Wastewater management planning in the Grand River Watershed

An innovative watershed model supports decision making

The City of Guelph's wastewater treatment plant located beside the Speed River

High Level Results

- The Grand River Simulation Model is a decision support tool that assists with evaluating the cumulative effects of multiple wastewater treatment plant discharges combined with rural and urban non-point sources of nutrients.
- River water quality will significantly improve as a result of planned wastewater plant upgrades
- Improved operation or optimization of wastewater treatment plants will further improve river water quality.
- Managing rural and urban non-point sources will improve river conditions, especially in the spring and reduce the amount of phosphorus getting into Lake Erie.

"*The Grand River Simulation Model is an effective tool that helped the Region of Waterloo plan future wastewater treatment requirements*"

Nancy Kodousek, Director,
Water Services, Region of Waterloo

Project Context

The Grand River watershed has a population of about 985,000 (2014) that is expected to reach 1.53 million by 2051. There are 30 wastewater treatment plants that discharge their treated effluent into rivers in the watershed. Significant population growth will result in more treated sewage being discharged into these rivers. This, combined with increased agricultural production, urban expansion and a changing climate, will have implications to the continued health of the river system and the prosperity of watershed communities.

This project demonstrates an approach to evaluate and plan for the cumulative effects of multiple wastewater treatment plants, and rural and urban non-point sources of pollution in the central Grand River region.

Challenge

There are ten municipal wastewater treatment plants that discharge treated sewage effluent into the central Grand River and lower Speed River. The urban footprint of this region is significant and the cumulative inputs can cause water quality problems (Figure 1). In addition to receiving treated wastewater, the rivers in the central region also receive urban stormwater and nutrients from upstream rural runoff.

