SECTION 5

Water Quality

Introduction

This section provides a summary of water quality data collected in streams from the six District basins. As discussed in Section 2, approximately 1,100 stream miles in the District do not fully support their designated use. Water quality impairment is a primary cause of this problem (Table 5-1).

TABLE 5-1
Stream Miles Failing to Fully Support Designated Use by Basin and Source of Impairment
Metropolitan North Georgia Water Planning District Watershed Management Plan

Basin	Bio	FC	Tox	Metals	CFB	FCG	Temp	DO
Coosa	0	158	0	0	25	34	0	0
Chattahoochee	23	463	3	16	0	57	9	9
Oconee	0	49	0	0	0	0	0	1
Ocmulgee	6	299	13	0	0	18	0	2
Flint	6	56	0	14	0	0	0	16
Total Miles Not Fully Supporting Designated Use	34	1,025	16	30	25	109	9	27

Stream miles exceed totals given in Section 2 for each basin because many streams have multiple sources of impairment.

Criterion Violated Codes - Bio = Biota Impacted, DO = Dissolved Oxygen, CFB = Commercial Fishing Ban, FC = Fecal Coliform Bacteria, FCG = Fish Consumption Guidance, Temp = Temperature, Tox = Toxicity Indicated

Water quality averages and trends are interpreted from summaries of data collected by the USGS from their gauging stations in the basin (Figure 5-1).

The parameters evaluated include:

- DO
- Turbidity
- Biochemical Oxygen Demand (BOD) <prob. Not a bad idea since the public will be downloading this in "chunks">
- Total phosphorus (TP)
- Fecal Coliform Bacteria

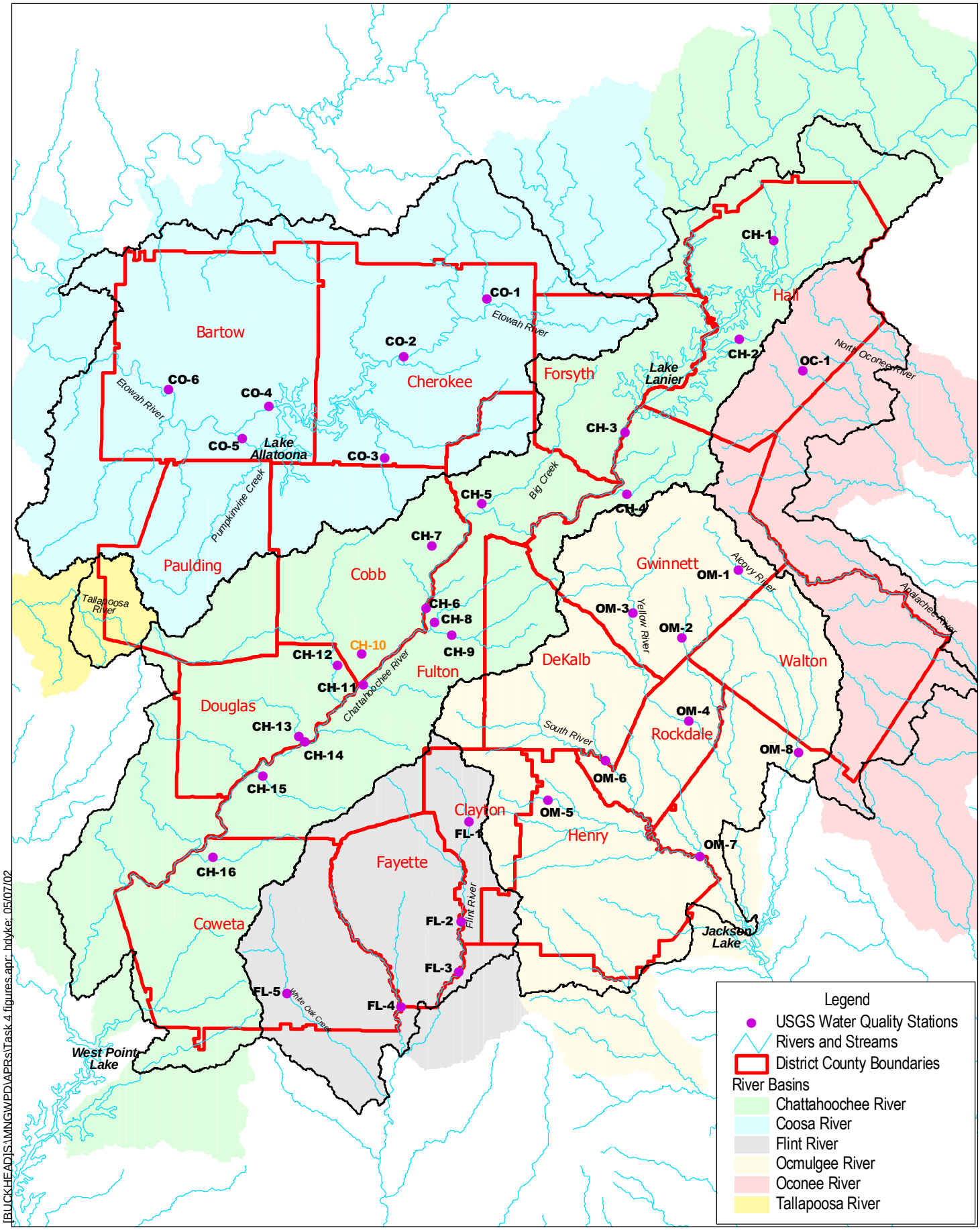


Figure 5-1
Locations of USGS Water Quality Stations
Metropolitan North Georgia Water Planning District Watershed Management Plan

Figure 5-1

These parameters are key stream condition indicators and provide information about potential land use effects on streams. DO, BOD, and turbidity are indicators of stress levels for aquatic biota. Turbidity is also used to show potential sediment loading that fills reservoirs and degrades aquatic habitat. TP is a limiting nutrient in Georgia lakes, and monitoring levels of this nutrient is necessary for managing water quality and minimizing eutrophication in drinking water reservoirs. The fecal coliform bacteria values provide a measure of potential human health concerns, and are indicators of pollution from animal wastes (point or nonpoint source origin).

Additional water quality data collected from other programs (e.g., County watershed assessments, State and County monitoring programs, and National Water Quality Assessment [NAWQA] Program) at these and other streams within the basin follow the USGS data summaries (USGS, Frick et al., 1998). For more detailed information on water quality data from these basins, please refer to the specific studies referenced under each basin.

Data Sources

Surface-water quality data have been collected throughout the District by various groups (government, academic, private, and other organizations) and for a variety of purposes. These data vary considerably in frequency of collection, and parameter set. The primary sources of information for this report were the databases maintained by the USGS and GA EPD, as well as databases developed for local watershed assessments performed by CH2M HILL and others. TM No. 4, Data Gap Analysis, of the District WMP identified the data from these three sources as most consistent and reliable.

Nationally, the USGS collects water quality data through various programs, which can be reviewed on their web site (www.usgs.gov). The NAWQA, designed to assess historical, current, and future water quality conditions in representative river basins and aquifers nationwide, was the primary USGS program source of the data. USGS long-term monitoring gauges in the District are typically located at road crossings on major and smaller stream segments.

The GA EPD monitors water quality to collect baseline and trend data for a variety of purposes, e.g., to document existing conditions, to monitor permit compliance and enforcement, and to develop technical support for regulatory standards (such as TMDLs). This information is summarized biennially in Georgia's 305b report to the U.S. EPA (GA EPD, 1998d) and in reports prepared by the Georgia Public Policy Foundation (GPPF, 1999).

Watershed assessments are performed in Georgia to support local governments developing improved or new Water Pollution Control Plants (WPCPs). The GA EPD watershed approach (Watershed Assessment and Protection Plan) manages water quality through the NPDES permit program. This approach requires that local governments building new WPCPs or expanding existing ones conduct a watershed assessment that includes monitoring, the identification of stressors, and planning steps necessary to improve conditions and ultimately meet water quality standards where waters do not support designated use. Data collected for watershed assessments are reviewed for quality and consistency and thus provide another valuable data source.

