Making Watersheds More Resilient to Climate Change
A Response in the Grand River Watershed, Ontario Canada:

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1.0 Introduction

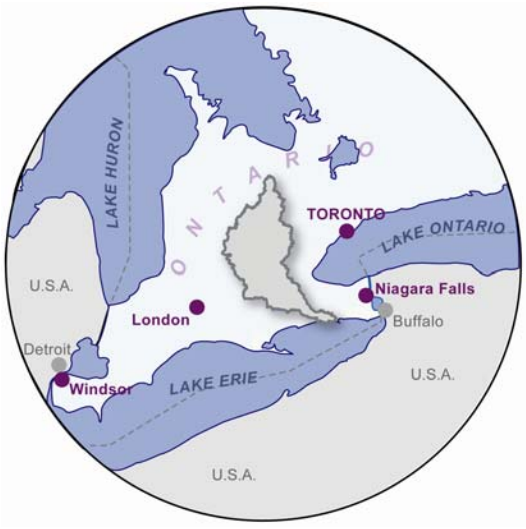
Each day we spend a little time talking about the weather. We think about the weather. We look at forecasts to decide what to wear when we go outside. We wear dark glasses when it is sunny outside and use umbrellas when it rains. In Canada we *weather* storms. We describe malaise as being *under the weather*. When we want to have casual conversations with friends, *we shoot the breeze.* When we are not sure what to say, we talk about the weather. We are fascinated with the weather.

With the release of the *Intergovernmental Panel on Climate Change Fourth Assessment Report* in 2007, and media attention around climate change, people are no longer just talking about the weather. We are starting to talk about climate change. More important, we are starting to speak about our individual and societal role in bringing about this change. We are beginning to understand and take ownership of the climate change issue. We are using phrases like: what can I do to make a difference?

2.0 The Grand River Watershed

It is expected that the Grand River watershed will be affected by climate change. With a drainage area of 6,800 square kilometres (km^2) the Grand is the largest watershed in southern Ontario. With its source in the Dundalk highlands, the Grand runs a course of 300 kilometres, before it reaches Lake Erie. Figure 1 shows the location of the Grand River watershed in relation to Southern Ontario.

Figure 1 – Grand River Watershed



The watershed is home to about 950,000 people, most located in the urban centers of Kitchener, Waterloo, Cambridge, Guelph and Brantford. A high growth area, the watershed is expected to support a population of over 1.4 million by 2031. Along with a thriving manufacturing and commercial economy, the watershed supports intensive agricultural production.

Agricultural and rural land uses predominate, with urban land uses concentrated in the central portion. In the Grand River watershed, 81 percent of the population lives on seven percent of the land, 93 percent of the watershed is rural. It is anticipated that despite population growth, agriculture will remain the major land use. There are approximately 6,000 farm operations in the Grand River Watershed.

Twenty-nine sewage treatment plants discharge to the Grand River and its tributaries. Coupled with variable weather, and runoff from agricultural and urban areas, signs of poor water quality are beginning to show in various reaches of the river. Population growth and the potential for impacts from climate change will continue to place high levels of stress on the river.

3.0 Precipitation in the Grand River Watershed

For many years the weather in southern Ontario has shown a high degree of variability. The Grand River watershed experiences warm periods, cool periods, wet periods, and dry periods.

On average, the watershed receives approximately 900 millimeters of precipitation per year. Figure 2 shows annual precipitation data from one climate station. Although 2008 is shaping up to be a wetter year, precipitation in the watershed is showing a ten year deficit of approximately 350 millimeters.

Figure 3 shows monthly precipitation data. The years 1998 and 2007 are particularly important, as they show very dry periods in the summer, when water temperatures peak. The resulting low dissolved oxygen level in the river, places stress on the aquatic communities.

