among partners

Water management is fragmented in Ontario. Roles and responsibilities are mandated by federal and provincial legislation and are shared among many government agencies and departments, municipalities and the GRCA (Veale, 2004). Water is also central to the culture of First Nations peoples. Coordination and collaboration among and within agencies is needed to achieve an integrated approach. One of the biggest hurdles in successful watershed management is building processes that are collaborative, yet streamlined, to match stakeholder capacity and sustain interest and enthusiasm over the long term. This requires conscious effort and a commitment and willingness to pool resources and work collectively to resolve issues of mutual concern. Partners contributed to a collaborative mindset by signing the Project Charter, which clearly spells out roles, responsibilities, guiding principles and expectations. The governance structure requires ongoing communication and

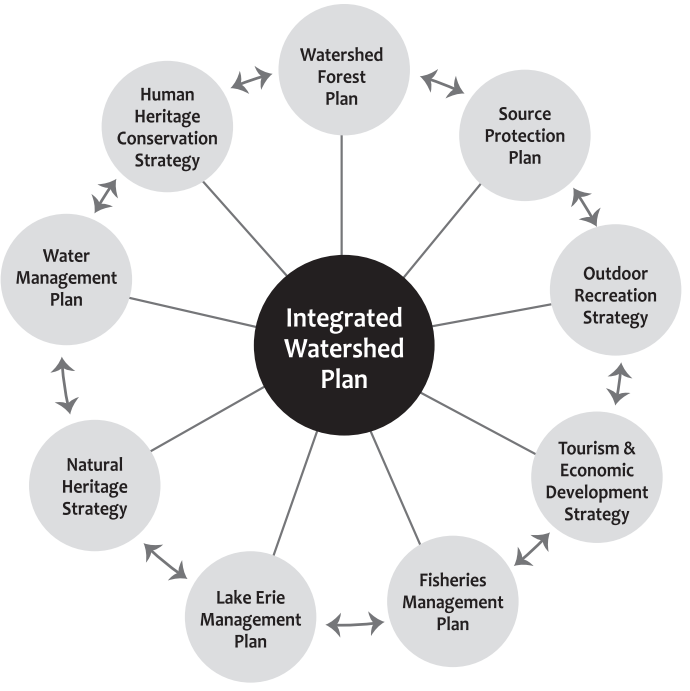

Figure 3. Components of the Integrated Grand River Watershed Management Plan.

collaboration among partners. As the secretariat, the GRCA will continue to organize meetings, collate and share information, write technical documents, and report on progress towards WMP objectives.

The preparation of the WMP began in 2010 and was endorsed in 2014; the five-year period has helped build good working relationships among the partners. There is a commitment among the WMP partners to continue to meet to discuss watershed water issues. The Water Managers Working Group collaborates through quarterly meetings. In 2015, the working group produced its first action report summarizing progress to date (Grand River Conservation Authority, 2015). In addition, there are commitments to host technical workshops to gather new knowledge and advance actions, and report on the status of implementation, which will enable partners to see progress. Evaluating resource conditions and trends at regular intervals (e.g. every five years) should provide insight into whether the partners' collective actions are achieving the goals of the WMP. The challenge will be to ensure that this assessment takes place and is communicated to all partners.

Experience demonstrates that collaboration is often the product of personal relationships, which are honed over time as an outcome of working with others to achieve common goals. Collaboration into the future will depend on the degree to which current participants are able to transfer their knowledge and experiences to their successors and the opportunities afforded to forge new relationships. As the watershed agency prescribed to facilitate agency partnerships at the watershed scale and given the aforementioned prerequisites, it is incumbent on the GRCA to continue to devote time and energy towards fostering good working relationships and establishing commitments among new participants.

Celebrating success

Sustaining interest throughout a long process is difficult. To keep partners motivated and engaged, it is important to celebrate accomplishments and share experiences to foster further action. Several examples are offered that illustrate this point.