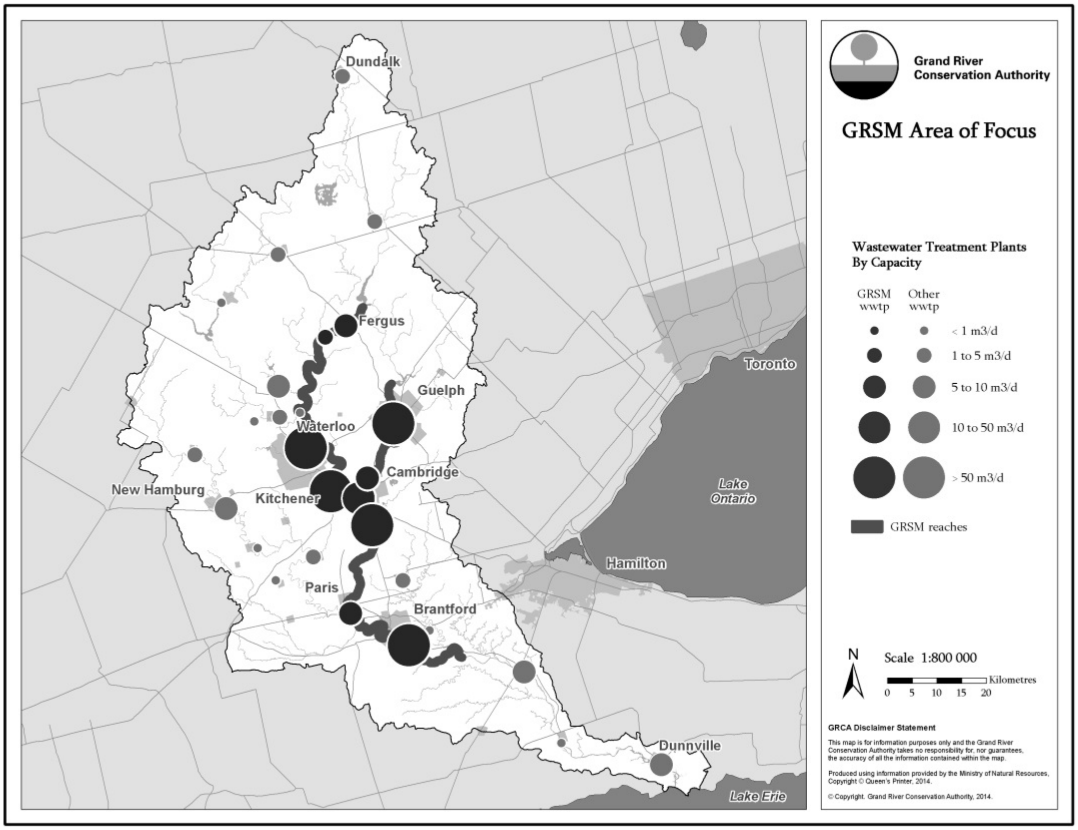

Figure 1. The Grand River watershed showing the extent of the Grand River Simulation Model on the Grand and Speed rivers. Wastewater treatment plants are also shown and their corresponding size (capacity).

The ten wastewater treatment plants service over 740,000 people, which represent about 75 per cent of the watershed's population. Over the next 25 years, the population in this region is expected to grow, placing more stress on these rivers to assimilate even more treated effluent and nutrients from rural and urban non-point sources.

A decision support tool – the Grand River Simulation Model – was used to evaluate the cumulative effects of various point and non-point source management scenarios for the central Grand River region. This approach helps to effectively plan for future population growth and identify best value solutions for improving future river water quality.

Project Goals

The Ontario Ministry of the Environment and Climate Change's Showcasing Water Innovation Program provided an opportunity to demonstrate the Grand River Simulation

Model for watershed wastewater management planning. This model has been a long-standing tool to help water managers evaluate various wastewater management scenarios to identify best-value solutions. The Grand River and its tributaries accept and assimilate the nutrients from multiple sources – wastewater discharges, urban stormwater and rural runoff. The goal of the project was to determine future water quality conditions in the Grand and Speed rivers by evaluating multiple wastewater treatment scenarios for the ten wastewater treatment plants in combination with rural and urban non-point source management approaches.

Solution

A working group of municipal wastewater managers and technical experts from the Ontario Ministry of Environment and Climate Change was established to assess future water quality conditions based on various wastewater treatment and rural/urban runoff management scenarios. The Grand River Simulation Model was used to evaluate seven scenarios:

1. The Base Case – current effluent loadings
2. 2031 Future Effluent Loadings that includes planned treatment plant upgrades
3. 2031 Optimized Future Effluent Loadings that includes planned upgrades and optimization of plant processes
4. 2031 Future Effluent Loadings and reduce rural non-point sources by 10%
5. 2031 Future Effluent Loadings and reduce rural non-point sources by 25%
6. 2031 Future Effluent Loadings and reduce urban non-point sources by 20%
7. 2031 Future Effluent Loadings and reduce urban non-point sources by 40%

The Grand River Simulation Model (GRSM) was first developed by the Province and the Grand River Conservation Authority (GRCA) in the 1970s and has been enhanced and updated continuously since then. The GRSM is a dynamic, one-dimensional stream water quality model for estimating changes in nutrient and dissolved oxygen concentrations, taking into account multiple point and non-point sources.

The model simulates the growth of the three predominant species of rooted aquatic macrophytes (weeds) that are found in the Grand and Speed rivers and various water quality parameters. Parameters include dissolved oxygen; carbonaceous biochemical oxygen demand; nitrogenous biochemical oxygen demand; un-ionized ammonia; nitrate; total phosphorous; and suspended solids. The model predicts what the future river water quality conditions may be depending on the various scenarios described above. The approach provides valuable information for future wastewater treatment requirements and options for managing other sources of nutrients like rural and urban stormwater.

Results

The assessment considered the cumulative effects of population growth on wastewater effluent quantity and quality, and urban and rural non-point sources of nutrients.