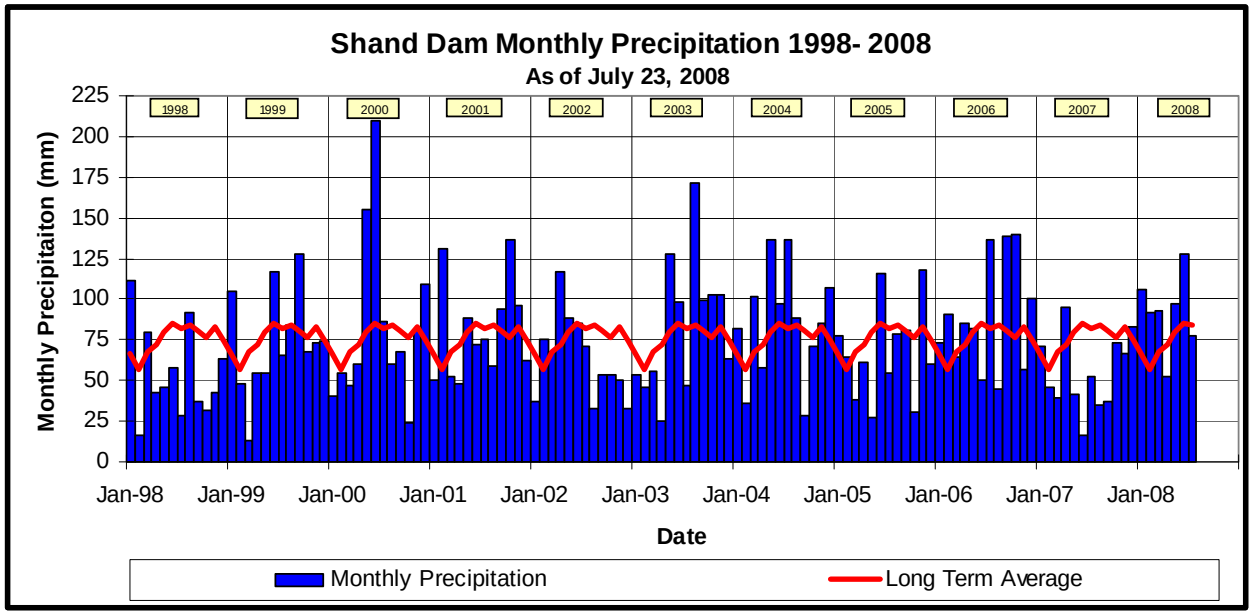
Figure 2 – Annual Precipitation at Shand Dam

Year	Annual total (mm)	Variance (mm)	Variance (%)
1998	648	- 260	- 29
1999	884	- 24	- 3
2000	994	86	10
2001	966	58	6
2002	765	- 143	- 16
2003	994	86	9
2004	1,027	119	13
2005	807	-100	-11
2006	1,063	155	17
2007	655	-253	-28
2008 [1]	645	133	26
total	9,951	-355	-3

[1] Data current to July 23, 2008

Note: Annual average from 1960-2007 is 908 mm

Figure 3 – Shand Dam Monthly Precipitation



4.0 Role of the Grand River Conservation Authority

Formed initially to deal with flooding and low water conditions, the Grand River Conservation Authority (GRCA) has a seven decade history of managing the resources in the Grand River watershed. Today the GRCA uses a mix of programs to achieve its vision: *A healthy and sustainable natural environment in the Grand River watershed.* The GRCA implements programs to improve water quality, reduce flood damages, maintain a reliable water supply, facilitate watershed planning, protect natural areas and biodiversity, and provide environmental education.

The Grand is a heavily managed river. The Grand River Conservation Authority operates seven multi-purpose reservoirs. The reservoirs serve two key functions: flood control, and supplying water to the river in periods of low flow (flow augmentation). Auxiliary benefits like hydro production and recreation result from the operation of the reservoirs. The reservoirs are filled in the spring with the runoff from the melting snow pack and the spring rains. Water is released over the summer and fall period to supply sufficient flow to the river to dilute treated effluent from the sewage treatment plants, provide sufficient water for municipal water supplies taken from the river and to maintain the river's ecological functions. The two functions of flood control and water supply have conflicting objectives. To provide flood control, as much available storage as possible is desired; to provide flow augmentation, as much water as can safely be stored in the reservoir is desired. To resolve these conflicting objectives, a reservoir operating policy has been developed.

In addition to active management of flow in the Grand and its major tributaries, GRCA runs several programs that impact the way water interacts with the landscape in the watershed. Although Conservation Services and Terrestrial Resource programs are highlighted in this paper, resource planning and engineering programs are involved in review of storm-water management plans, among other important activities related to watershed management.

5.0 Expected Impacts from Climate Change

The current climate change models are large scale models that do not account for the local or regional effects of the Great Lakes. The models are not equipped to provide precise regional or local scale predictions. In the absence of precise scientifically based forecasts, we can anticipate some of the potential impacts or changes. Quantifying the anticipated changes allows water managers to match adaptive strategies with expected impacts to improve watershed resiliency to potential impacts.

There is some uncertainty about the range or magnitude of impacts of climate change on the Grand River watershed. There is no clear evidence that the recent variances from average annual precipitation values are a result of climate change; nevertheless, these variances do create a challenge for water managers. Some of the potential impacts include:

5.1 Changes in precipitation patterns – There is potential for more extreme rainfall events, causing increased runoff, and leaving less water available to recharge groundwater. In addition, the extreme events have potential to cause localized flooding in urban centers, and flooding, soil erosion and crop damage in rural areas. Changes in rainfall patterns may also result in more frequent and prolonged periods of drought in the summer. Dissolved oxygen levels in the Grand River are very sensitive to flow rates and temperature. The low rainfall totals in the summers of 1998, 2002, and 2007 put pressure on the GRCA's reservoirs, challenging the ability to provide sufficient flows to maintain ecological health in the Grand.

