# WATER QUALITY IN THE HEADWATERS OF THE UPPER OCONEE WATERSHED

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**Abstract.** Development in the Southern Piedmont of the USA is increasing urban demand for clean water for recreation and municipal supplies. Agricultural production is perceived to be a non-point source of pollution in this region. To effectively target efforts to reduce agricultural pollution, we are working to estimate the impact of conservation practices and to develop water-sampling strategies for identifying key areas for conservation efforts. Nine sites were selected for sampling surface water quality in the headwaters area of the Upper Oconee Watershed of Georgia. Significant variation in water quality was observed among the 9 sites. In some cases, high levels of N and P may have been the result of holding ponds associated with agricultural processing or confined animal operations located adjacent to the water body and near the sample sites. Dilution of upstream impacts was apparent at downstream sites particularly with the samples representing the Middle Oconee River.

## INTRODUCTION

Urban development in traditionally agricultural regions of the southeastern United States has increased the demand for surface water to supply domestic and recreational needs. In addition to protecting natural resources, the movement of pollutants from agricultural lands must be controlled to minimize agricultural-urban conflicts.

The Upper Oconee Watershed of northeast Georgia is 760,000 ha (2,900 miles$^2$) in a mix of residential, industrial, forest, and agricultural lands. In the northern portion of the watershed are the headwaters of the North Oconee River, the Middle Oconee River, and the Mulberry River. These rivers are used for municipal, industrial, and agricultural purposes and eventually join to form the Oconee River and flow into Lake Oconee (Fisher et al, 2000). Lake Oconee is used for recreation and power generation. The largest municipality supported by this watershed is the city of Athens.

Our objectives were to focus on the northern portion of the watershed (Figure 1) and 1) test for significant variation in water quality and 2) relate the observed water quality to variation in land use and the use of conservation practices.

## METHODS

We selected nine sites to represent a contributing area extending north from Winder, west from Arcade and Maysville, and southeast of Blackshear Place, Chicopee, and Gainesville (100,530 ha or 388 miles$^2$). The contributing areas of the sample sites furthest upstream ranged from 4,522 ha (17 miles$^2$) to 11,586 ha (45 miles$^2$) (Table 1). Data are reported for the period from October 1999 to October 2000. Drought impacted these samples and consequently the - observed concentrations of nutrients are more representative of base flow and have relatively little impact from surface runoff events.

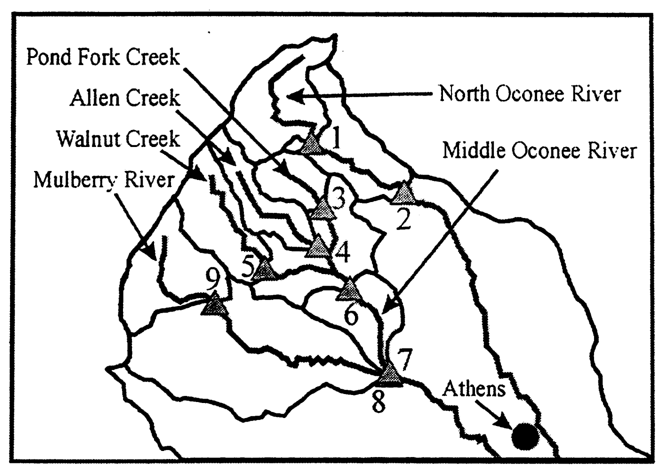


**Figure 1. Location of nine sampling points, sub-watershed boundaries, and waterways in the northern portion of the Upper Oconee Watershed of Georgia.**

