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Utilizing intensive monitoring and simulations for identifying sources of phosphorus and sediment and for directing, siting, and assessing BMPs: The Genesee River example

J.C. Makarewicz *, T.W. Lewis, M. Winslow, E. Rea, L. Dressel, D. Pettenski, B.J. Snyder, P. Richards, J. Zollweg

The College at Brockport, State University of New York, USA

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ABSTRACT

An assessment of sediment and phosphorus concentrations and load, identification of phosphorus allocation and sources, and the effectiveness of management practices on the main stem (Upper Genesee River, Lower Genesee River) and on the four major Genesee tributaries (Canaseraga, Honeoye, Black, and Oatka Creeks) were conducted. The P load allocation analysis indicated that 60% of the total phosphorus load to Lake Ontario was due to anthropogenic sources and that only 40% was due to natural sources. With a P load of 412,505 kg P/yr, the Genesee River carries the second highest load, after the Niagara River, to Lake Ontario. Such a large P load of anthropogenic origin suggested that a managed reduction in P loss from the Genesee watershed is possible. SWAT was employed to test the effectiveness of best management practices (BMPs) on land use and to determine the minimum potential phosphorus concentration expected in the subcatchments. Simulations of BMPs on both point and nonpoint sources indicated that phosphorus could effectively be maintained within the watershed and out of Lake Ontario, where elevated phosphorus stimulates algae production and is implicated in beach closings in the Rochester Embayment AOC. Using our most effective simulated scenario of grassed waterways and upgrading of wastewater treatment plants to tertiary treatment, a 32.9% (135,714 kg P/yr) reduction in P loading to the nearshore of Lake Ontario was predicted. With this reduction in P, concentrations of 65 μg P/L, which is within the debated target goal of 65 μg TP/L in NYS, were also predicted.

Introduction

Excessive nutrient inputs from tributary watersheds are often linked with persistent degradation in the nearshore waters of large lakes (Makarewicz and Howell, 2007). Tributary discharge plumes, a pervasive feature of the nearshore, are spatially variable, with the predominating alongshore currents frequently orienting water quality gradients parallel to the shoreline away from tributary mouths. Even smaller tributaries, by themselves and cumulatively, may have a major impact in the coastal zone — bays, river mouths, and the nearshore itself. Considerable variability in nutrients, major ions, suspended solids, and *Escherichia coli* observed throughout the nearshore of large lakes correlated with proximity to the shoreline and among geographic areas (Howell et al., 2012a). For example, this thin band of tributary-influenced nearshore water with a unique and often elevated but variable nutrient chemistry, temperature, specific conductance, TP, and turbidity extends up to 4 km from the shoreline into the open waters of the southern coast of Lake Ontario during the late spring and summer (Makarewicz et al., 2012b, 2012c). In years where a spring thermal bar developed, phosphorus and suspended solid flux from tributaries contributed to elevated turbidity and P concentrations on the shoreside of the thermal front that were not immediately transported to the lakeside of the thermal front (Makarewicz et al., 2012d). Howell et al. (2012b) built on this characterization of nearshore water quality and demonstrated the influences of tributary discharge, wastewater outfalls, circulation, and lake biology on observed water quality patterns. Transport of nutrients and sediments from watersheds via streams to lakes is important in determining the timing and extent of nutrient availability and in structuring the biological communities such as the benthic algae *Cladophora* and dreissenid mussels found in the nearshore region. That is, the plume of river water into the nearshore zone of large lakes generates a constant but variable source that increases the inventory of TP, bioavailable P, and other nutrients (Makarewicz et al., 2012c). The impact of large tributaries and the cumulative impact of numerous small streams on the nearshore of large lakes as drivers of nearshore conditions have become more evident (Makarewicz and Howell, 2012; Larsen et al., 2013).

These tributary impacts are evident along the south shore of Lake Ontario. For example, the Rochester Embayment Area of Concern, which receives water from the Genesee River, is impacted by benthic blooms of large algal mats leading to beach closings and diminished esthetic value as well as contributing to aquatic habitat degradation that greatly influence fish, benthos, and phytoplankton populations

* Corresponding author.
E-mail address: Jmakarew@brockport.edu (J.C. Makarewicz).

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(Makarewicz and Howell, 2012). With the second largest phosphorus load to Lake Ontario after the Niagara River (Makarewicz et al., 2012a), the Genesee River is likely a major cause of many of the beneficial use impacts observed. The necessity of current and detailed information on tributary and other surface water discharges to the shores of a large lake, such as Lake Ontario, is self-evident if nearshore water quality and lake trophic state are to be managed for the beneficial use of society (Makarewicz and Howell, 2012).