First, the successes achieved in implementing a wastewater treatment plant optimization programme by two municipal partners, the city of Guelph and Haldimand County, were introduced to other municipal WMP partners. This programme uses the principles of the Composite Correction Program and guides wastewater operators and managers by helping them identify design, administrative or operational/maintenance barriers to achieving high-quality effluent (Hegg, DeMers, & Barber, 1996). Using this approach, both municipalities realized sufficient improvement in sewage effluent quality to defer millions of dollars in capital infrastructure costs. Through a series of workshops and hands-on training to transfer skills, a community of practice emerged around the optimization concept, and other watershed municipalities have implemented individual optimization programmes.

Second, the Region of Waterloo and the city of Guelph are established leaders in water conservation, and representatives were willing to share experiences. The GRCA hosted two workshops to identify opportunities and barriers to implementing water conservation methods and techniques, share best practices and develop a toolkit. The toolkit has been completed and includes a decision-making matrix to help municipalities identify an appropriate suite of demand management tools, based on their specific water constraints and objectives. Several 'primers' were also developed, based on shared learning among participating municipalities. These tools are being used as a basis for continuing dialogue with watershed municipalities. Several municipalities have considered and piloted the 'soft path' approach (Brooks, Maas, Brandes, & Brandes, 2015) in water supply plans, and some have set new (lower) water demand management objectives. The soft path is an alternative approach to the traditional supply-focused water planning. Rather than viewing water as an end product, the soft path considers water a means to accomplish specific tasks and changes the role of water management from merely investing in capital infrastructure to providing water-related services such as drought-resistant landscapes, low-impact development for stormwater management, and alternative ways of providing sanitation that require less water to function.

Third, collaborative programmes to tackle water quality issues associated with non-point sources of pollution have been implemented since 1998 (Project Team, Water Management Plan, 2014). The Rural Water Quality Program encourages the agricultural community to voluntarily implement best management practices (BMPs). The programme helps farmers prepare nutrient management plans and provides financial incentives for BMPs. A review of BMPs was undertaken by the WMP partners to develop effective strategies for expanding the geographic scope of the programme and encouraging uptake. Mapping tools and approaches using 3-D hydrography and high-resolution digital elevation models were developed to identify erosion source areas for remediation. The presentation of model results to the agriculture community has re-engaged many farmers, who have shown renewed interest in implementing BMPs.

Although celebrating 'early wins' is fundamental to building momentum and partner engagement, sharing challenges and barriers to implementation is equally insightful. Deliberate and focused discussion was facilitated at Project Team meetings on sensitive issues, such as municipal water supply security and the cumulative impact of multiple

wastewater discharges on water quality. Mindful, honest and open discussion allowed partners to tackle and remove barriers to improved water management in the watershed.

Scoping the plan

The Project Charter emphasized that the WMP needed to be scoped according to available time, funding, human resources, data and science. Rather than undertaking new studies, collecting new data or developing additional computer models, the planning process was designed to be cost-effective, building on a wealth of existing information, available expertise and the collective knowledge of the partners. It also took into account the many programmes, activities, models and studies undertaken since the completion of the Basin Study (GRCA, 1982).

For instance, the Grand River Simulation Model was developed in concert with the Basin Study. It is a continuous, dynamic dissolved oxygen model that takes into account contributions from point and non-point sources of nutrients and oxygen-consuming materials to predict in-river aquatic plant growth and associated dissolved oxygen levels (Willson, Kwong, Weatherbe, & Post, 1982). The GRCA, in collaboration with watershed municipalities, provides data to validate and calibrate the model. The model is used to evaluate the cumulative effects of the 10 wastewater treatment plants that discharge effluent to the central watershed, and to guide wastewater master planning. The previously calibrated and validated model was a valuable predictive tool for the WMP. Modelling scenarios were run for planned and future wastewater plant upgrades and optimization. The results showed that improvements in water quality can be expected when all planned wastewater treatment plant upgrades are completed. Even greater water quality improvements are predicted when the planned upgrades to wastewater facilities are combined with plant optimization. This analysis was instrumental in confirming the value of wastewater treatment upgrades and convincing partners that plant optimization was a worthwhile and practical strategy.

