BIOLOGICAL APPROACH TO USE ATTAINABILITY

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INTRODUCTION

The 1987 Clean Water Act amendments placed greater emphasis on toxicity-based approaches to improving surface water quality. To guide states having NPDES authority, a number of criteria documents have been prepared by the USEPA for specific metals that describe numerical limits for metals in effluents. The primary objective of these numerical limits is the protection of 95 percent of the aquatic species present in a receiving stream. Georgia has the responsibility for issuing National Pollutant Discharge Elimination System (NPDES) permits for release of treated effluents into surface waters of the state. Lacking any other guidance, the state has used these national criteria to set new discharge limits on metals for NPDES permits up for renewal in Gwinnett County. The objective of these limits presupposes that the more restrictive newer toxicity based limits are necessary to protect the designated uses of the stream.

The determination of whether the new limits are required to protect the designated uses of specific water bodies is discussed in 40 CFR 131.10(g). Under this section of the regulations, where it can be demonstrated that other conditions not related to the applicant preclude the attainment of the designated uses, procedures are provided for a variance from specific standards.

The objective of this study was to determine if the state designated uses of the upper segment of the Yellow River in Gwinnett County would be affected by proposed changes in discharge permits for selected Waste Water Treatment Plants (WWTPs). This paper describes a biological approach for evaluating the factors affecting the designated uses for the upper segment of the Yellow River.

PROJECT DESCRIPTION

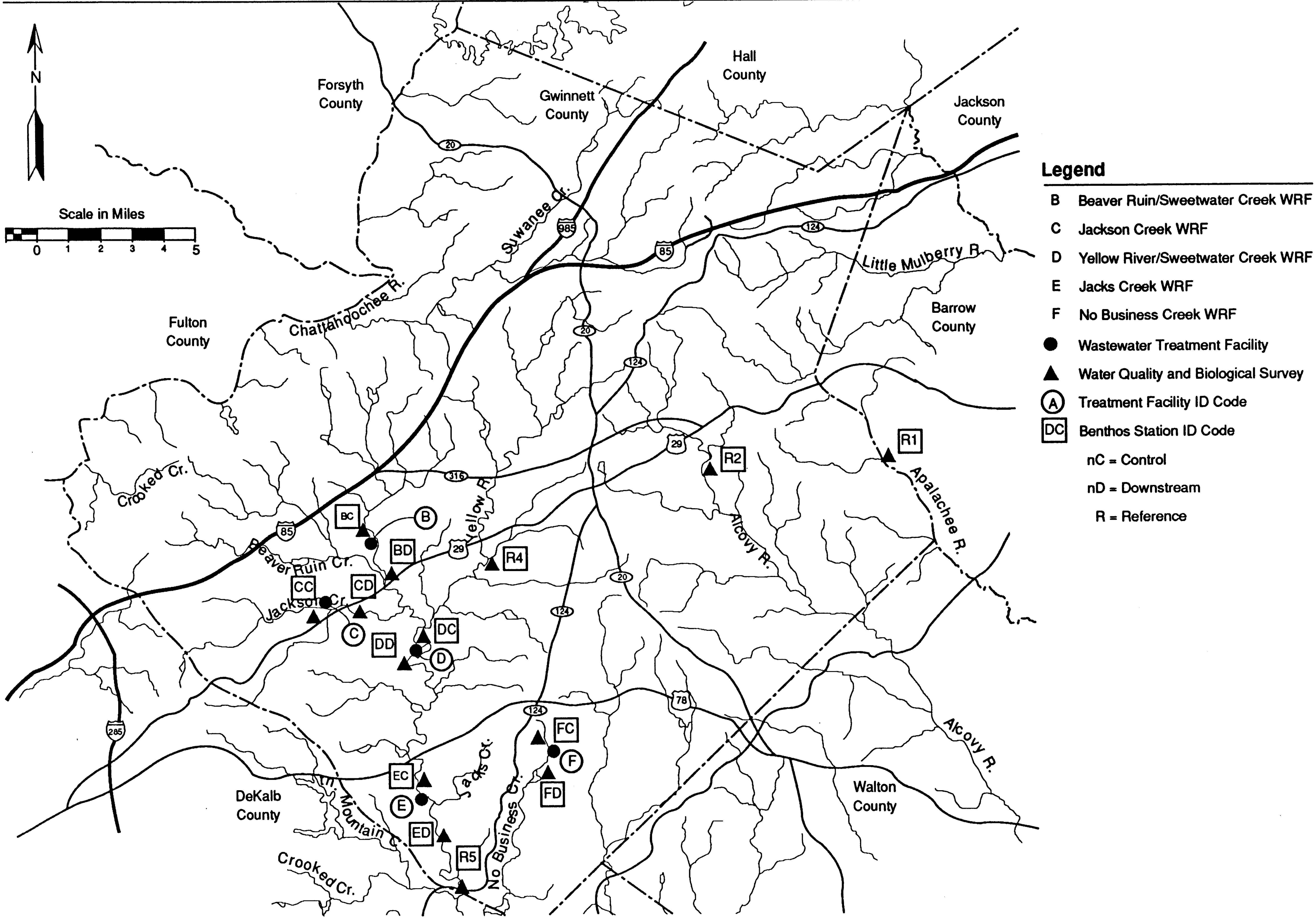
Gwinnett County, Georgia has been recognized as one of the faster growing counties in the United States. Most of this growth is in an area of Gwinnett County that includes upper reaches of numerous tributaries to the Yellow River. The overall drainage basin provides very low flows, characteristic of other upper piedmont streams. Since numerical standards set for many pollutants, such as metals, are based on the seven day, ten year low flow (7Q10) for the receiving stream, the WWTPs that service this area are constrained by these low flows to meet very restrictive water quality standards. New limits proposed by the state for the latest draft NPDES permits issued to these facilities include values for a few metals that are near or below the detection limit.