Basin Surface-Water Quality

Coosa River Basin

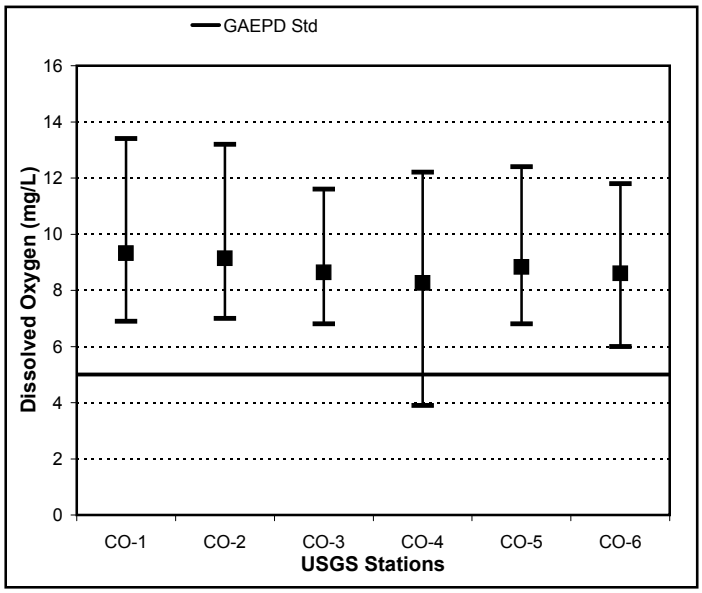
USGS gauging station data (Table 5-2, Figure 5-2: CO-1 through CO-6) were used to examine general water quality conditions in the Coosa River basin. The data provided in Figure 5-2 were compiled from stations with available data during the period 1992 – 1999 and do not necessarily reflect data from equal sample sizes or concurrent years.

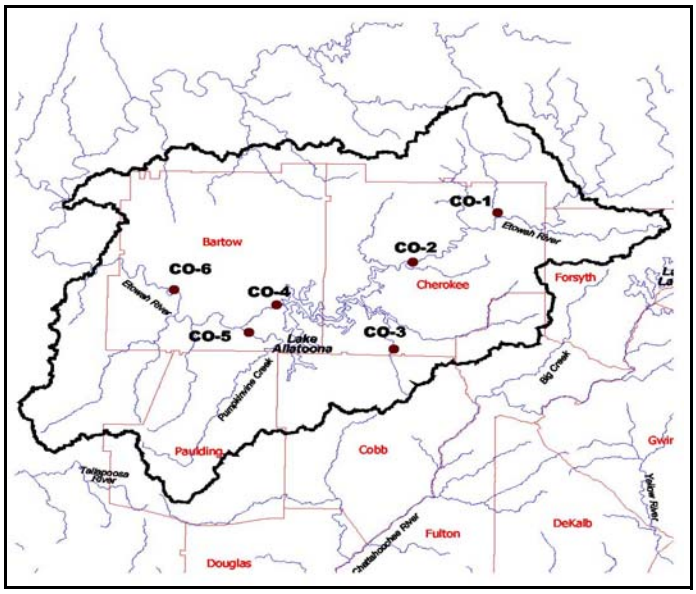
TABLE 5-2
Names and Codes of USGS Stations in the Coosa Basin Used as Water Quality Data Sources
Metropolitan North Georgia Water Planning District Watershed Management Plan

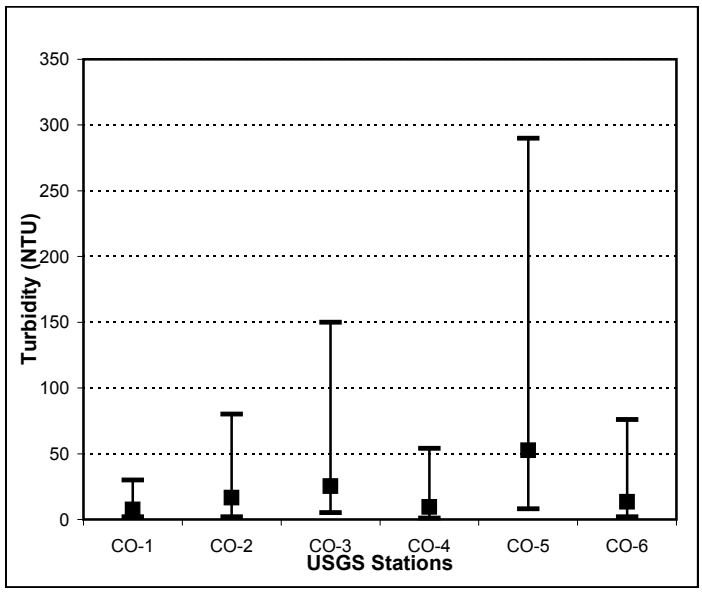
Stream	Station Name	USGS Station Code
Long Swamp Creek	CO-1	02390500
Etowah River	CO-2	02392000
Little River	CO-3	02393000
Etowah River	CO-4	02394000
Pumpkinvine Creek	CO-5	02394520
Etowah River	CO-6	02394980

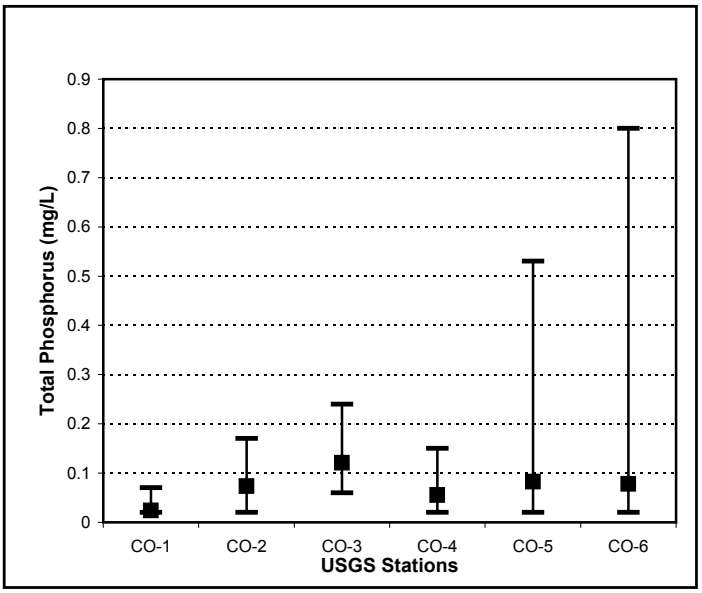
Water quality in the Coosa basin is fairly good. The average DO concentrations (Figure 5-2) are above the state standard of 5 milligrams/liter (mg/L). The range of average DO values shown in Figure 5 2 is essentially due to seasonal variation. The low DO measured at Station CO-4 (on the Etowah River below Lake Allatoona Dam) may be due to the release of water from the bottom of the lake. The average BOD levels at these 6 stations are below 1.5 mg/L and therefore would not exert a demand on DO that would be detrimental to the biota. Even the highest BOD values of 3.0 and 3.3 mg/L on the Little River and Pumpkinvine Creek (CO-3 and CO-5, respectively) probably do not have long-term effects on the biota. Turbidity and TP levels are typical for this area and do not indicate long-term problems. The high turbidity values (e.g., 300 Nephelometric Turbidity Units [NTU]) may be due to the hydrologic characteristics of these systems. The region is characterized by high runoff values and the streams in the area respond rapidly to rainfall events with dramatically increased flows. Average fecal coliform bacteria data range between 100 and 1,000 most probable number (MPN) per 100 milliliters (mL). These data averages are mostly in the range indicative of clean systems. The data ranges probably result from seasonal influences.