Since the 1982 Basin Study, several watershed-scale studies have improved the understanding of hydrological processes and water quality. A regional groundwater characterization study (Holysh, Pitcher, & Boyd, 2000) and an integrated water budget (AquaResources Inc., 2009a) investigated and described the interactions between surface and groundwater. The Drinking Water Source Protection Program, which is administered by the Ministry of the Environment and Climate Change under the Clean Water Act (2006), funded a watershed characterization report to support the drinking water source protection planning process (Lake Erie Source Protection Region Technical Team, 2008). Water quality conditions and trends in the watershed provided comprehensive assessments of the state of the water resource (Cooke, 2006; Loomer & Cooke, 2011). The knowledge gained through an analysis of these reports and others provided new insights into what actions or management options might be appropriate for the WMP.

For example, the integrated water budget and the Water Quantity Stress Assessment Report (AquaResources Inc., 2009b) highlighted the Norfolk Sand Plain, south-west of Brantford, as an area of potential water stress. Agricultural irrigation, using water from groundwater-fed creeks, is common in this area. With the support of WMP partners, Farm & Food Care Ontario and others, a successful pilot project was initiated to move irrigation water sources from direct in-creek withdrawals to reconditioned, abandoned off-line ponds, reducing direct impacts on creek water levels. This pilot project effectively mobilized the

collective knowledge gained through previous technical studies, leveraged funding opportunities and built stronger working relationships and trust among the local farming community.

While an abundance of information and studies were available, the WMP partners recognized that there were some fundamental knowledge gaps. For instance, partners acknowledged the need to better understand the relationships among the physical, chemical and biological attributes of the river system. When the Canadian Water Network, a national centre of excellence that connects water research and knowledge to decision makers, issued a call for research proposals to establish a regional (watershed) monitoring framework focused on cumulative aquatic effects, the partners took advantage of the opportunity to address a key research gap and submitted a successful research proposal.

The Canadian Water Network provided CAD 600,000 to fund a three-year, multi-disciplinary research project in the watershed. The research will identify specific biotic indicators that can detect change induced by watershed stressors (e.g. population growth, land use change, changing climate) or management approaches (e.g. reservoir operations) and recommend an aquatic biological monitoring approach that builds on existing water quality and river flow monitoring. The results were received in 2015. It is anticipated that these findings will provide the cornerstone for an integrated monitoring framework for cumulative aquatic effects assessment in the Grand River watershed for consideration by the WMP partners.

Continuous improvement

The Project Charter emphasized the need for continued monitoring, assessment and reporting to support adaptive management and decision making. Adaptive management, in the context of the WMP, is an ongoing process for continually improving policies, programmes, and practices by learning from the outcomes of management actions. To determine whether management actions are having the desired effect on river health, a number of water quality indicators were selected, and associated targets and milestones for these indicators were developed (Grand River Water Management Plan, 2012, 2013).

Milestones are quantitative descriptions of future water quality conditions that are expected to result from the specific actions undertaken over a given timeframe (Project Team, Water Management Plan, 2014). Milestones will be used to gauge progress, whereas *targets* represent the end condition that supports ecosystem health. A review and rationalization of the collective monitoring undertaken by partners is required to determine whether there are sufficient data and information to report on the stated milestones.

The partners have acknowledged that the goals, objectives and targets set in the WMP may take decades to achieve. A key difference between the WMP and the Basin Study is the commitment by partners to an adaptive approach. This introduces a new generation of IWRM for the Grand River watershed. Regular reporting to assess the status of plan actions and on-the-ground effects is critical to continued engagement and a key component of the plan. Each partner has committed to providing regular updates to the Water Managers Working Group on the progress of their actions and any additional activities they have initiated in support of the WMP.

Currently, there is a commitment that the GRCA will assist the Water Managers Working Group in preparing an annual implementation progress report, starting in 2015, and

assembling a technical watershed report on the progress towards meeting milestones and targets every five years. These assessments will be used to adjust implementation strategies and actions to make them more effective and economical. Further, as knowledge gaps are addressed and new data, science, technologies or approaches are developed, there will be opportunities to adjust and improve the plan.

Conclusions

Many agencies in Ontario share responsibility for implementing IWRM. Collaboration among decision makers is required to align actions to achieve common goals. While innovative technologies and infrastructure investments can help solve water problems, the people responsible for all aspects of water management (the implementers) are central to achieving the goals. A coordinating agency, which can oversee the planning process, engage and galvanize partners, ensure effective use of time and resources and manage partner expectations, is critical to the success of a collaborative approach.

