TRENDS IN INSTREAM TOTAL NITROGEN AND TOTAL PHOSPHORUS UPSTREAM AND DOWNSTREAM OF WASTEWATER FACILITIES IN GEORGIA LEVEL III ECOREGIONS 1967-2010

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Abstract. Using the Georgia Water Resources Database (WRDB), analysis was conducted of instream Total Nitrogen and Total Phosphorus trends at water quality sampling sites in each Level III Ecoregion of Georgia. Over 71,000 individual samples from 1967 - 2010 were analyzed. Each sample station was cataloged using GIS coverages as being either upstream or downstream of a permitted wastewater discharge or land application systems (LAS). Generally, over the period of record, sites downstream of permitted wastewater facilities show higher Total Phosphorus statewide. Total Nitrogen values are split between north Georgia (Ecoregions 68, 67, 66, and 45) and south Georgia (Ecoregions 75 and 65). In north Georgia, Total Nitrogen appears to be greater in downstream sites, whereas the trend is unclear in south Georgia. Decadal trends for each Ecoregion were also analyzed. Generally a declining trend was observed for Total Phospohrus, whereas Total Nitrogen was flat or increasing.

INTRODUCTION

The regulation and management of nutrients represents a particular challenge. While it has been well documented that excess nutrients can impair the biological integrity of receiving waters (Duarte 1995, Vitousek et al. 1997, Carpenter et. al. 1998, Smil 2000, Bennett et al. 2001, Stevenson et al. 2004 Reckhow et al. 2005, Rier et al. 2006), nutrients are also essential for healthy growth. Nutrients in natural waters can also exhibit a relatively high degree of variability (Dubrovsky et al. 2010, US EPA 2010).

Consistent with the US EPA (2010), Georgia EPD has initiated a process of developing numeric nutrient criteria for the State. Criteria have been developed for several Georgia water bodies (391-3-6.03). Additionally, Georgia EPD has a plan to develop criteria for other types of water bodies, including streams. This study is an overview of the currently available monitoring data of instream nutrient parameters for Total Nitrogen and Total Phosphorus recorded in the Georgia Water Resources Database (WRDB 2010). Data were further subdivided by using GIS to catalog sample sites upstream and downstream of permitted wastewater treatment facilities (NPDES or LAS) and using Level III Ecoregion data (Griffith 2001). These data were collected by Georgia EPD's monitoring program and other monitoring programs adhering to Georgia EPD's approved Quality Assurance Program Plan for Surface Water Quality Monitoring (Georgia EPD 2008).

METHODS

First, each station sampling point was analyzed using GIS to determine whether the station was upstream or downstream of a permitted wastewater treatment facility and to determine the particular Level III Ecoregion (Table 1) where the station was located. Figure 1 shows the distribution of the data with the number of records divided by ecoregion and whether the station is upstream or downstream of a wastewater treatment facility. The data was then analyzed to ascertain trends as reported in Figures 2-13. There was very limited data for Ecoregion 68, the Southwestern Appalachians, since it covers a relatively small portion of Georgia's land area. Due to the limited amount of data, trends for Ecoregion 68 are not reported.

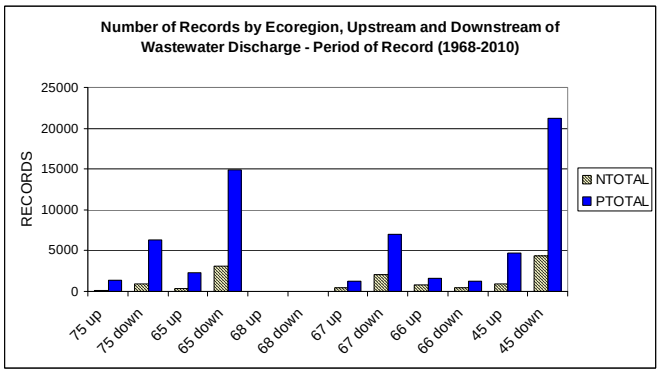

Figure 1. Number of Records by Ecoregion and whether upstream or downstream of a wastewater facility.