Scenarios included effluent improvements from planned infrastructure upgrades and the outcomes of optimizing wastewater treatment plant processes to achieve a higher quality effluent. Wastewater optimization is a continuous improvement process that can result in improved plant performance and higher quality effluent through the application of strategic knowledge, process control concepts and problem solving techniques. For additional information see Case Study - The Grand River Watershed-wide Wastewater Optimization Program.

Non-point source management strategies relied on adjustments of the nutrient loading (e.g. 25% reduction of nutrient loading) from rural and urban areas as there was no information or approaches available to translate the bulk nutrient load adjustment to on-farm best management practices required to reduce nutrient loads. Future work for Water Managers will target linking the Grand River Simulation Model with upstream landscape or non-point source models to identify what practices would have to be applied in specific areas to achieve a 10% or 25% reduction in non-point sources.

Water quality in the Grand River watershed will improve. Planned wastewater treatment plant upgrades will go a long way to improve the water quality in the central Grand River watershed, especially in the summer. In addition, operational improvements through wastewater treatment plant process control and optimization will further improve water quality in the river. Figure 2 shows the concentration of phosphorus in the river being reduced with planned upgrades and improved operations. Wastewater managers saw the utility in investing additional operational funds to defer major capital infrastructure investments to see additional river water quality improvements. However, it was recognized that there is a point at which plant upgrades are no longer the most cost effective means of improving water quality.

In the spring, runoff from rural and urban areas is a significant source, or load, of nutrients to the river and Lake Erie downstream. A nutrient load reduction from rural areas was shown to reduce phosphorus and sediment levels downstream in the Grand River during the spring. Results for evaluating nutrient and sediment load reductions from urban areas were less conclusive at a watershed scale, although it appears that urban stormwater quality impacts are important locally. However, wastewater managers acknowledged that the reduction in the amount of non-point sources of nutrients from both rural and urban areas through the adoption of best management practices will ultimately aid in improving downstream river water quality.

A report – An assessment of future water quality conditions in the Grand and Speed rivers[1] – summarizes the results of the scenarios. This information has helped wastewater managers make decisions on what the best value solutions are for managing both point and non-point sources in the central Grand River region to achieve the Grand River Watershed Water Management Plan's goal to improve water quality.