**Table 1. List of Sampling Site Locations with Approximate Contributing Areas.**

| Site | Latitude | Longitude | Water Source | Crossroad | Contributing Area |
|---|---|---|---|---|---|
| | - degrees - | - degrees - | | | -- ha -- |
| 1 | 34° 16.946' | 83° 41.365' | North Oconee River | Gillsville Highway | 11586 |
| 2 | 34° 13.828' | 83° 34.129' | North Oconee River | Chandler Cemetery Road | 21126 |
| 3 | 34° 12.845' | 83° 40.452' | Pond Fork Creek | Lipscomb Lake Road | 4522 |
| 4 | 34° 10.411' | 83° 40.418' | Allen Creek | Wayne Poultry Road | 6251 |
| 5 | 34° 08.997' | 83° 45.064' | Walnut Creek | Pocket Road | 9185 |
| 6 | 34° 07.767' | 83° 38.387' | Middle Oconee River | Old Pendergrass Road | 31737 |
| 7 | 34° 02.507' | 83° 35.240' | Middle Oconee River | Double Bridges Road | 39033 |
| 8 | 34° 02.289' | 83° 35.279' | Mulberry River | Double Bridges Road | 40371 |
| 9 | 34° 06.821' | 83° 48.893' | Mulberry River | New Liberty Church Road | 10698 |

The pH, conductivity, dissolved oxygen, temperature and turbidity were measured on site with a Horiba[1] mulitparameter probe. Nitrate, ammonia, and total phosphorus were determined in the laboratory with a Hach[1] spectrophotometer.

To test for potential fecal contamination we enumerated *E. coli* and *enterococci* using Colilert® and Enterolert™ substrates (IDEXX[1] Laboratories, Inc., Westbrook, ME). Samples were enumerated by presence and absence in Quanti-Tray™ cells (IDEXX Laboratories, Inc., Westbrook, ME) and data were expressed as the most probable number (MPN) per 100 ml. All sites were sampled on each sample date. To avoid saturating the assays, samples were diluted at ratios of 1 to 10 or 1 to 100 when we anticipated high numbers of microbes.

Preliminary data analysis was used to test for a need for a log transformation. When appropriate a log transformation was used and analysis of variance was conducted on the transformed data.

All variables were tested by analysis of variance with site and date as class variables and as the only components in the model using the GLM procedure of SAS (SAS, 1990). A Waller-Duncan t-test (k ratio=100) was used to separate the means. Letters were assigned indicating significant differences and the values transformed to the original units for presentation.

**Table 2. Observed Water Quality at Sampling Sites from October 1999 to October 2000.**

| Site | pH | COND† | DO | TEMP | TURB | $NO_3$-N | $NH_3$-N | P | ECOLI | ENTC |
|---|---|---|---|---|---|---|---|---|---|---|
| | | mS | mg/l | °C | hach | ---------------- | mg/l | ---------------- | ---- MPN/100 ml ---- | |
| 1 | 7.35 a | 0.16 b | 10.4 a | 15.8 a | 19 c | 0.82 de | 0.030 e | 0.07 ab | 543 a | 368 a |
| 2 | 7.30 ab | 0.15 c | 9.3 e | 16.1 a | 31 b | 0.90 cd | 0.041 e | 0.07 ab | 492 ab | 381 a |
| 3 | 7.17 cd | 0.13 d | 9.5 c | 15.0 bc | 20 c | 1.21 ab | 0.065 d | 0.06 b | 401 abc | 291 abc |
| 4 | 7.23 bc | 0.19 a | 9.8 bc | 15.1 bc | 17 c | 1.47 a | 0.093 bc | 0.09 a | 162 e | 205 bc |
| 5 | 7.21 c | 0.12 e | 9.9 b | 14.8 cd | 22 c | 0.66 e | 0.021 f | 0.03 c | 339 bcd | 229 abc |
| 6 | 6.97 e | 0.14 c | 9.7 c | 14.4 d | 23 c | 1.15 abc | 0.096 b | 0.06 ab | 353 bcd | 342 ab |
| 7 | 6.84 f | 0.14 c | 9.4 de | 15.3 b | 30 b | 1.01 bcd | 0.080 bcd | 0.05 b | 377 abcd | 345 ab |
| 8 | 6.64 g | 0.16 b | 8.8 f | 16.1 a | 67 a | 0.85 de | 0.066 cd | 0.05 b | 319 cd | 246 abc |
| 9 | 7.11 d | 0.13 d | 9.8 bc | 15.0 bc | 21 c | 1.07 bcd | 0.148 a | 0.03 c | 262 d | 187 c |

† COND = Conductivity, DO = Dissolved Oxygen, TEMP = Temperature, TURB = Turbidity, $NO_3$-N= Nitrate-N, $NH_3$-N= Ammonia-N, P = Phosphorus, ECOLI = *E. coli* bacteria, and ENTC= *Enterococci* bacteria. Numbers followed by different letters in a column are significantly different according to the Waller-Duncan K-ratio t-test.