Table 1. Level III Ecoregions of Georgia
(Griffith et al. 2001)

45	Piedmont
65	Southern Plains
66	Blue Ridge
67	Ridge and Valley
68	Southwestern Appalachians
75	Southern Coastal Plain

RESULTS AND DISCUSSION

Figures 2 and 3 report the box plot (95%, 75%, median, 25%, 5%) distribution of the Total Nitrogen and Total Phosphorus data for each ecoregion subdivided by stations upstream and downstream of wastewater facilities.

Total Nitrogen values are split between north Georgia (Ecoregions 68, 67, 66, and 45) and south Georgia (Ecoregions 75 and 65). In north Georgia, Total Nitrogen appears to be greater in downstream sites, whereas the trend is unclear in south Georgia. It is possible that in south Georgia, nonpoint sources found in upstream and downstream watersheds exhibit a proportionally larger effect than in north Georgia. Alternatively, the generally smaller wastewater discharges in South Georgia may have a proportionally smaller impact on nitrogen values. Additionally, Ecoregion 45 (Piedmont) exhibits the highest total nitrogen values.

Total Phosphorus levels show higher levels downstream of wastewater facilities than upstream. This suggests that wastewater facilities have a proportionally larger impact on total phosphorus values than wastewater facilities have on total nitrogen values.

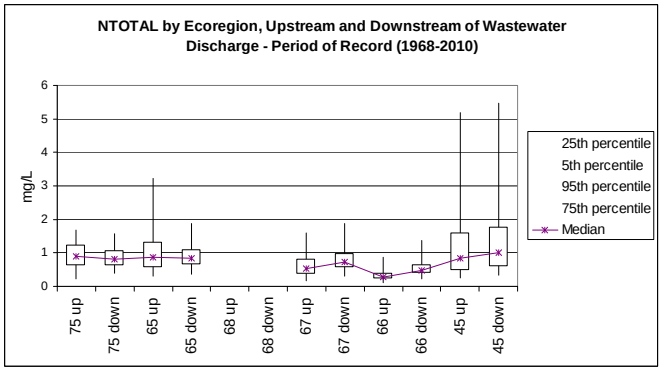

Figure 2. Box plot of Total Nitrogen (mg/L) by Ecoregion or Upstream and Downstream of Wastewater Facilities.

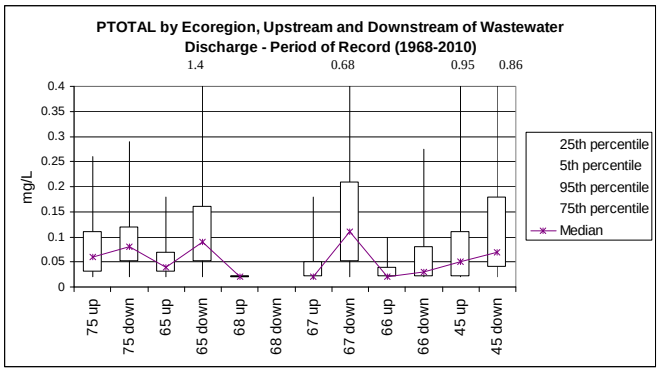

Figure 3. Box plot of Total Phosphorus (mg/L) by Ecoregion Upstream and Downstream of Wastewater Facilities.

Figures 4-13 show box plot (95%, 75%, median, 25%, 5%) distributions of Total Nitrogen and Total Phosphorus across decadal trends (1970-2010 as data is available), again divided by those monitoring location upstream and downstream of wastewater facilities.

Trends for Total Nitrogen are generally flat across decades for each Ecoregion, except ecoregion 45 which shows an increasing trends in 95% measurements.

Trends for Total Phosphorus show generally flat measurements for upstream facilities and marked declines for Total Phosphorus for downstream facilities over the decades (1970-2010) in many Ecoregions (45, 67, 65). These declines in downstream Total Phosphorus values are likely attributable to improvements in wastewater treatment.