This paper describes an approach to seek a site specific variance for selected standards based on a demonstration that either stream uses are being met without the new standard, or that stream uses can not be met because of factors that do not relate to the applicant. Stream evaluation for use attainability is based on 40 CFR 131.10(g) which describes procedures that may be followed to obtain a variance from specific standards. This variance requires a demonstration that (1) the designated stream uses are being met under the existing standards, (2) a designated use of a stream can not be met because of one or more factors described in the referenced regulation, or, (3) that the permitted discharge is not the causative factor affecting stream use.

STUDY DESIGN

This study was conducted on a segment of the Yellow River in Gwinnett County that receives discharges from several WWTPs affected by the proposed permit limits. The area of interest described in this paper is illustrated in Figure 1. WWTPs along the study area include facilities that discharge into Sweetwater Creek (Area B), Jackson Creek (Area C), Yellow River (Areas D and E), and No Business Creek (Area F). Streams that were out of the Yellow River basin, but in the same upper Piedmont drainage basin, were designated as Reference Areas (R1 and R2, Figure 1) and included in the evaluation. These latter study areas were selected to compare biological communities in streams that do not receive WWTP effluent with biota in the Yellow River basin.

The study was designed to evaluate biological characteristics of each segment of the receiving stream during high flow (spring) and low flow (fall) conditions. The spring sampling took place during the first two weeks of May 1990; fall sampling was completed during late August and early September 1990. Sampling stations were established above and below the point of release of each WWTP to provide data that would represent the influence of the plant effluent on biological communities in the receiving stream. Every effort was made to select upstream and downstream stations that represented comparable habitats.



Notes:
WRF: Gwinnett County Water Reclamation Facility
WPCP: City of Conyers Water Pollution Control Plant

Figure 1
Gwinnett County
Use Attainability Study Area

The downstream station was selected first for each study area along a segment of the receiving stream where the discharge was fully mixed, based on measurements of conductivity across the stream section. This location varied, but in most cases was less than 100 feet below the discharge point. The habitat features of this downstream station were then used as a basis for evaluating the appropriate location above the discharge where comparable habitats could be found. Generally, the upstream station was less than 100 feet above the discharge point. Additional stations were selected on the Yellow River, one to represent areas above the influence of any WWTPs on the Yellow River (Station R4, Figure 1), and the other to represent the combined influence of all but one of the WWTP discharges on the biota in this water body (Station R5, Figure 1). The two Reference Stations that represented streams not affected by WWTP releases (R1 and R2) were located on the Alcovy and Apalachee Rivers in eastern Gwinnett County.

The sampling program for each station included habitat descriptions, field measurements of water quality, and sampling for benthic invertebrates. Habitat descriptions included measurements of stream width, water depth, and physical features (such as type of substrate or presence of snags) and other characteristics affecting use by benthic invertebrates and fish. In situ measurements were made using electronic instruments for dissolved oxygen, temperature, pH, and specific conductance. Benthic invertebrate samples were collected as three grab samples from similar habitat at each station. The devices used were Ponar grabs in pools and Surber samplers in shallow areas. In the fall, two racks of five artificial substrate (Hester-Dendy) samplers were also emplaced in Jackson Creek and Jacks Creek. These were retrieved for analysis after four weeks to evaluate the biota that had colonized these samples above and below WWTP discharges in these two areas.