5.2 Temperature changes – A shift in the average annual air temperature has potential to cause substantive impacts. Earlier warming in the spring would lead to a shift in the timing of the

snowmelt, leading to rapid melt, and riverine flooding. There is potential that the traditional late summer thunderstorms will shift into spring, when fields are bare and reservoirs are full, leaving little active storage available for flood control. In addition, warmer temperatures would increase the growing season, potentially moving high value row crops to areas historically planted in forage crops.

Overnight water temperatures are forecast to increase with climate change. Increased overnight water temperatures reduce the ability of water to retain dissolved oxygen placing further stress on the aquatic ecosystem.

6.0 Potential Watershed Response

With a change in precipitation patterns and air temperature, a response from the watershed can be expected. The range of potential responses includes:

6.1 Increased flooding and erosion – Even if the annual precipitation totals remain the same, but occur in more intense, high volume rainstorms the watershed will respond with higher runoff rates. In the Grand this would lead to higher levels of surface erosion and stream-bank erosion. High intensity storms also generate flash flooding, particularly in the urban areas. Higher runoff volumes would lead to a corresponding reduction in water available for recharge to groundwater. This would result in lower base flows, especially in those reaches of the tributaries that have no support from the reservoir discharges.

6.2 Reduced fisheries, wetland and marsh habitat – With less available water there is potential for reduced water quality, leading to impacts on the in-river aquatic communities. Also, there would be changes in the composition and quality of riparian wetland. Reduced groundwater recharge rates would affect those wetlands that depend on shallow groundwater for their water supply.

7.0 Preparing for Change

Before we can adapt, we must understand. The 1982 *Grand River Basin Water Management Study* has been an effective guide over the past quarter century. With the mounting pressures of population growth and climate change, it is time to update the plan. The three key focal points of the update will be flood control, water quality, and water quantity. The watershed plan update will provide an opportunity to confirm a collective vision of what the Grand should look like in the future.

The GRCA has a long history of on-the-ground delivery of conservation programs. With uncertainty around climate change, and the pressures of population growth, it will be important to continue efforts to build resilience in the watershed's ecosystem. In this paper, *building resilience* refers to actions that can be applied to reduce the negative impact of climate changes and normal climate variability. Key to these efforts is the implementation of tried and true conservation practices.

It will be necessary to evaluate the GRCA flood control and flow augmentation infrastructure and determine if current operating policies and procedures will serve the watershed needs into the future. It will be necessary to review design standards to ensure storm-water is delivered from the landscape to a safe outlet. It will be necessary to review existing emergency response plans, to prepare for extreme flood events.

Implementing tried and true conservation practices is a key element in building watershed resilience. The GRCA currently carries out watershed restoration programs in the forestry departments and through the Rural Water Quality Program (RWQP). Some of the effective practices are:

- Implementing riparian buffers
- Planting trees
- Enhancing and restoring wetlands
- Restricting livestock access to watercourses
- Putting more water storage back on the landscape

The Rural Water Quality Program is the first source water protection program in Ontario funded by municipalities to improve and protect water quality in upstream areas. The program is built on partnerships with the agricultural community and recognizes the role of the landowner as steward of the land. There is an intrinsic understanding that practices carried out on agricultural lands can maintain and protect water quality for the future. It is a program with a broad vision that empowers and embraces the actions of landowners.

The development of the Rural Water Quality Program has been a collaborative process involving input from several local farm organizations and provincial organizations. The farmer representatives designed the program to meet the needs of local farmers while at the same time improving and protecting water quality. The program funds a variety of best management practices. One key element of the program's success is the one-on-one service delivery model. GRCA extension staff members meet with individual landowners, and develop project plans that are specific to the site, and the farmer's practices, and operational constraints. Staff members employ a *people, not paper* perspective, developing solutions that fit the needs of the farmer.

Across the Grand River watershed there have been more than 2,190 projects implemented by rural landowners. Watershed municipalities and other agencies have invested approximately $7 million in the projects. Landowners have contributed more than $14 million to the projects. Using rough estimates these projects have kept over 56,500 kilograms of phosphorus on the land. Approximately 400 hectares of fragile land has been retired from agricultural production and planted to trees. This includes riparian areas, wetland buffers, steep slopes and areas or groundwater recharge and discharge.