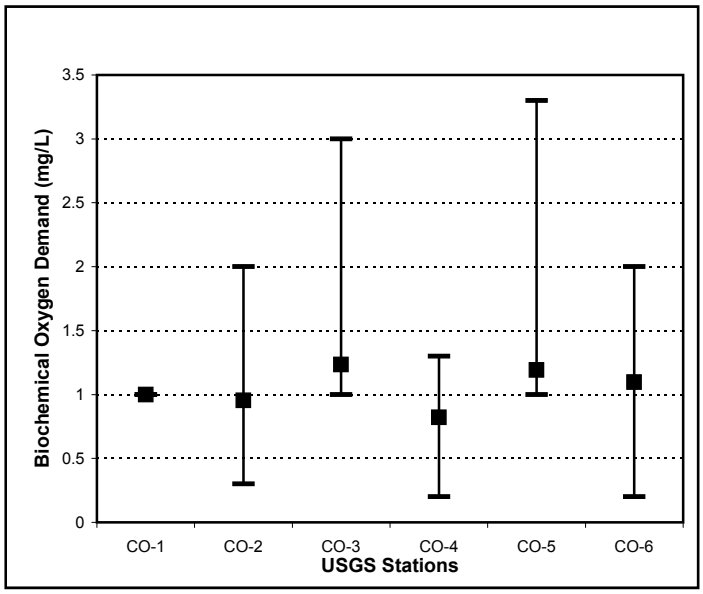
While the data suggest that the system is presently in relatively good condition, the high values are indicators that degradation is possible if extreme values become more common. Numerous authors such as Mulvey and Hamel (1998); David (1995); Herricks (1995); Omernick (1976); and Schueler (1994) have demonstrated that prolonged high turbidity and TSS levels degrade stream systems and reduce biotic integrity.

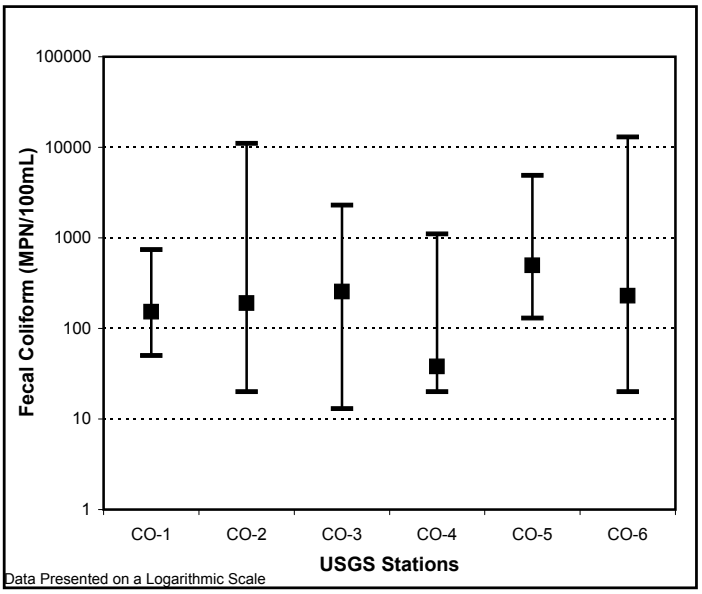












Legend

(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-2

Water Quality Data Summaries for the Coosa River Basin

Metropolitan North Georgia Water Planning District Watershed Management Plan

Few trends are evident in the yearly data collected at CO-6 on the Etowah River (Figure 5-3). The strongest trend is evident in BOD, where average annual values have been increasing. However, even with increasing values, the yearly average remains below 2 mg/L, so BOD probably does not have long-term effects on the biota. However, should the trend continue, BOD could reach levels that might impact biota. Localized areas may exhibit BOD-induced depression of DO and resulting impacts on biota. Other parameters examined do not show strong trends, but there is evidence of episodic high levels of contaminants, as shown by the maximum values reported for each parameter during each year (Figure 5-3).

Water quality data have been collected as part of watershed assessments on streams in Forsyth County (CH2M HILL, 2000a), the Noonday Creek/Little River watershed (CCWS and CH2M HILL, 1997), Pumpkinvine Creek watershed (CH2M HILL, 1997a), Bartow County (Dirnberger et al., 2001), Cherokee County (Welker and Associates Inc., et al., 2001) and Lake Allatoona (LAPA, 2001).

In addition, the GA EPD has developed a Coosa Basin Management Plan (GA EPD, 1998a), which also provided water quality data for this report. GA EPD conducts regular and periodic sampling of the Coosa River in the Etowah basin above and below Lake Allatoona and of the Etowah River in western Bartow County. Nutrients, sediment, and related pollutants from nonpoint source pollution, urban and rural runoff, animal wastes, and sanitary sewer overflows cause the greatest impacts to water quality in these area (GA EPD, 1998a).

For the purposes of describing water quality conditions, the Coosa basin is subdivided into the following three sub-basins with their associated water bodies (Table 5-3):

- Upper Etowah River basin, which includes Lake Allatoona and streams that discharge to the lake
- Lower Etowah River basin, which includes the area below Lake Allatoona to the point where the Etowah leaves the District in western Bartow County
- Coosawattee River basin, which includes smaller watersheds draining into this river in northern Cherokee and Bartow Counties

TABLE 5-3
Major Streams Sampled for Water Quality in Coosa Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

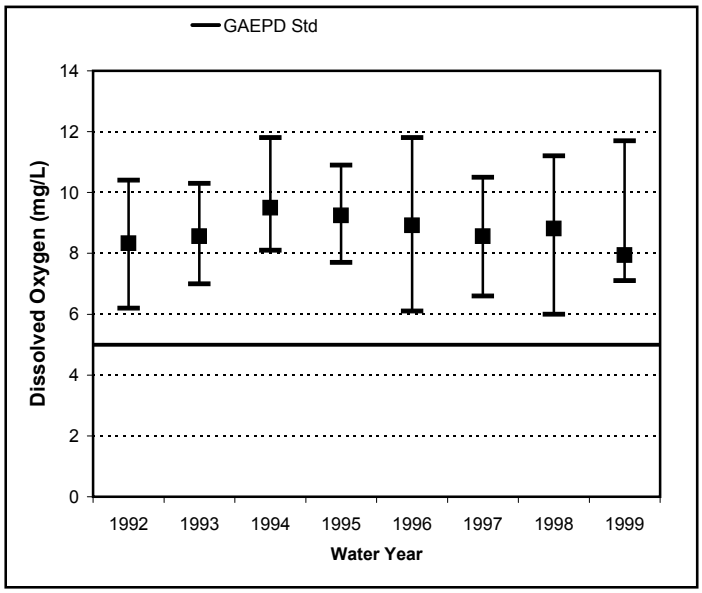
Stream or Water Body Name	HUC	County	Comments
Upper Etowah River Basin			
Long Swamp Creek		Cherokee	Water quality is generally good in this stream.
Settingdown Creek		Forsyth	Water quality was severely impacted due to runoff from rural land uses and especially sedimentation and bed and bank erosion.
Etowah River		Cherokee, Forsyth	Upstream of Lake Allatoona water quality is affected by runoff from streams draining developed urban and

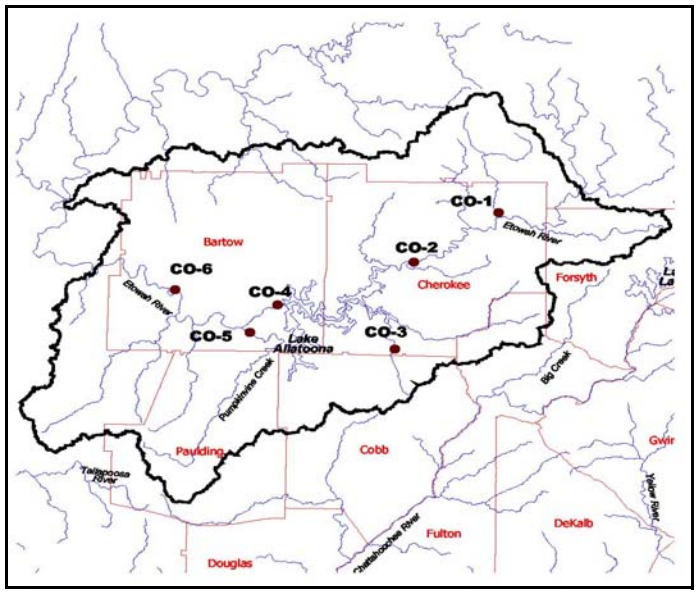
TABLE 5-3
Major Streams Sampled for Water Quality in Coosa Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