A key to understanding the nature of water quality issues in the nearshore of Lake Ontario and large lakes in general is an appreciation of the inputs and transport mechanisms of nutrient runoff from watersheds to a lake. Study designs capable of resolving the variable scales of land effects on water quality are needed. To achieve this goal, we developed a robust data set on the Genesee River by monitoring the Genesee from August 2010 to August 2012 in an ongoing study generally referred to as the Genesee River Watershed Project. Sampling was conducted at numerous sites along the river and its tributaries with analyses focused primarily on total suspended solids (TSSs) and total phosphorus (TP) concentrations and loads of six subbasins: Black Creek, Oatka Creek, Canaseraga Creek, Honeoye Creek, the Upper Genesee River, and the main stem of the river (Lower Genesee River) which included storm runoff water from the City of Rochester (Fig. 1).

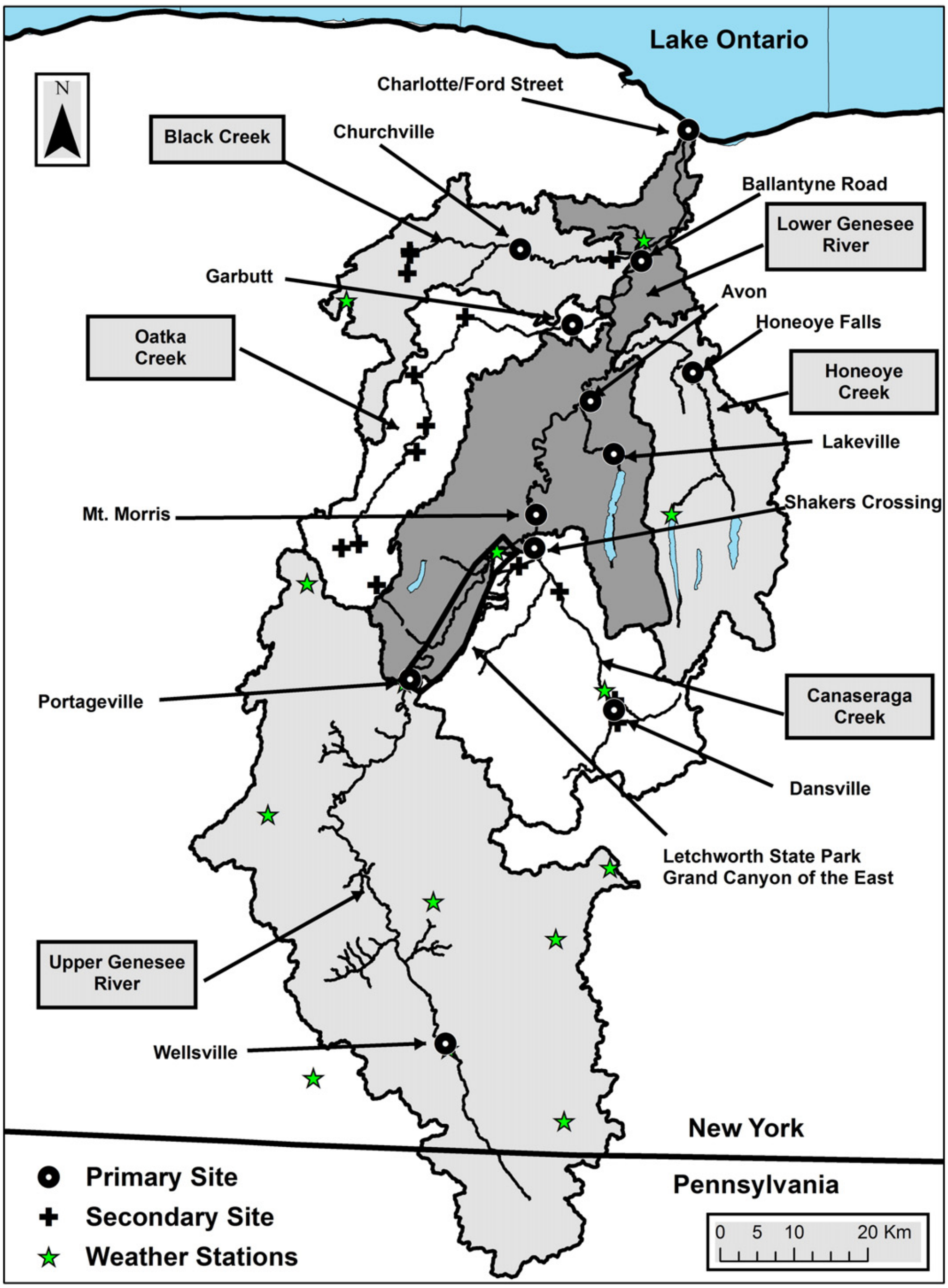

Fig. 1. The Genesee River watershed showing locations of weather stations, the primary and secondary water sampling and flow monitoring sites, and the subbasins of Black, Canaseraga, Honeoye, and Oatka Creeks and the Upper Genesee and Lower Genesee Rivers. Water samples were taken at both the primary (USGS flow gaging stations) and at the secondary (non-USGS flow gaging stations) sites. Modified from Makarewicz et al. (2013a).