RESULTS

Field measurements for dissolved oxygen, temperature, conductivity, and pH were all within state standards and within ranges that would support a balanced aquatic community. Stream flow calculations for the two sampling events, based on gage data provided for the Yellow River ranged from 157 to 367 cfs in the spring and from 76 to 201 cfs in the fall period (USGS, 1991).

The stream habitats for the stations on the Alcovy and Apalachee Rivers were similar to those in the Yellow River basin and appeared to provide suitable areas for comparison with aquatic communities in the study areas receiving WWTP effluent. Construction activities near the Reference Streams had resulted in some sediment deposition, but to a lesser extent than that found in the Yellow River. Throughout most of the Yellow River basin, particularly at the confluence of tributaries to the Yellow River, the mainstream had been greatly affected by large inputs of sediment and sands transported from upstream areas. Figure 2 compares the number of species of invertebrates collected using different sampling methods to illustrate the influence of sediments on habitats used by these organisms.

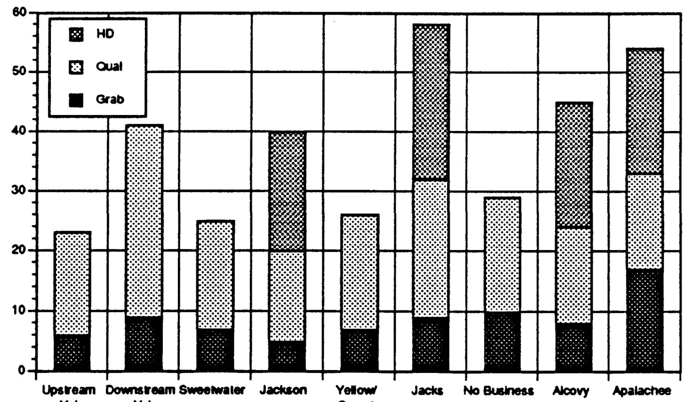


Figure 2. Comparison of Species Present on Various Substrates

Stream bottom samples (grabs) provided fewer species than were collected from snags and floating leaves (qualitative) or artificial substrates (Hester-Dendy) in the Yellow and Alcovy Rivers. These latter two sample types provide an estimate of the potential community that might be present along the stream bottom were the available habitat not occluded by sand. The Apalachee River, which had more silt/clay substrate, provided comparable numbers of species among all three sample types.

Several estimates of benthic community characteristics were reviewed, including species diversity and percent similarity. Species diversity used for this study was Shannon-Wiener (Pielou, 1966, 1974), which is one of a number of measures of community structure, and relates to the distribution of species among the total number of organisms present. The application of this index to this study is based on the premise that a natural, balanced community will have many species, with no species present in overwhelming numbers. This 'balanced' community would be expected to result in a diversity index of about 3 or higher (using the Shannon-Weiner calculation). Where one or more species increase in density so that they greatly outnumber the other species present, the diversity index drops to a lower value. This latter case is generally attributed to stress on the community such that the conditions are optimal for only one or a few species. Comparison of diversities above and below a treated wastewater release provide a measure of the influence of the effluent on water quality. The presence of pollutants may be expected to cause a shift down in the index as compared to the community upstream.

Table 1 summarizes the data for each study area by number of species collected, diversity index, and similarity between selected stations. These values represent the average of the two sampling seasons using all data collected by other than artificial substrates. A review of the spring data indicated no substantive differences between upstream and downstream stations, except at Jackson Creek and Jacks Creek. Sampling in the fall at these two tributaries was expanded to include the use of artificial substrate (Hester-Dendy) samples. The data from these studies are summarized in Table 2.

Table 1. Summary Data for Samples Collected From Sediments by Grab (a)

	Species	Diversity	Similarity
Reference Stations			
Alcovy River	28	3.7	
Apalachee River	23	3.8	49
Yellow River Stations			
WWTP Stations			
Sweetwater Creek			
Upstream	21	2.9	
Downstream	20	3.1	55
Jackson Creek			
Upstream	16	3.5	
Downstream	18	2.5	33
Yellow/Sweet			
Upstream	24	3.1	
Downstream	21	2.8	68
Jacks Creek			
Upstream	22	3.2	
Downstream	30	2.8	36
No Business (b)			
Upstream	18	3.2	
Downstream	23	3.4	62
Reference Stations			
Upstream	21	3.5	
Downstream	37	3.5	39

(a) Except as noted, all values represent average of spring and fall seasons.
(b) Data represent spring samples only.