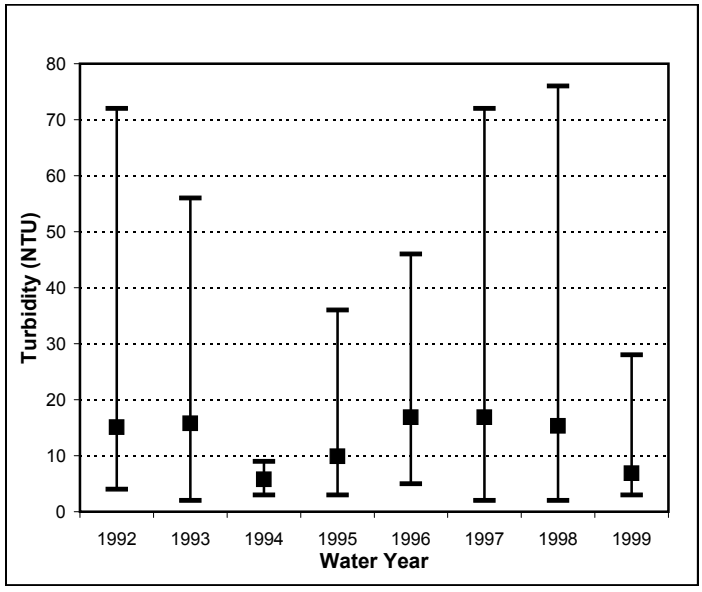
Stream or Water Body Name	HUC	County	Comments
			rural lands. See Settingdown Creek.
Little River		Cherokee, Fulton	The water quality is impacted due to runoff from urban areas and sedimentation and bed and bank erosion.
Noonday Creek		Cherokee, Cobb	The water quality was severely impacted due to runoff from urban areas and sedimentation and bed and bank erosion.
Stamp Creek		Bartow	Generally the water quality is good to excellent, but is occasionally affected by silviculture practices (i.e., sedimentation).
Lake Allatoona		Bartow, Cobb, Cherokee	Water quality is affected by cumulative impacts from NPS pollution in tributaries.
Lower Etowah River Basin			
Etowah River		Bartow,	Downstream of Lake Allatoona, water quality effects are mostly from rural developments.
Pumpkinvine Creek		Paulding, Bartow	Water quality in Pumpkinvine Creek is generally good, varies with land use, and is affected by agricultural uses (especially cattle and horses) and urban runoff.
Pettit/Nancy Creek		Bartow	Water quality is impacted by the City of Cartersville.
Etowah River Tributaries (Raccoon, Euharlee, Two Run, Connesena, Ward, Tom's, Richland Creeks)		Bartow	Water quality is affected by elevated TSS and nutrients and in some cases low flow conditions.
Coosawattee River Basin			
Salacoa Creek		Bartow	Water quality is generally good.
Little Pine Log Creek		Bartow	Water quality is affected by high nutrient loading.
Pine Log Creek		Bartow	Water quality is heavily affected by sedimentation.

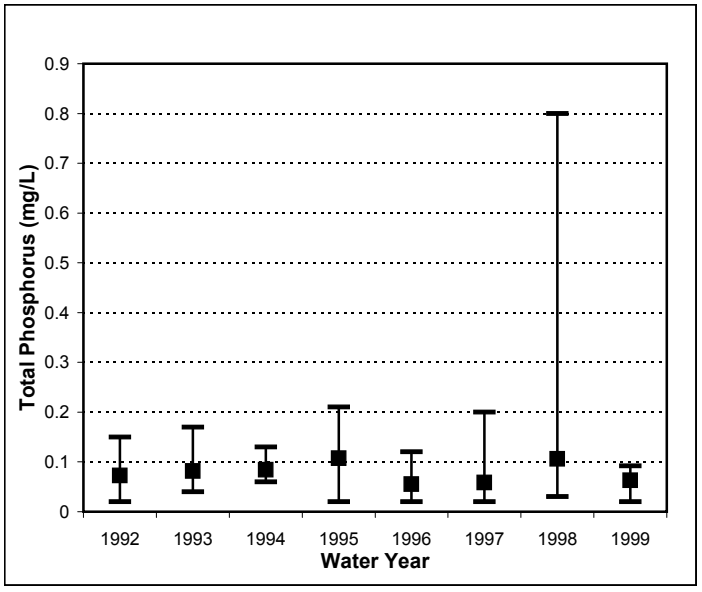
The Etowah River basin, located in the northwest section of the District, includes several watersheds and streams that drain mostly agricultural areas in Bartow, Paulding, Cobb, and Cherokee Counties.

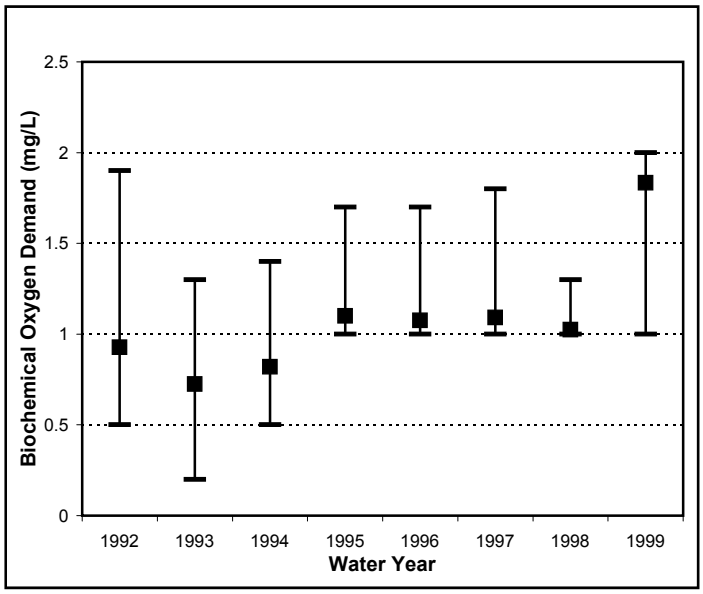
GA EPD identified violations of water quality standards in the Etowah River basin for fecal coliform, and metals (copper, lead, zinc, cadmium, selenium, and arsenic) in mainstem and tributary segments. Threats to water bodies from erosion and sediment loading were also identified (GA EPD, 1998a).

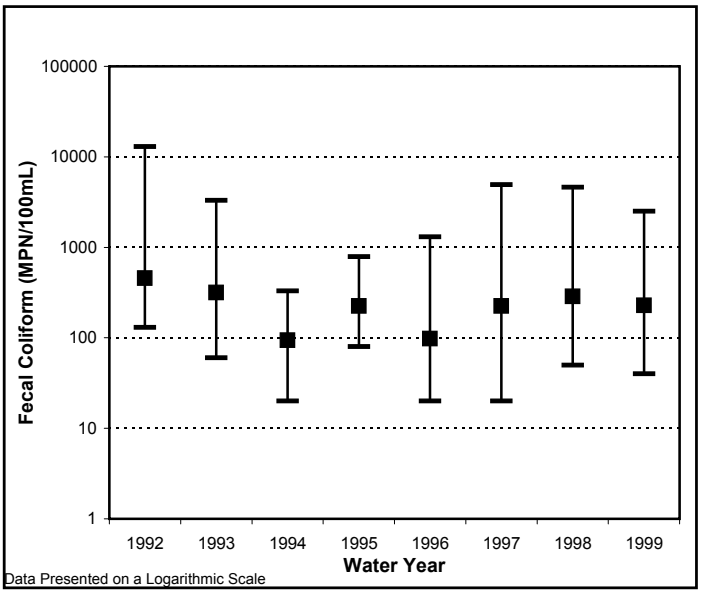












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(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-3

Annual Water Quality Trend Analysis for Station CO-6 (Located in the Coosa River Basin)

Metropolitan North Georgia Water Planning District Watershed Management Plan

Upper Etowah River Basin

In Forsyth County, the Brewton, Settingdown, Shoal, and Stamp Creek sub-basins were evaluated for water quality integrity. Stamp Creek was also evaluated in Bartow and Cherokee Counties (CH2M HILL, 2000a; Dirnberger et al., 2001; Welker and Associates Inc., et al., 2001).

Although water quality levels varied considerably, water quality was generally good and exceedances of water quality criteria were limited, with the exception of fecal coliform. Watershed assessments conducted by CH2M HILL (2000a), Dirnberger et al. (2001), and Welker and Associates Inc. et al. (2001) indicated that the major contributors to stream degradation were sedimentation and streambank erosion. The reports concluded that these were the result of the watershed transitioning from natural forest communities to other developed land uses. Settingdown Creek is significantly degraded as a result of sedimentation from historical agricultural operations and channel alterations.

