# Determining Waste Load Allocations for Water Bodies by Combining an In-stream Nutrient and Macroinvertebrate Model with SWAT

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## Introduction

The Clean Water Act requires states to identify water bodies that do not meet water quality criteria for their designated use (human consumption, aquatic life support, recreational use, etc.) and develop total maximum daily loads (TMDLs) as a way to control pollutant influx to receiving bodies. Watershed scale models that tie anthropogenic, geochemical, and hydrologic activity to changes in chemical water quality are widely used to develop TMDLs and policy mechanisms to restore water quality. Current trends in water quality monitoring of streams and lakes have moved from exclusively chemical sampling (total nitrogen, total phosphorus, dissolved oxygen) to biological sampling due to the low resource requirements and the ability to capture long-term water quality through biological sampling.

## Study Area

Black Creek is located in western New York passing through Wyoming, Genesee and Monroe counties before reaching the Genesee River at Rochester, NY. In 2004, the New York State Department of Environmental Conservation (NYSDEC) listed both upper and lower Black Creek as an impaired water body with phosphorus listed as the contributing cause.

**Table 1. Features of the each watershed**

| | Black Creek | Oatka Creek | Little Tonawanda Creek |
|---|---|---|---|
| Drainage Area | 202 mi² | 200 mi² | 22 mi² |
| Annual Precipitation | 903 mm | | |
| Average Temperature | 14.3 °C | | |