Over the past ten years, many lessons have emerged from the start-up and implementation of the RWQP. The need to involve all stakeholders is critical to the success of this program as is the investment of time to cultivate a common understanding and language amongst the partners. There is a need to have champions and to develop "believers" in not only the farm community, but at the municipal staff level and political level. To overcome barriers, programs need to have long horizons. This allows landowners to develop trust in the process and to properly plan for their investments. It also instills a level of credibility in the staff, the funding program and the organization. Consistency and continuity are critical to success.

Environment Canada reports that 30 per cent forest cover is required to maintain a healthy ecosystem. Although the Grand River forest was once reduced to five to six per cent of the land cover, it currently stands at 19.3 per cent (*A Watershed Forest Plan for the Grand River, 2003, GRCA*). Efforts continue to increase this value. The GRCA runs an effective private lands forestry program, whereby staff work with landowners to establish trees on their property. There has been a shift away from large block monoculture tree plantings to a more diverse planting, which more closely mimics a natural forest. Native species plantings are a key component of the program, and GRCA runs a nursery to ensure an adequate source of seedlings. As a major land-holder, the GRCA continues its efforts to plant trees and restore lands. Also, restoration activities often include some land shaping or grading, to promote the development of micro-habitats and increase opportunities for groundwater recharge.

8.0 Building Resilience in the Watershed

This section shows examples of a number of practices employed to build resilience in the Grand River watershed. The photos illustrate the practice or activity, and the text describes the benefits. More hands make lighter work. Engaged local land owners can help contribute to practical solutions or strategies. Often local land owners want to contribute, and there are plenty of opportunities to be involved. Climate change is a big challenge, the more residents that become engaged the better the odds we can rise to the challenge. Actions to date include:

8.1 ***Implementing riparian buffers*** is the practice of planting a vegetative buffer adjacent to a watercourse. The upper photo shows a farm stream, with tillage up to the top of the bank. The lower photo shows that same stream after the establishment of buffer on either side of the stream. In this case, the buffer is a forage crop that can be used to feed livestock. In addition to providing aquatic habitat, many of the watershed's streams remove runoff from farm fields, and water from sub-surface tile drains. Normally trees are planted on only one side of these *working drains* to allow continued access for maintenance equipment.

Before the buffer

After

The benefits of the riparian buffers are:

- Reduced stream bank erosion
- Reduced maintenance of the channel, as sediment captured in the buffer does not travel into the channel
- Increased habitat for aquatic organisms
- Increased water quality, as nutrients are trapped in the vegetative buffer

8.2 ***Tree planting programs*** have their roots in the early years of the GRCA, when it was recognized that re-establishing the watershed forest was intimately linked with watershed health. Today, in addition to organizing tree planting for landowners, the GRCA organizes several community tree planting events each year.

The photo to the right shows children from a watershed school planting trees adjacent to a highly impacted stream. Note the new fence, which will limit livestock access to the stream. Not only do the children prove to be effective workers on the project, they come to understand why it is important to plant trees. With this early exposure to the values of tree planting, these young people have an opportunity to carry what they learn when they become some of the watershed's farmers.

8.3 ***Enhancing and restoring wetlands*** is accomplished by grading the land and planting wetland vegetation. The Grand River watershed has lost many of its historic wetlands. Although there is protection in place for existing wetlands, there is still an opportunity to enhance degraded wetlands.

Benefits include increase wildlife habitat, increased potential to uptake and utilize water-borne nutrients, and increased biodiversity.

8.4 Restricting livestock access to watercourses continues as one of the most visible activities under the Rural Water Quality Program. To date, over 116 kilometers of stream has been fenced to restrict over 10,000 head of livestock from watercourses.

The benefits include reductions in stream-bank erosion and direct pollutant loading to the watercourse. If a riparian buffer is included in the project, all its benefits accrue as well.

The upper photo on the right shows a stream with highly trampled banks, with very little vegetation. The lower photo shows that same stream after livestock (cattle) have been excluded. The vegetation will eventually grow to provide shade to the stream, lowering the potential for solar warming, and increasing aquatic habitat.

The natural buffer reduces erosion during extreme events and is self healing after these events.

Before fencing

After fencing

8.5 Putting more storage on the landscape is achieved by including land grading in restoration projects. The photo to the right shows a project with several small constructed depressions in the ground, imitating the hummocky terrain of the watershed moraines. These pools fill up during rainstorms, and provide specialized micro-habitat. In addition, there is an opportunity for water trapped in the pools to recharge groundwater, rather than running off directly to the river.

9.0 Concluding Remarks

There is some uncertainty about the potential impacts of climate change in the Grand River watershed. A current watershed plan will be an important tool in identifying a vision of the Grand River into the future. There is a need to have an effective program to monitor watershed health, and modify land restoration programs, to optimize the benefits from the resources expended. In the mean time, building resilience in the watershed's ecosystem will be a key component in ensuring the watershed is best prepared to respond to the coming pressures of climate change.