Brewton Creek, the least developed watershed, exhibited the least disturbed conditions (CH2M HILL, 2000a). The upper reach of Stamp Creek, which drains the Pine Log Wildlife Management Area, has generally good water quality with low concentrations of nutrients, metals, and TSS. Further downstream on Stamp Creek, the TSS and turbidity increase during rainfall events. Rowland Springs Branch, a small watershed in Bartow County, shows the influence of road crossings and impoundments. High water temperatures, heavy siltation, and relatively high total Kjeldahl nitrogen (TKN) concentrations were measured in this stream (Dirnberger et al., 2001).

The Noonday Creek and Little River watersheds of the Etowah River include portions of Cherokee, Forsyth, Fulton and Cobb Counties. These watersheds are undergoing suburbanization, and these changes are impacting downstream water quality, including that of Lake Allatoona. Most impacts are related these land cover changes within the watershed, especially the streambank erosion and sedimentation associated with residential and commercial development. Other impacts include increased water temperature where banks and riparian zones have been cleared of vegetation. The CCWS and CH2M HILL (1997) and Welker and Associates Inc. et al. (2001) demonstrated that phosphorus loading is increasing in this basin. In the Little River embayment of Lake Allatoona, which includes Noonday Creek, large increases in turbidity were observed during wet weather sampling events. Two nearby streams in Cherokee County, Kellogg and Owl Creeks, showed similar degraded water quality conditions. (CCWS and CH2M HILL, 1997, Welker and Associates Inc. et al., 2001).

Lake Allatoona

Most impacts within the upper Etowah River watershed are nonpoint sources and are having cumulative effects on water quality within tributaries and in Lake Allatoona, which is located in Cherokee, Bartow, and Cobb Counties. Increases have been observed in TSS, phosphorus loading, bacteria, and heavy metals resulting from erosion, sedimentation, and urban runoff, primarily during rainfall events (LAPA, 2001). Historical limnological data compiled by GA EPD suggest the lake is becoming increasingly eutrophic (GA EPD, 1998a). To offset further degradation of the lake, a TMDL study was conducted and as a result, GA EPD established water quality standards for chlorophyll a, TP, DO, and pH (Beck et al.,

1999). In 2001, the lake exceeded the limit for chlorophyll at the five specified monitoring locations (LAPA, 2001).

The water quality in the embayments of Lake Allatoona appears to be somewhat independent of the main lake. Because the embayments are semi-enclosed, the discharge from each tributary tends to affect water quality to a greater extent (GA EPD, 1998a). Sedimentation in the main body of the lake is consistently light, while high rates occur in the outermost reaches. These outermost sections of the lake receive flows primarily from the main tributaries of Lake Allatoona such as the Etowah River, Shoal Creek, Little River, Stamp Creek, Proctor Creek, and Allatoona Creek (LAPA, 2001).

Lower Etowah River Basin

The Pumpkinvine Creek watershed is located in Paulding and Bartow Counties. The watershed assessments conducted in this sub-basin (CH2M HILL, 1997a; Dirnberger et al., 2001) included data on the mainstem and seven tributaries:- Westbrook, Bone, Picketts Mill, Little Pumpkinvine, Pace, Whitehead, and Weaver Creeks. The watershed in general is meeting water quality standards and overall quality is good to excellent, with a few localized areas of impairment. Fecal coliform counts have occasionally exceeded state water quality standards. The impairment is primarily due to erosion and sedimentation as a result of timber harvesting in the southern and eastern portions of the basin, suburban development in the east, agriculture in the north, and storm water from the City of Dallas.

Wet weather sampling in the Pumpkinvine Creek watershed identified substantially higher levels of fecal coliforms in areas using septic tanks. TSS, turbidity, ammonia, nitrate/nitrite, TP, and metals (chromium, copper, cadmium, nickel, lead and zinc) also show increases throughout the watershed during rainfall events (CH2M HILL, 1997a).

Near the confluence of Pumpkinvine Creek and the Etowah River in Bartow County, turbidity, TSS, chemical oxygen demand (COD) and BOD concentrations are elevated during rainfall events. TP concentrations exceed EPA recommended standards during both wet and dry sampling events, and high fecal coliform concentrations were recorded. Copper and lead levels slightly upstream of the confluence exceeded standards during rainfall events (Dirnberger et al., 2001).

Water quality in Etowah River tributaries in Bartow County is generally good. One exception is the Pettit/Nancy Creek watershed, which is experiencing multiple impacts. Pettit Creek is experiencing elevated TSS and sediment, especially below Cartersville. Lead concentrations exceeded state standards during wet weather and base flow conditions (Dirnberger et al., 2001).

Other water quality problems noted in tributaries to the lower portion of the Etowah watershed include elevated TSS and nutrients, particularly TP, on Euharlee Creek. The pH was above the state standard on Connesena Creek during wet weather. Low DO was measured on Upper Tom's and Ward Creeks, possibly due to low flow conditions. Richland Creek, a small tributary, may be showing the effects of water withdrawals. High TSS and turbidity levels were measured during wet weather flows in Raccoon Creek. That creek also has relatively high nitrate and COD values, possibly due to agricultural activities. Two Run Creek is in generally good overall condition (Dirnberger et al., 2001).

Coosawattee River Basin

This basin includes Salcola, Little Pine Log, and Pine Log Creeks in northern Bartow and Cherokee Counties (Table 5-3). GA EPD conducts regular sampling in the Coosawattee basin. Water quality conditions are being affected primarily by nonpoint source pollution, urban and rural runoff and sanitary sewer overflows, animal wastes, unpaved roads without storm water controls, forestry practices, and agriculture. Water quality sampling identified violations of water quality standards for fecal coliform in mainstem and tributary segments. Erosion and sediment loading also threaten streams (GA EPD, 1998a).

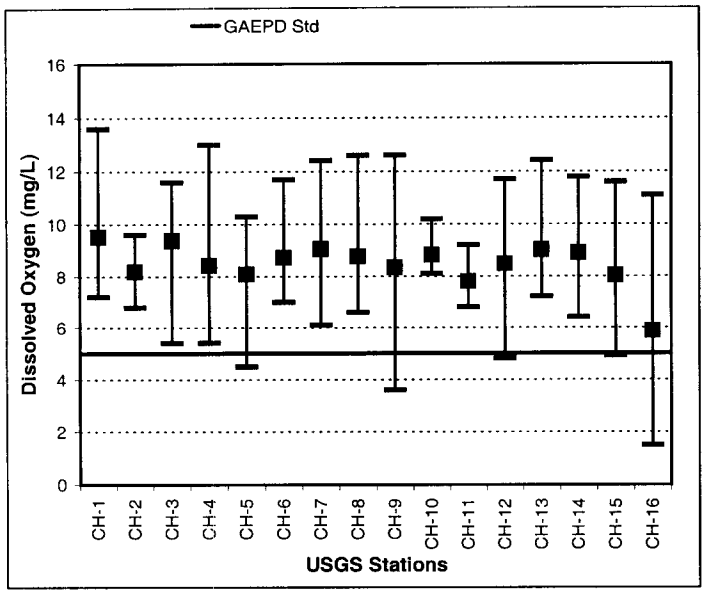
Pine Log Creek is heavily affected by sedimentation. Elevated fecal coliform and relatively high TKN concentrations were also measured. Little Pine Log Creek has high nutrient and metals concentrations relative to other streams in Bartow County. Salacoa Creek has generally good water quality, although elevated metals and fecal coliforms were measured (Dirnberger et al., 2001).