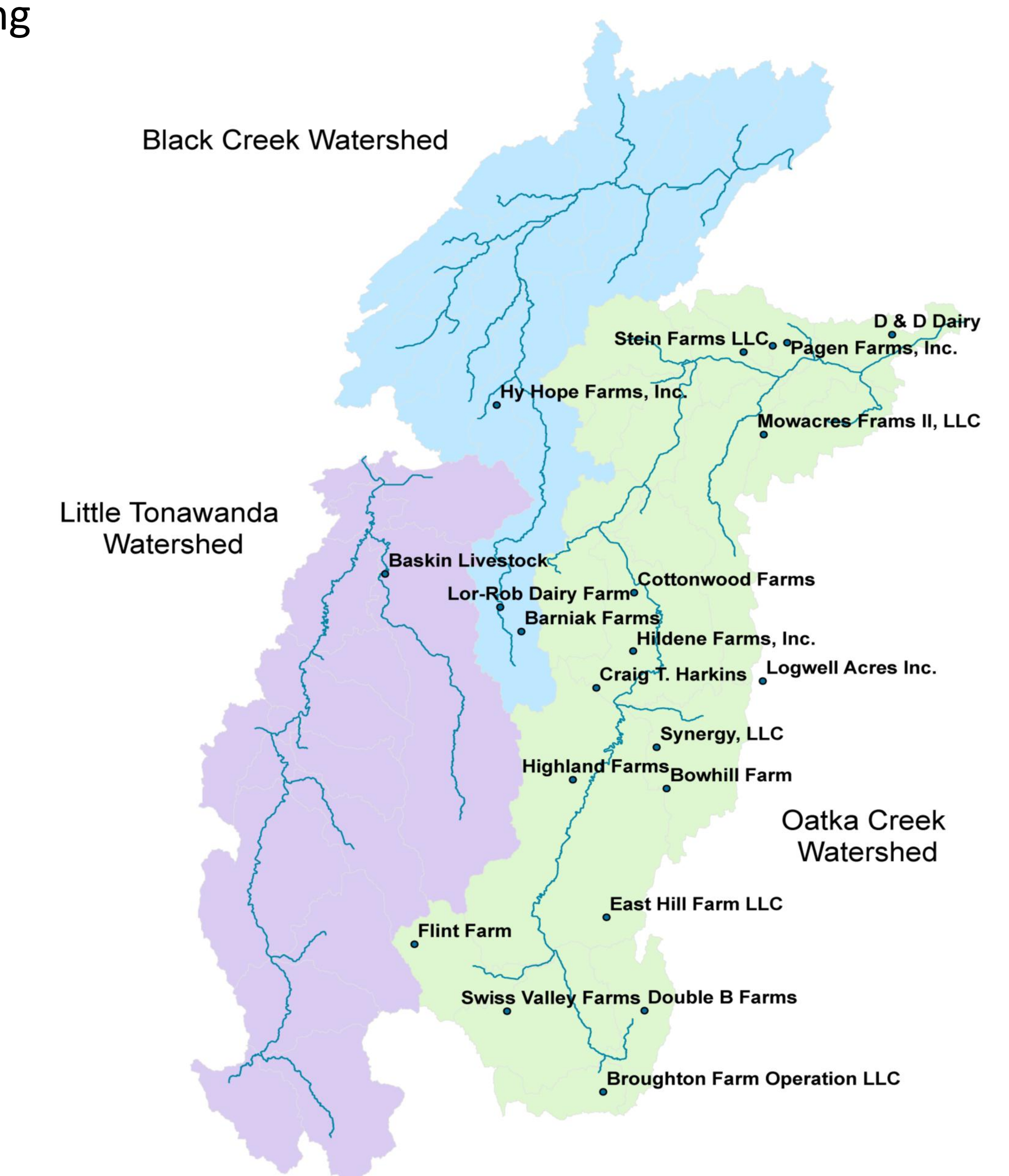



Figure 1. Watersheds used in study and locations of large and medium CAFOs.

## Using the Soil and Water Assessment Tool (SWAT)

The Soil and Water Assessment Tool (SWAT) is a widely used model for TMDL development. This semi-distributed, mechanistic model created at the Texas A&M University simulates hydrologic activity, pollutant transport and transformations, and climate impacts on water resources. It uses QUAL2E developed by Brown and Barnwell to route in-stream nutrient transformations based on land based inputs.

We are using SWAT 2009 with the ArcMap10 interface. The 2006 National Land Cover Dataset (NLCD) was combined with a 10 arc second digital elevation model and FAO world soil database to run the model. A topographic index was created for the project to better predict surface runoff from saturated areas. See maps in Figure 3.

***Advantages of SWAT:***

- Accepted use as TMDL tool
- Open source availability
- Worksbetter with agriculturally based watershed
- Integrates management practices