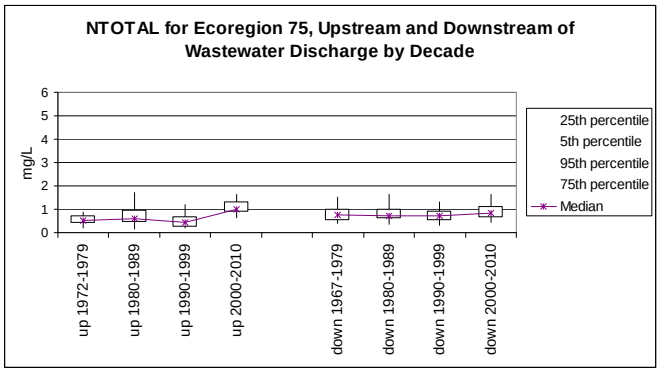

Figure 4. Box plot of Total Nitrogen (mg/L) by decade for Ecoregion 75 Upstream and Downstream of Wastewater Facilities

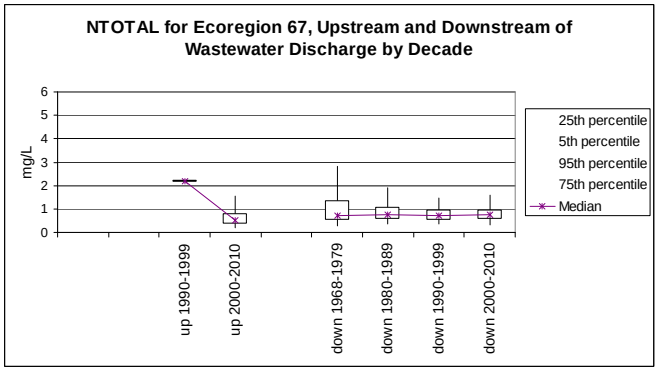

Figure 5. Box plot of Total Nitrogen (mg/L) by decade for Ecoregion 67 Upstream and Downstream of Wastewater Facilities

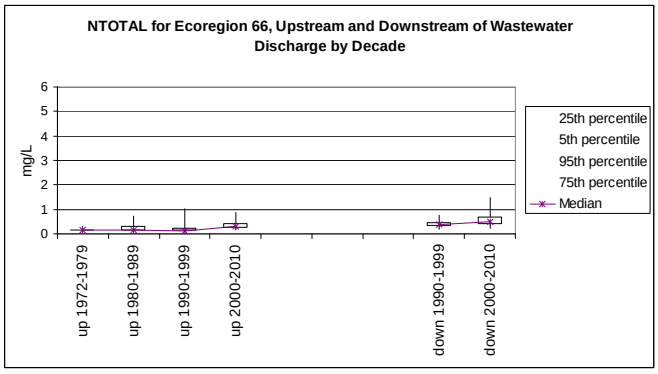

Figure 6. Box plot of Total Nitrogen (mg/L) by decade for Ecoregion 66 Upstream and Downstream of Wastewater Facilities

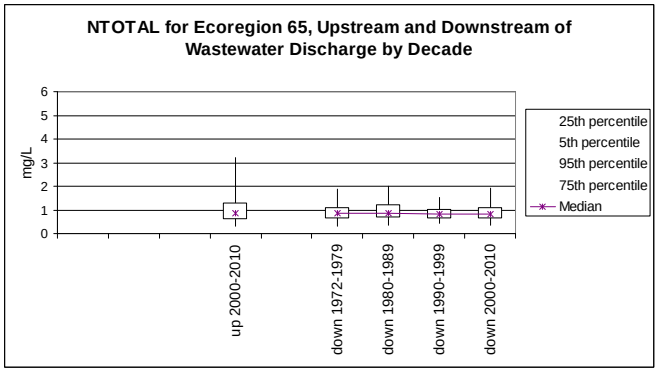

Figure 7. Box plot of Total Nitrogen (mg/L) by decade for Ecoregion 65 Upstream and Downstream of Wastewater Facilities

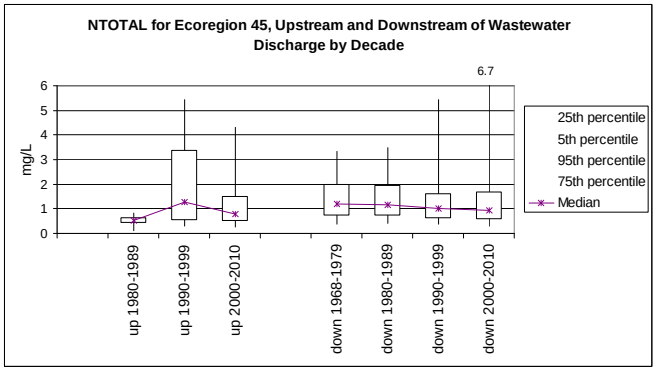

Figure 8. Box plot of Total Nitrogen (mg/L) by decade for Ecoregion 45 Upstream and Downstream of Wastewater Facilities