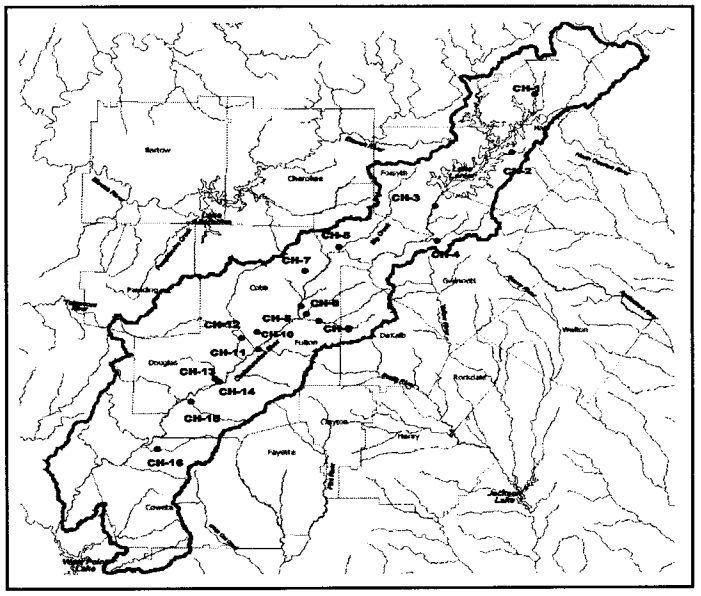
Chattahoochee River Basin

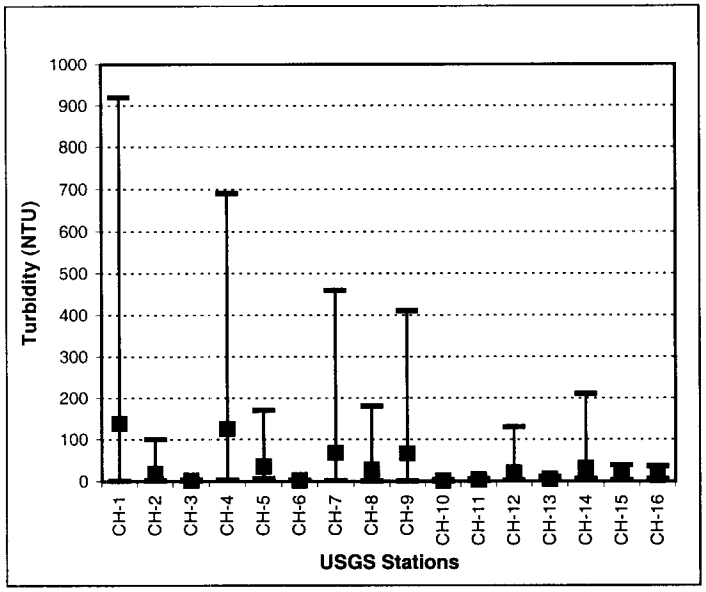
The Chattahoochee River basin includes portions of Hall, Forsyth, Gwinnett, Fulton, DeKalb, Cobb, Paulding, Douglas, Clayton, and Coweta Counties. Data from the 16 USGS sampling locations listed in Table 5-4 is illustrated in Figure 5-4. These stations (Figure 5-4, upper right corner) cover the mainstem and tributary streams, extending from a station north of Lake Lanier through the Atlanta metropolitan area and slightly beyond. The data provided in Figure 5-4 were compiled from stations with available data during the period 1992 – 1999 and do not necessarily reflect data from equal sample sizes or the same time periods.

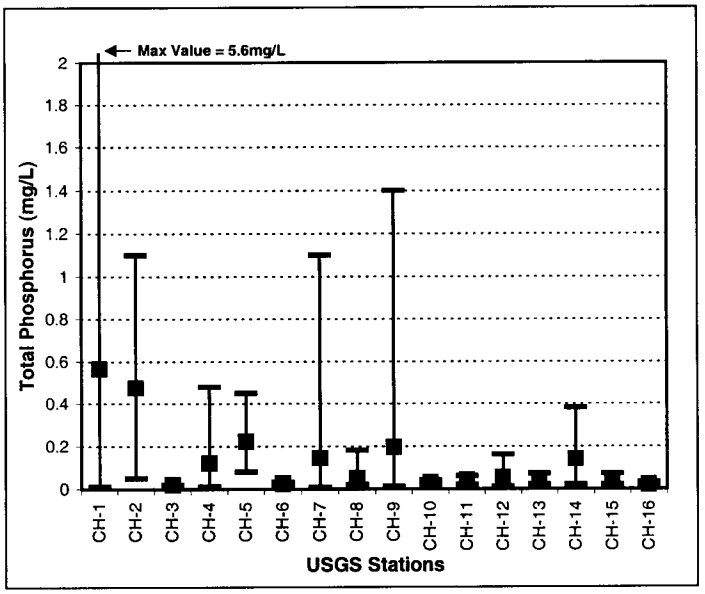
TABLE 5-4
Water Quality Data Sources among USGS Stations in the Chattahoochee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

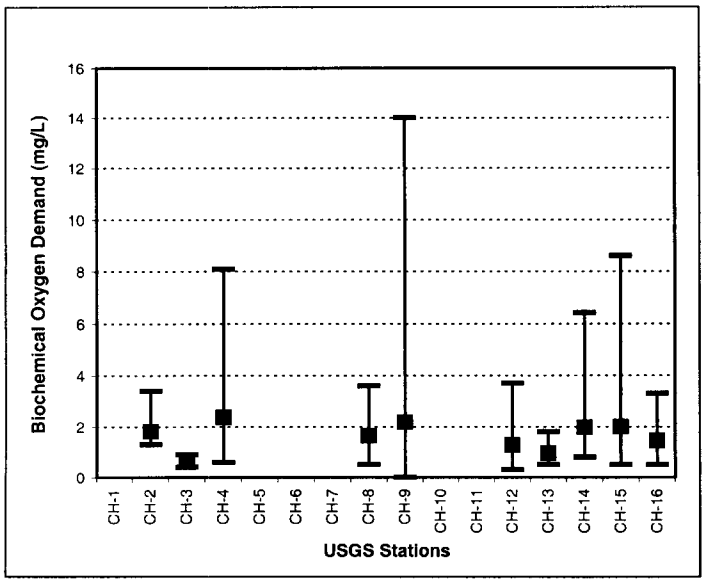
Stream	Station Name	USGS Station Code
West Fork of Little River	CH-1	02332830
Flat Creek	CH-2	02334140
Chattahoochee River near Buford	CH-3	02334500
Suwanee Creek	CH-4	02334885
Big Creek	CH-5	02335741
Chattahoochee River at Atlanta	CH-6	02336000
Sope Creek	CH-7	02335870
Nancy Creek	CH-8	02336410
Peachtree Creek	CH-9	02336300
Nickajack Creek	CH-10	023336610
Utoy Creek	CH-11	02336728
Sweetwater Creek	CH-12	02337000
Annewakee Creek	CH-13	02337200
Chattahoochee River near Fairburn	CH-14	02337170
Bear Creek	CH-15	02337320
Cedar Creek	CH-16	02337985