The process of updating the WMP brought the implementers to the table, fostered good working relationships and elicited respect and trust among the partners. This provided a foundation for open communication and shared experiences. The success of the process was manifested in well-attended workshops and meetings, synthesis of existing technical studies, update of computer models, development of communities of practice, commitment by the partners to undertake actions, and a formal endorsement of the final WMP.

The WMP was voluntary, driven by the desire of partners to continually improve and strive for common goals, in the public interest. A voluntary, collaborative process can be more progressive and innovative than a regulatory approach, since there is little risk to implementers in setting the bar just a bit higher and little fear in making adjustments if things change. Furthermore, the implementers were willing to align their actions with others to achieve the goals of the WMP because they maintained control of activities that affected them. In addition, actions were discussed in the context of 'best value' solutions – those actions that will give the best return on investment (although it was acknowledged that a more robust economic analysis is required). Many partners were willing to try new management approaches, such as the Composite Correction Program, based on the experiences and recommendation of other partners, and were able to realize cost savings through improved operations or deferral of capital infrastructure investments.

The Project Charter was the primary mechanism for obtaining initial buy-in and was a crucial first step towards collaboration by setting out the collective goals and guiding principles for partners. While the influence of several individuals who provided important support and leadership by sharing information with their agency counterparts and securing financial support is essential, the success of the WMP thus far is largely due to the commitment of the GRCA to facilitate and administer the process and rally the partners.

Sustaining a collaborative approach into the future will continue to be a challenge as agencies evolve and partner representatives change, and as fiscal, social and environmental priorities unfold. Regarding the former, a commitment to succession planning is needed so that knowledge is captured and transferred to new participants. Lack of such planning was one of the failings of the Basin Study. Long-term institutional commitment from all partners is required and needs to be continually fostered at all levels within partner agencies (e.g. technical staff and senior managers).

It is hoped that by taking an adaptive management approach, the value of voluntary collaboration will be reinforced through the process of monitoring, assessing and reporting on progress and successes. The commitment of the partners to continuous improvement and regular plan review and renewal is how the goals and targets for the Grand River watershed will ultimately be achieved. The challenge lies in maintaining the engagement of the partners and the commitment of the GRCA to continue to support the Water Managers Working Group despite competing priorities and periods of fiscal austerity.

Integrated watershed management is not easy, but it is a concept that has a multitude of practical applications that can achieve positive environmental, social and economic results, as illustrated by the successes achieved in the Grand River watershed.

Notes

1. Under the federal Indian Act, an 'Indian reserve' is land held by the Crown 'for the use and benefit of the respective bands for which they were set apart' (Section 18 (1)). Two reserves, the Six Nations of the Grand River Territory and the Mississaugas of the New Credit, are located just south of Brantford. The Six Nations reserve is the largest in Canada, with a land base of 18,000 ha and a population of over 25,000 people.
2. In 1973, the towns of Galt, Preston and Hespeler amalgamated to become the city of Cambridge.
3. The Mississaugas of the New Credit reserve does not obtain drinking water from sources in the Grand River watershed; rather, it is served by water drawn from Lake Erie, treated and distributed by pipe from Nanticoke, Ontario (Dupont et al., 2014).
4. Ontario has three types of municipalities, which include upper- and lower-tier municipalities within a two-tier structure, and single-tier municipalities. In the Grand River watershed, there are 7 upper-tier municipalities, 27 lower-tier municipalities and 5 single-tier municipalities.
5. Resilience, in the context of the WMP, refers to the longer-term capacity of a natural system or watershed to deal with change, either gradual or sudden, such as a large storm event, and continue to function as expected. Increasing the resiliency of a watershed requires new or modified beneficial practices, the safeguarding of green infrastructure, and improved management approaches to maintain or enhance the watershed's natural ability to function as expected (Project Team, Water Management Plan, 2014).
6. A Lakewide Action and Management Plan is a plan of action to assess, restore, protect and monitor the ecosystem health of a Great Lake. It is used to coordinate the work of all collaborating partners to improve the lake ecosystem.

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