***Disadvantages of SWAT:***

- No ecological component
- Unreliable nutrient transformation simulation

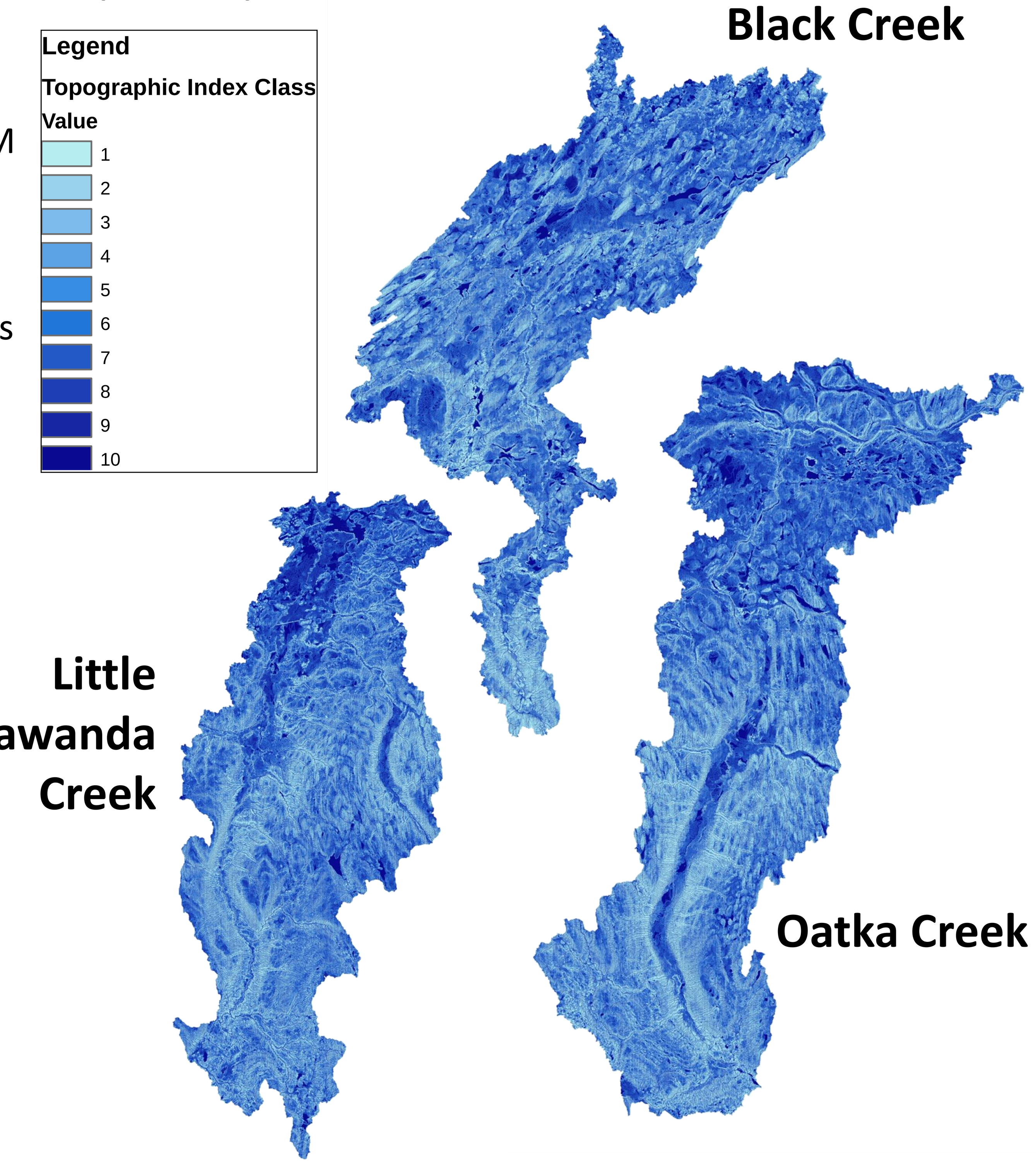



Figure 3. Black, Oatka, and Little Tonawanda Watersheds with calculated topographic index.

## Macroinvertebrates as Indicators

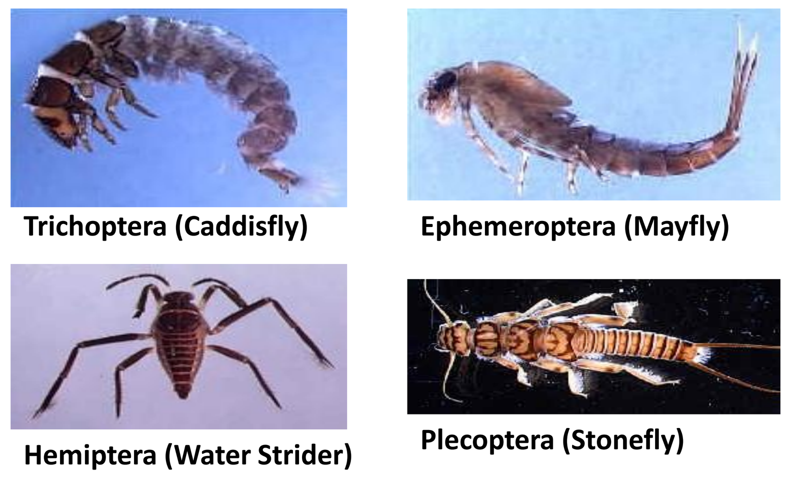



Figure 2. Examples of macroinvertebrates used iin biological assessments.
Photos from NYSDEC Stream Biomonitoring Unit (http://www.dec.ny.gov/animals/35772.html)

Chemical sampling only provides a snapshot of the current stream conditions and are relatively expensive and require frequent sampling in order to make accurate conclusions about nutrient fluctuations in streams. In response to the short comings of chemical sampling, biological sampling is growing in use. Because if their lack of mobility in streams , relatively long life cycle, and low cost of sampling, macroinvertebrates have emerged as a group that can supplement water quality assessments.

NYSDEC has chosen to use a multimetric approach to determine stream health called the biological assessment profile (BAP). Four different parameters species richness, EPT richness, Hilsenhoff Biotic Index and Percent Model Affinity (descriptions in Table 1 ) are calculated. BAP scores are determined by taking a weighted average of these values.

**Table 2. Assessments used to calculate biological assessment profiles (BAP) for streams in New York State**

| Measure | Ranges for Impairment | Description |
|---|---|---|
| *Species Richness* | Non-impacted >26<br>Slightly impacted 19-26<br>Moderately impacted 11-18<br>Severely impacted <11 | Total count of taxa in sample |
| *EPT Richness* | Non-impacted >10<br>Slightly impacted 6-10<br>Moderately impacted 2-5<br>Severely impacted 0-1 | Total count of Ephemeroptera, Plecoptera, and Trichoptera (EPT) |
| *Hilsenhoff Biotic Index* | Non-impacted 0-4.50<br>Slightly impacted 4.51-6.50<br>Moderately impacted 6.50-8.50<br>Severely impacted 8.51-10.00 | Tolerance values are assigned to each species and used to calculate an overall tolerance |
| *Percent Model Affinity* | Non-impacted >64<br>Slightly impacted 50-64<br>Moderately impacted 35-49<br>Severely impacted <35 | Measures similarity to non-impacted reference sample |