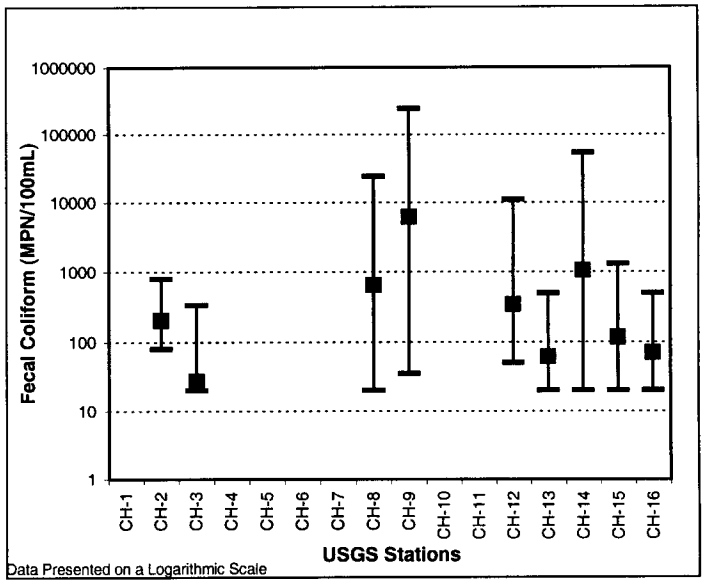












Legend

(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-4

Water Quality Data Summaries for the Chattahoochee River Basin

Metropolitan North Georgia Water Planning District Watershed Management Plan

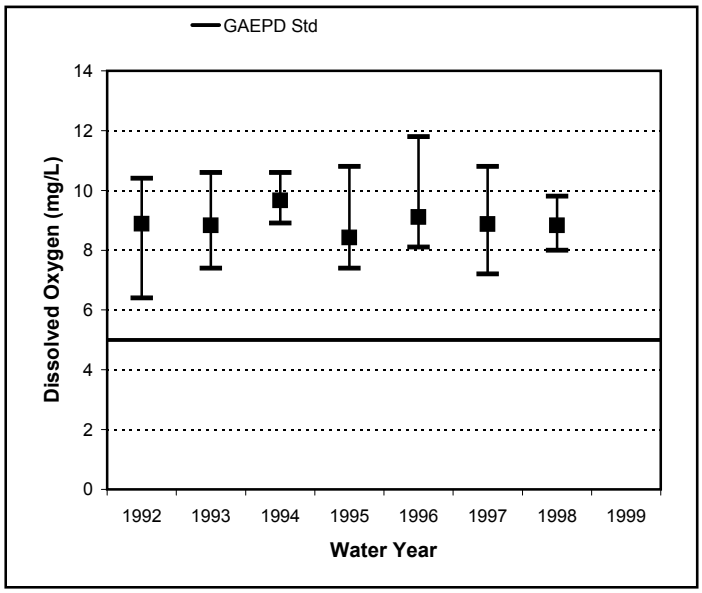
The overview of the Chattahoochee basin provided by USGS data indicated that the water quality is lower compared with the other basins in the District. The average DO concentrations are above the state standard of 5 mg/L. The range of average DO values (Figure 5-4 upper left) is essentially due to seasonal variation. Station CH-16 in Cedar Creek, a rural area of the County, exhibited the lowest average DO concentration in this basin. The BOD levels at the 10 stations where this parameter was recorded indicate average values of approximately 2.0 mg/L. This level should not exert a demand on DO that would be detrimental to the biota. However, spikes in BOD values, such as the maximum value recorded for Station CH-9 (about 14 mg/L) may exert localized pressure on biota.

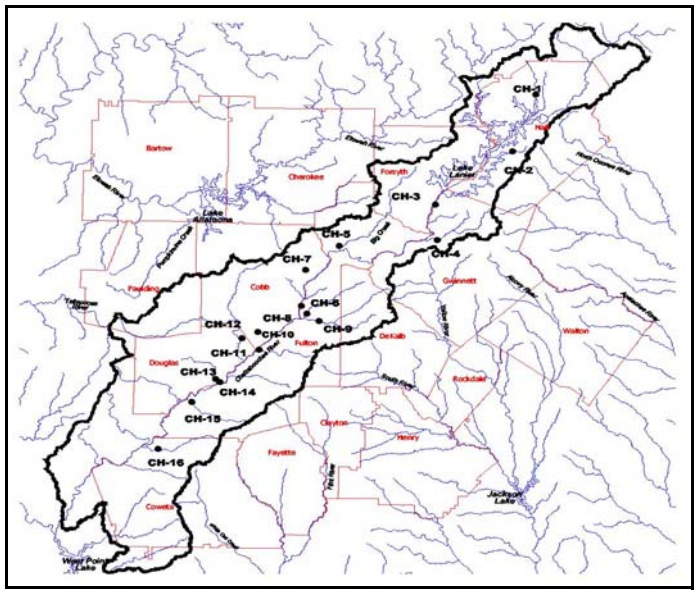
Average turbidity levels at several of the stations (CH-1, CH-4, CH-5, CH-7, CH-9, CH-9, and CH-14) are relatively high (i.e., greater than 20 NTU), indicating potential long-term problems. The high turbidity values (i.e., ranging from 100 NTU to 920 NTU) may be due to the 'flashy' nature of these systems (rapidly rising stream levels and resulting high-velocity flows during rainfall events due to rapid storm water runoff in the region). Prolonged high turbidity and TSS have been shown to degrade stream systems and reduce biotic integrity (Mulvey and Hamel, 1998; David, 1995; Herricks, 1995; Omernick, 1976; Schueler, 1994). TP values typically are below 0.5 mg/L, but a maximum value of 5.6 mg/L was recorded at Station CH-1 on the West Fork of the Little River. This station also had the highest recorded turbidity level. These two features may be indicative of water quality problems arising from nonpoint (agricultural) source runoff in this watershed.

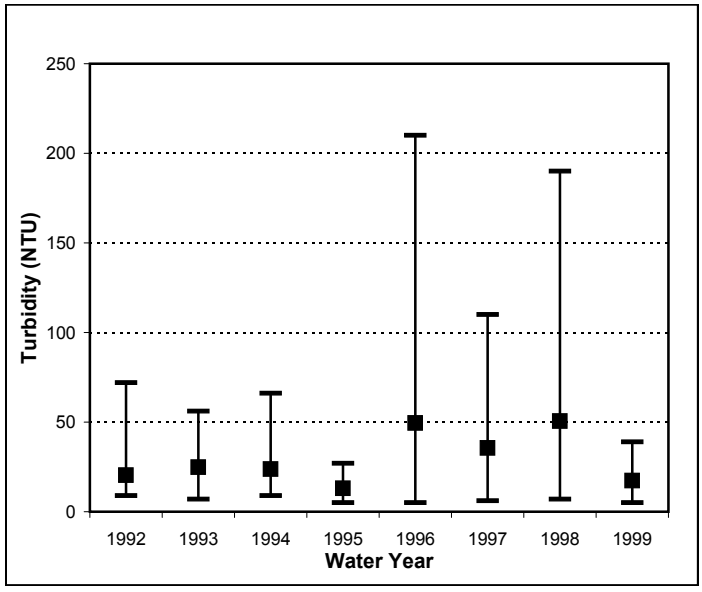
Average fecal coliform bacteria data showed wide variability among the 16 stations, with 2 stations (CH-9 and Ch-14) exceeding average yearly values in excess of 1,000 colonies per 100 mL and 4 stations having maximum levels in excess of 10,000 colonies per 100 mL. Stations CH-9 and CH-14 receive input from the City of Atlanta. One of the other two stations (CH-9) with maximum values in excess of 10,000 colonies per 100 mL is within Atlanta and the other is in the rapidly urbanizing border area of Cobb/Douglas Counties (CH-14). Station CH-9 on Peachtree Creek, with an average value of over 6,000 colonies per 100 mL, appears to indicate a chronic problem and would likely exceed the state standard for this parameter. Urban runoff, sewer line problems, and CSOs are probable contributors to the elevated fecal coliform bacteria levels.

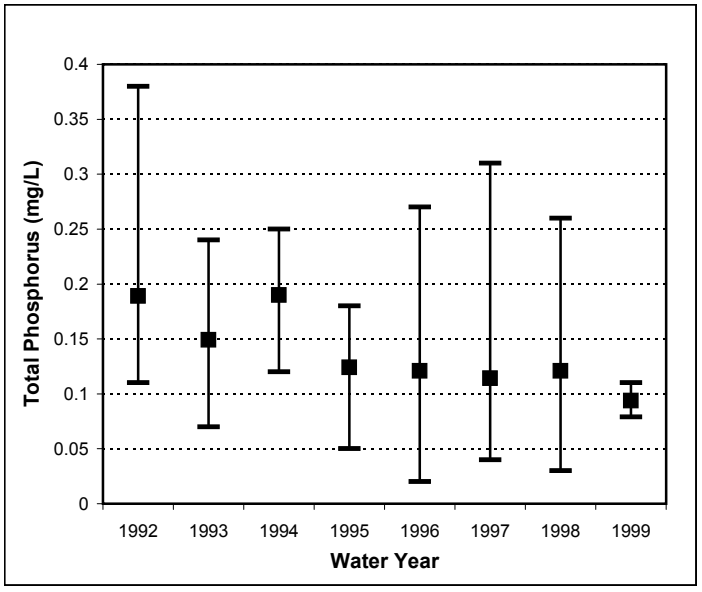
Few trends are evident in the yearly data collected at CH-14 on the Chattahoochee River near Fairburn (Figure 5-5). The strongest trend is evident in TP, where average annual values have been decreasing since 1999. These reductions in TP have been due primarily to recent improvements in the discharge water quality from City of Atlanta wastewater treatment facilities. Fecal coliform bacteria have exhibited a mild increasing trend through time, but the extreme variability in these data may obscure trends. Other parameters examined do not show strong trends, but there is evidence of random elevated levels of contaminants as shown by the maximum values reported for each parameter during each year (Figure 5-5).