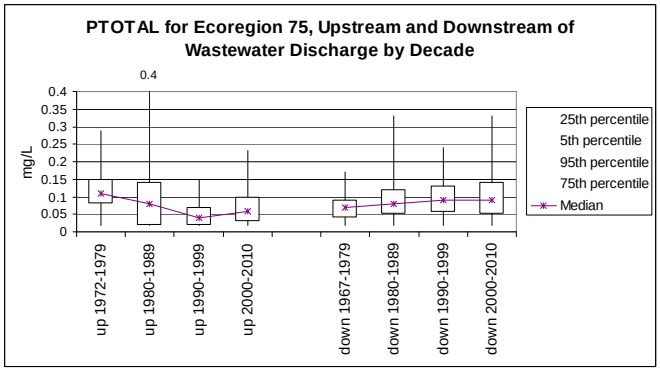

Figure 9. Box plot of Total Phosphorus (mg/L) by decade for Ecoregion 75 Upstream and Downstream of Wastewater Facilities

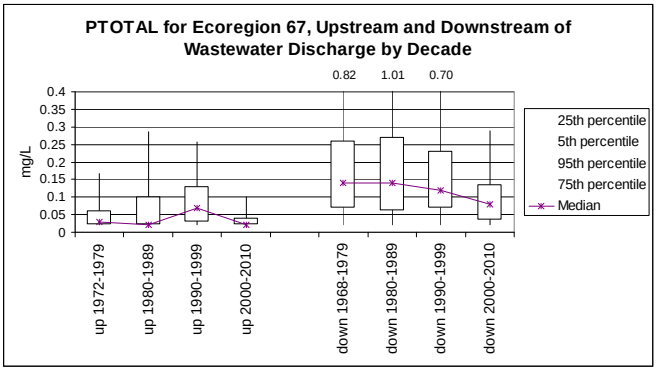

Figure 10. Box plot of Total Phosphorus (mg/L) by decade for Ecoregion 67 Upstream and Downstream of Wastewater Facilities

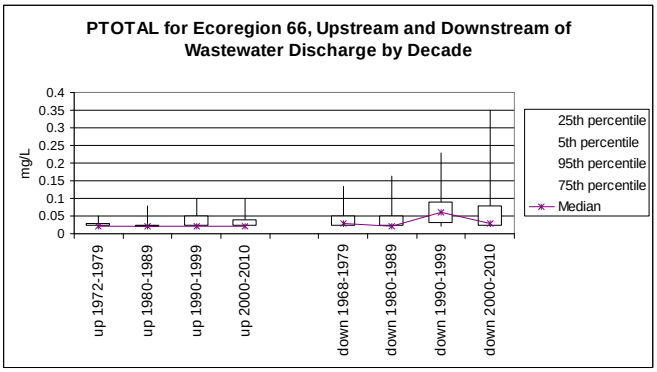

Figure 11. Box plot of Total Phosphorus (mg/L) by decade for Ecoregion 66 Upstream and Downstream of Wastewater Facilities

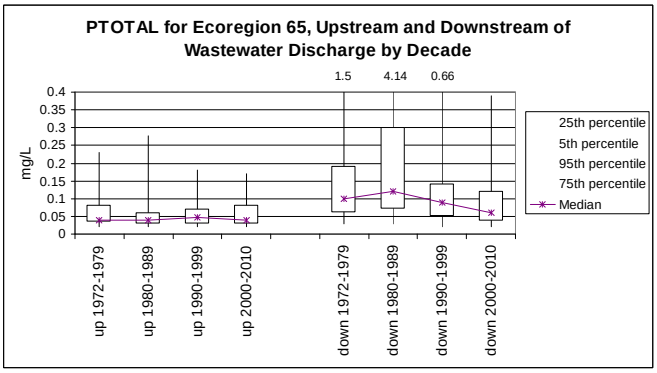

Figure 12. Box plot of Total Phosphorus (mg/L) by decade for Ecoregion 65 Upstream and Downstream of Wastewater Facilities