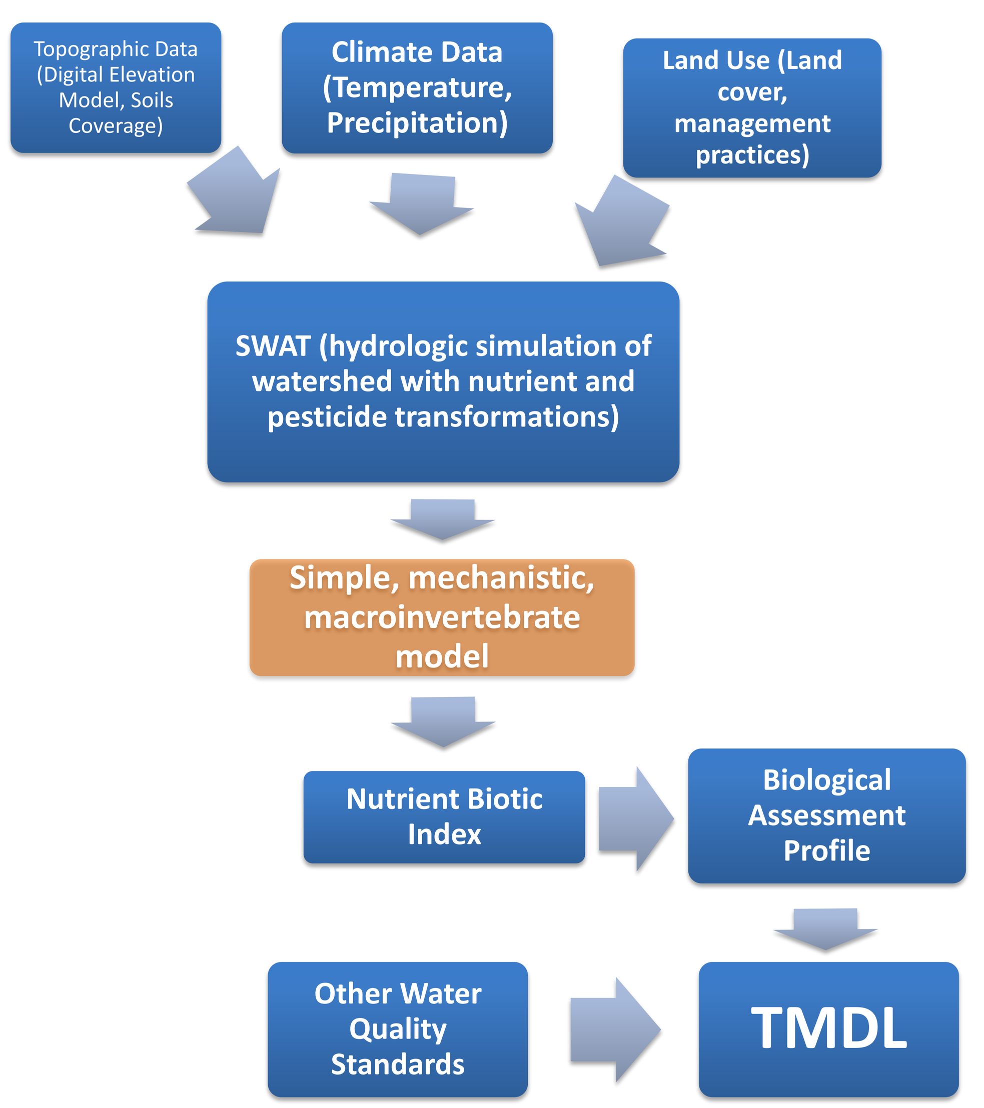
*Adapted from NYSDEC 30 Year Trends in Water Quality of Streams and Rivers in New York State[a]*

## Future Research

Our goal is to develop an in-stream macroinvertebrate model that links watershed characteristics to changes in biological profiles to help decision makers set numerical criteria for TMDLs. Current macroinvertebrate models are not integrated into the TMDL framework. Previous sampling events on Black, Oatka and Little Tonawanda Creeks in conjunction with additional sampling measures in the Summer of 2012 along Black and Little Tonawanda Creek will provide a baseline to calibrate and verify our model.

***Goals for Macroinvertebrate Model:***

- Develop easy to use model from widely used and available programs
- Limit required inputs to reduce resources needed for assessments
- Make model adaptable to other TMDL cases
- Incorporate management practices

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**References:** [a]New York State Department of Environmental Conservation. 30 Year Trends Report of River and Stream Water Quality in New York State: 1972-2002. [b]Chu, TW, Shirmohammadi, A, Montas, H, and A. Sadeghi. Evaluation of the SWAT model's sediment and nutrient components in the piedmont physiographic region of Maryland. Transactions of the ASABE. Vol. 47(5): 1523–1538