Table 2. Summary Data for Samples Collected on Artificial Substrates

	Species	Diversity	Similarity
Jackson Creek			
Upstream	17	3.1	
Downstream	22	3.2	38
Jacks Creek			
Upstream	26	3.4	
Downstream	26	3.2	60

An additional measure of the effect of the WWTP discharges on the receiving water body is the Jaccard Coefficient. This calculation is used to provide a measure of community similarity between two communities (Mueller-Dombois and Ellenberg, 1974). This comparison is calculated as follows:

$$CC = \frac{c}{S_1 + S_2 - c}$$

where S_1 and S_2 are the numbers of species in communities 1 and 2, respectively, and c is the number of species common to both communities. Assuming the habitats are similar for the two communities being compared, impacts to the community from the treated effluent should be reflected by dissimilarity with the upstream community. Comparisons between stations may be expected to approach 40 to 50 % similarity. These data that are also summarized in Tables 1 and 2.

DISCUSSION

The silt load found in all of the stations in the Yellow River and its tributaries is apparently associated with the construction in the area resulting in excessive runoff of erodible materials into these streams. These sediments represent three types of impacts affecting aquatic communities: (1) scouring, removing organisms from attached surfaces of rocks and branches, (2) smothering, whereby gills and reproductive materials are covered with sediments and destroyed, and (3) occlusion, where shifting sediments fill voids beneath submerged structures, such as stones, thereby reducing the available habitat for some species of fish and invertebrates that need these areas for protection or reproduction. As the data illustrated in Figure 2 indicate, those samples that were obtained from areas not subject to occlusion and scouring by sediment (the snag and artificial substrate samples) had substantially greater numbers of species present than were found in areas along the bottom of the creeks and rivers.

The summary data for each of the sampling stations (Tables 1 and 2) indicate that, in general, the Yellow River and associated tributaries have a lower diversity and fewer numbers of species than are found in either the Alcovy or Apalachee Rivers.

A comparison of the numbers of species at stations upstream and downstream of each of the WWTPs indicates that all stations are similar. At several stations below the WWTPs (Jackson Creek, Jacks Creek, and No Business Creek), the number of species increases below the respective WWTP. Diversity indexes among these stations are also similar at most stations. The low diversity index at the Jackson Creek station from these grab samples suggests an influence on the downstream community may be associated with this facility. The similarity of the upstream and downstream communities also indicates no substantive influence of the WWTPs affecting these aquatic systems, except at Jackson Creek and Jacks Creek. The low similarity at Jackson Creek (33%) further suggests that the WWTP may be affecting the downstream community. The low similarity coefficient at Jacks Creek (36% average for two seasons) was partly a result of habitat differences in the spring survey. A review of this study area and relocation of the stations to more comparable habitat types resulted in a slightly higher value (39%) in the fall survey.

The data for the two reference stations in the Yellow River represented an overall estimate of the influence of most of the WWTPs on this basin. The upstream station, located above any of the plants had fewer species than the downstream reference station which was below all but one of the WWTPs. The low similarity coefficient for these two stations is probably a result of the difference in habitats, the downstream study area being much wider and having slower flow than found at the upstream area.

The data from the artificial plate samplers (Table 2) provided an additional interpretation of the low diversities and similarity coefficients for Jackson and Jacks Creeks. These data indicate that the WWTPs at these two stations do not seem to be affecting the numbers of species or the diversity at these two locations. However, the low similarity coefficient between the two stations at Jackson Creek supports the suggestion that the community downstream from this facility is substantially different from the one above the plant, changes that may be influenced by the WWTP effluent.

CONCLUSIONS

This study demonstrates that the stream uses of the Yellow River basin have been most dramatically affected by the effects of sediment transported into this water body from associated construction in this region of the county. These sediment loads have occluded much of the available habitat space that would otherwise be available for a balanced aquatic community. Thus, the affected streams do not fully meet their designated use for aquatic life for reasons not associated with the WWTPs. Except for Jackson Creek, the available data suggests that the WWTPs are not having a deleterious effect on the benthic community associated within the streams studied.

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