[1] The use of trade names in this publication is for the information and convenience of the reader. Such use does not constitute endorsement or approval by USDA, ARS of any product to the exclusion of others that may be suitable.

## RESULTS AND DISCUSSION

Considering all the observed data, Site 5 located on Walnut Creek (Table 1) had the highest water quality during the period of our observations. The pH was intermediate between the high values observed on the North Oconee River and the low values observed on the Middle Oconee River and the Mulberry River. Conductivity was very low at Site 5 (Table 2). Dissolved oxygen and temperature were intermediate while turbidity was low. Nitrate, ammonia, and phosphorus were low and numbers of E. coli were intermediate and enterococci numbers were high. These levels of microbes may have been due to wildlife since nutrient levels were so low but pastures located near the sample site allow some livestock access to the creek and may also be responsible. Aerial photography (1996) shows that, except for a small amount of pasture along the last 1.6 km of creek above the collection site, the riparian zones are heavily buffered with forest extending a minimum of 100 meters to either side over the last 5 km above the sample site. Lott Creek joins Walnut Creek approximately 1 km above the sample site and Lott Creek is also well buffered by forest from surrounding land use over the last 5 km with the exception of limited residential development. Although some residential development is present it is not extensive and is not adjacent to Walnut Creek. The riparian zone immediately above the sample site is heavily wooded for approximately 10 km.

Site 4 on Allen Creek contrasts sharply with Site 5 even though the two subwatersheds are located side by side (Figure 1). At Site 4, the conductivity, nitrate, ammonia, and phosphorus were high (Table 2). Both microbial assays were abnormally low. Over the last kilometer of Allen Creek above the sample site, a poultry processing plant is located to the northeast of the creek and a turf farm is located to the southwest of the creek. The riparian zone is narrow between both operations. The poultry processing plant is using land application of waste and has located lagoons adjacent to the creek. The cause of the abnormally low levels of microbes is unclear. These levels would normally indicate the presence of an impoundment such as a lake but there is no impoundment of Allen Creek near the sample site. Another poultry processing plant is located approximately 6.5 km above the sampling point on Allen Creek.

Site 9 has the highest concentration of ammonia and moderate nitrate but low phosphorus and microbe numbers. This site was downriver from a large egg production facility. The egg operation has a series of lagoons located along the Mulberry River only 2-km upstream from the sample site. Even though ammonia levels were relatively high the sum of N as ammonia and nitrate was less than the nitrate concentration at Site 4 on Allen Creek.

A large number of poultry houses surrounded by pastures with generally limited riparian zones characterized Sites 1 and 2 on the North Oconee River. Water temperature and microbial numbers were high and in particular the numbers of E. coli near the top of the North Oconee River were higher than found at the other sample sites. Land application of poultry litter and grazing animal access to riparian zones are potentially responsible for the elevated microbial numbers.

The relatively high water temperature and turbidity at Site 8 on the Mulberry River may be a reflection of the observed poorly vegetated streamside beginning approximately 5 km upriver and continuing for 2 km with only limited riparian buffering. Much of the area is characterized by pasture with cattle using creeks and rivers for drinking water. However, there are relatively few poultry houses associated with the pastures along the river corridor.

## SUMMARY

Non-point source pollution from agriculture is generally considered to be due to surface runoff from upland farm operations. Due to the prolonged drought conditions during this study period, upland operations had a reduced impact on water quality. However, water quality varied significantly across the subwatersheds and variation was attributed to land use in the riparian zone and also to land use near the sampling sites. While cattle access to streams and litter application are still concerns, adequate riparian buffering minimized these impacts. The impacts of point sources of pollution were also minimized through dilution in the watershed.

## LITERATURE CITED

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