



Potential for treatment wetlands to reduce non-point source nitrogen loads on a watershed scale: Modeling the Conestoga River watershed, Pennsylvania, USA

1 C. Woltemade

Department of Geography-Earth Science, Shippensburg University, Pennsylvania, USA
(cjwolt@ship.edu / Fax: +01 717-477-4029 / Phone: +01 717-477-1143)

The 1200 km² Conestoga River watershed, Pennsylvania, USA generates the highest nitrogen yield of any tributary within the 165,700 km² Chesapeake Bay watershed (47.2 kg/ha/yr total nitrogen, 44.7 kg/ha/yr nitrate-nitrogen). Nitrogen is generated by point and non-point sources, with agricultural runoff the primary source. The watershed has been selected as the site of a model nutrient trading program that allows farmers, municipalities, and industry to trade pollution reduction credits to meet state and federal water quality goals. Point and non-point nutrient reduction strategies have been evaluated to support this model program.

This paper examines the potential to lower Conestoga River nitrogen loads on a watershed scale by treating agricultural runoff in restored and constructed wetlands. Previous research has documented the ability of individual wetlands to reduce nitrogen loads in agricultural runoff, yet the potential to improve water quality on a watershed scale has not been well established. Such a watershed scale assessment was accomplished with the use of geographic information systems (GIS), field site assessment, and hydrologic modeling.

A GIS including data on land use, hydrology, soils, geology, topography, and existing wetlands in the Conestoga watershed was used to identify potential sites for construction or restoration of two types of wetlands: "on-channel" wetlands, which would receive all of the discharge from relatively small drainage areas (<243 ha), and "off-channel" wetlands along larger streams, which would treat a portion of the total stream

flow diverted into the wetland.

The GIS analysis yielded 238 potential on-channel wetland sites. Field investigation eliminated 98 of those sites due to topographic, hydrologic, and/or land use constraints, resulting in 140 viable sites. Detailed investigation of 18 sample sites distributed throughout the watershed included surveying site topography with an electronic total station, modeling sub-catchment hydrology with the USDA-NRCS TR-55 computer model, modeling nitrogen removal with a mass-balance model, and estimating construction costs based on comparable completed projects. Mean total nitrogen removal in the 18 sites was estimated at 37.4% with mean nitrate-nitrogen removal of 53.8%. Construction of all 140 on-channel wetlands would treat runoff from 11,121 ha (10.4 % of the watershed) including 7,858 ha of agriculture (13.5% of agricultural lands). Under conservative assumptions, the wetlands would reduce the watershed-wide total nitrogen load by 3.9% and the nitrate-nitrogen load by 5.6%.

GIS analysis identified 42 potential off-channel wetland restoration sites at larger watershed scales. Field assessment of land use and topography caused the rejection of 9 sites, resulting in 33 viable off-channel wetland sites with a total area of 223 ha. Modeling site hydrology and nitrogen reduction indicated those wetlands could remove a maximum of 52.8% of total nitrogen and 75.9% of nitrate-nitrogen in runoff from 31,534 ha (29.4% of watershed area).

Combining the nitrogen reduction estimates for on-channel and off-channel wetlands yields a capacity to reduce watershed-wide total nitrogen loads by 19.4% and nitrate-nitrogen loads by 27.9%. The estimated cost of constructing all of the potential wetlands is \$3.5 - 4.1 million.