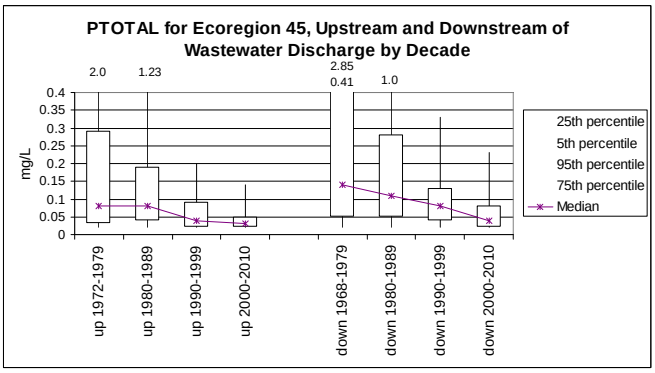

Figure 13. Box plot of Total Phosphorus (mg/L) by decade for Ecoregion 45 Upstream and Downstream of Wastewater Facilities

CONCLUSIONS

These measurements provide a basis for scientific nutrients management. Future work may include efforts to further characterize the data beyond Ecoregion and location upstream or downstream of wastewater facilities, monitoring to determine biological nutrient response, and additional probabilistic modeling of watershed response.

REFERENCES

Bennett, E.M., S.R. Carpenter, and N.F. Caraco. 2001. Human impact on erodable phosphorus and eutrophication: a global perspective. *BioScience* 51:227-234.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications* 8: 559-568.

Duarte, C.M. 1995. Submerged aquatic vegetation in relation to different nutrient regimes. *Ophelia: International Journal of Marine Biology* 41:87–112.

Dubrovsky, N.M., and Hamilton, P.A. 2010. Nutrients in the Nation's streams and groundwater: National Findings and implications: U.S. Geological Survey Fac Sheet 2010-3078, 6 p.

Georgia EPD. 2008. Quality Assurance Program Plan: Surface Water Monitoring. Georgia Dept. of Natural Resources, Environmental Protection Division, Atlanta, Georgia.

Griffith, G.E., J.M. Omernik, J.A. Comstock, S. Lawrence, G. Martin, A. Goddard, V.J. Hulcher, and T. Foster. 2001. Ecoregions of Alabama and Georgia, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,700,000).

Reckhow, K.H., G.B. Arhonditsis, M.A. Kenney, L. Hauser, J. Tribo, C. Wu, L.J. Steinberg, C.A.Stow, and S,J. McBride. 2005. A Predictive Approach to Numeric Nutrient Criteria. *Environmental Science and Technology*. 39:2913-2919.

Rier, S.T., and R.J. Stevenson, 2006. Response of Periphytic algae to gradients in nitrogen and phosphorus in streamside mesocosms. *Hydrobiologia*, 561:131-147.

Smil, V. 2000. Phosphorus in the environment: natural flows and human interferences. *Annual Review of Energy and the Environment* 25:53-88.

Stevenson, R.J., A. Pinowska, and Y.K. Wang. 2004. Ecological Condition of Algae and Nutrients in Florida Springs. Florida Department of Environmental Protection, Tallahassee, FL.

US EPA. 2010. Using Stressor-response Relationships to Derive Numeric Nutrient Criteria. EPA-820-S-10-001. U.S. Environmental Protection Agency. Office of Water, Washington, D.C.

Vitousek, P.M., J.D. Aber, R.W. Howarth, G.E. Likens, P.A. Matson, D.W. Schindler, W.H. Schlesinger, and D.G. Tilman. 1997. Human alternation of the global nitrogen cycle: sources and consequences. *Ecological Applications* 7:737-750.

WRDB 2010. Georgia Water Resources Database. Georgia Environmental Protection Division. Atlanta, Georgia. http://www.gaepd.org/Documents/EPDOnlineWaterQualityData.html