[1] http://www.grandriver.ca/waterplan/TechBrief_AssimilativeCapacity_2012.pdf

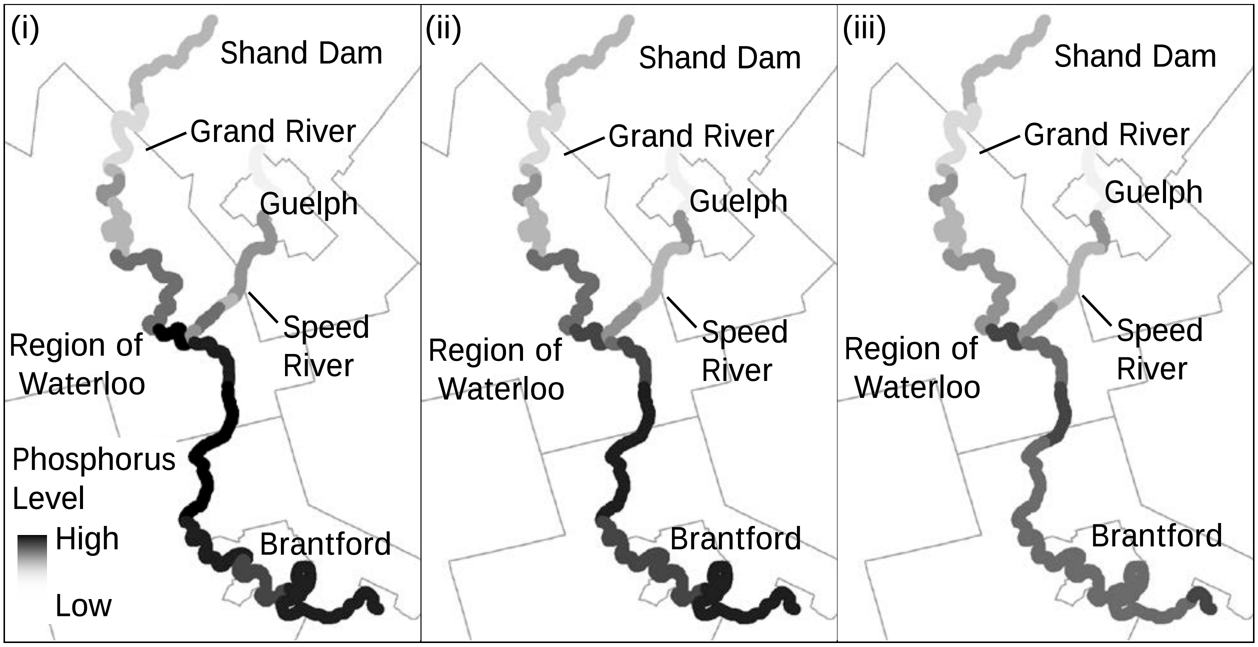

Figure 2. Summer phosphorus concentrations in the river are expected to decrease as a result of plant upgrades and optimization. Predicted phosphorus concentrations in the Grand and Speed Rivers under (i) current conditions (2011); (ii) following the implementation of planned upgrades to the plants; and (iii) following planned upgrades and optimized performance of the plants.

Lessons Learned

The study brought municipal wastewater managers, conservation authority and Ministry of the Environment and Climate Change staff together to develop a common understanding of the state of water quality in the watershed and what the future conditions may be, based on individual municipal wastewater master plans. Having all partners at the table was essential to produce reasonable wastewater management scenarios for the watershed and it created a broader understanding of the potential outcomes.

The forum for discussing municipal wastewater management strategies was coupled with the discussion regarding the need for non-point source management strategies. The outcomes resulted in a strengthened commitment to rural non-point source management strategies like GRCA's Rural Water Quality Program and acknowledged the need for initiating discussions with urban stormwater managers.

Evaluating the cumulative inputs of multiple wastewater treatment plants and rural and urban non-point sources was necessary for a river system where the capacity of surface water resources to assimilate nutrients from multiple sources is finite. This analysis allowed best value solutions to be found that included actions other than costly investments in infrastructure upgrades.

The quality of effluent from wastewater treatment plants is regulated by the Ontario Ministry of the Environment and Climate Change. However, the effluent criteria for each wastewater treatment plant are established for each plant individually without necessarily taking into account the cumulative impact of other wastewater plants in the area. The number of wastewater treatment plants using the Grand River and its tributaries in addition to the significant contributions from non-point sources warrants a broader approach to managing the cumulative impacts. Provincial policy is required to be updated to assist with evaluating both point and non-point sources collectively to determine the best value solutions.

Next Steps

There is a commitment by the Water Managers Working Group – a consortium of municipal water managers, provincial and federal staff and the Grand River Conservation Authority – to maintain and continuously improve the Grand River Simulation Model for future wastewater master planning and water quality assessments.

Data collection continues by the Conservation Authority to ensure appropriate and sufficient data are collected to calibrate and validate the model. In addition, ongoing collaboration with university researchers will strengthen and improve the knowledge and understanding of in-river nutrient, dissolved oxygen and aquatic plant growth processes which will strengthen and improve the algorithms in the model over time.

Water managers continue to discuss linking the GRSM to other decision support models for improving decisions regarding rural and urban non-point source management strategies. Additionally, there is discussion among the partners whether the GRSM can be coupled with other tools and approaches to assist with modelling fluvial lake processes in the southern Grand River.

Application for Ontario Communities

The approach for assessing the assimilative capacity of a river using the GRSM can be applied to other river systems where nutrients are a concern, dissolved oxygen concentrations are highly variable and primary production of the system is dominated by rooted aquatic plants.

The GRSM program is available for download on the GRCA website (www.grandriver.ca) and the source code is available under a standard data license agreement.

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