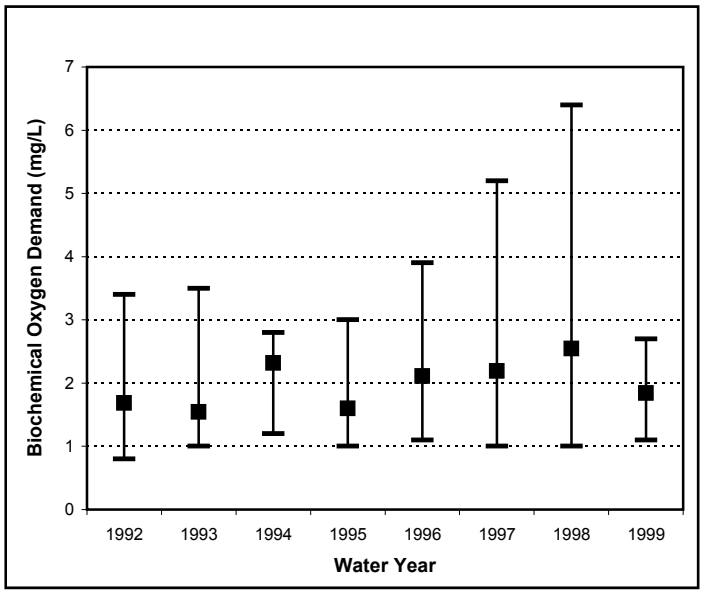
The USGS assessed water quality in the Apalachicola, Chattahoochee, and Flint basins from 1992 to 1995 (Frick et al., 1998). According to that report, pesticide concentrations in streams draining urban and suburban land uses often exceeded chronic exposure criteria for protection of aquatic life. Most of the pesticide loading is carried via storm water runoff (Frick et al., 1998).

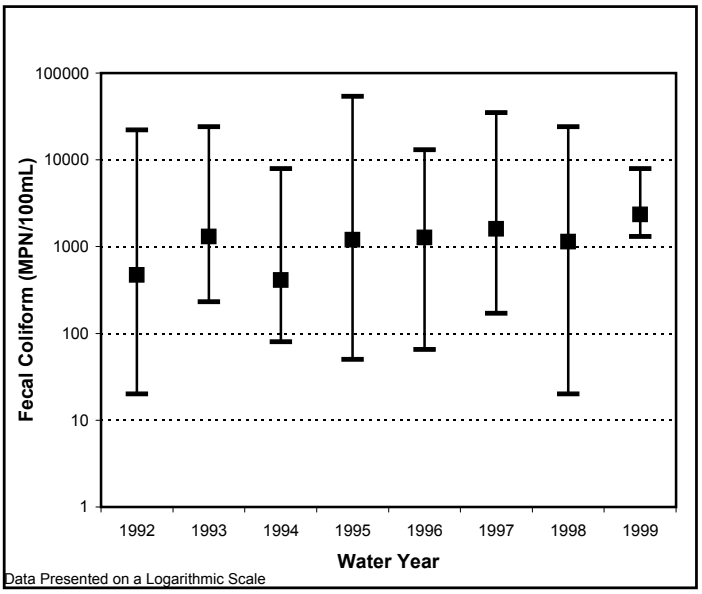












Legend

(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-5

Annual Water Quality Trend Analysis for Station CH-14 (Located in the Chattahoochee River Basin)

Metropolitan North Georgia Water Planning District Watershed Management Plan

Nutrient concentrations are highest in streams with poultry operations and urban and suburban land uses, particularly during storm flow. Levels of nutrients from nonpoint source pollution show an increase over time. TP levels also increase in the river as it flows through Atlanta. Point sources from wastewater treatment plants (WWTPs), and sewers, and CSOs contribute to this increase. During storm flows, the US EPA criterion for TP is often exceeded on the lower Chattahoochee River.

Concentrations of metals and organic compounds are generally proportional to the amount of development in a watershed. As land converts from forested to developed uses such as commercial and transportation, concentrations of those elements and compounds increase. Most loading occurs via storm water runoff (Frick et al., 1998).

Results of other aquatic sampling programs were used to assess conditions at representative stream locations throughout the Chattahoochee basin. GA EPD and USGS perform regular monitoring in the watershed. Many counties and municipalities have also conducted monitoring. Primary water quality conclusions for major streams reviewed in this report are summarized in Table 5-5 (CH2M HILL, 2000c; CH2M HILL, 2000a; Camp Dresser and McKee, 2000; CH2M HILL, W.L. Jorden and R&D Environmental, 1998b; CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 1998a; CH2M HILL, 2000b; GA EPD, 1997a).

TABLE 5-5
Major Streams Sampled for Water Quality in Chattahoochee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

Stream or Water Body Name	County	Comments
West Fork Little River	Hall	Major impacts to water quality are sedimentation, erosion, certain metals, and fecal coliform related to land use.
Flat Creek	Hall	Water quality is impacted by sedimentation, elevated nutrients, and TSS.
Chattahoochee River	Hall and Forsyth	The upper portion of the Chattahoochee within the District is receiving loads of sediments and nutrients as the result of NPS runoff.
Lake Lanier	Hall and Forsyth	Water quality is generally good, although the lake is showing a trend towards greater eutrophication.
Dave's, Big Creeks	Forsyth	Water quality is moderately degraded due to sedimentation associated with ongoing development in the watershed.
Suwanee Creek	Gwinnett	Sedimentation is affecting water quality in this watershed.
Big Creek	Fulton, Forsyth	The principal water quality concern is sedimentation and other pollution caused by storm water runoff.
Sope Creek	Cobb	Water quality is affected by nutrients and high levels of sedimentation.
Chattahoochee River	City of Atlanta, Fulton	Water quality declines as the river enters more urbanized areas with greater nonpoint and point sources of pollution.
Nancy Creek	City of Atlanta/Fulton	Water quality is affected by urban and suburban runoff.

TABLE 5-5
Major Streams Sampled for Water Quality in Chattahoochee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

Stream or Water Body Name	County	Comments
Peachtree Creek	City of Atlanta/Fulton	Water quality was severely affected by point and NPS pollution and storm water runoff including minimally treated waste from CSOs.
Nickajack Creek	Cobb	Water quality is generally good, but sedimentation and degraded habitat reflect the suburban setting of the creek.
Utoy Creek	City of Atlanta/Fulton	Water quality is affected by point and NPS pollution and storm water runoff, including minimally treated waste from CSOs.
Sweetwater Creek	Douglas	Water quality is impacted by sedimentation.
Chattahoochee River		This portion of the river carries high levels of nutrients, metals, bacteria, and other wastes. This reflects contributions from heavily urbanized areas of Atlanta and surrounding communities.
Annewakee Creek	Douglas	Water quality is generally good, though fecal coliform concentrations are elevated.
Bear Creek	Fulton	Water quality is affected by NPS runoff.
Cedar Creek	Coweta	Water quality is affected by low levels of DO.

The natural flow regime of the Chattahoochee River has undergone substantial changes over the past century, including the building of two major impoundments (i.e., Lake Lanier and Bull Sluice Lake), as well as several smaller structures for water withdrawal. For purposes of this assessment, the Chattahoochee River basin is divided into three sub-basins:

- The Lake Lanier basin, which includes the lake and streams that discharge to the lake. This area is unique because much new commercial and residential development in metropolitan Atlanta is occurring in Hall and Forsyth Counties. In the short term, the effects of this development on water quality would likely be limited to the nearby streams and Lake Lanier.
- The Upper Atlanta Chattahoochee basin includes the area from Buford Dam to Peachtree Creek near the City of Atlanta water intake. The water quality in the streams in this area is impacted primarily by runoff from residential developments.
- The Lower Atlanta Chattahoochee basin from Peachtree Creek to the District boundary in Coweta County.

Lake Lanier Basin

GA EPD conducts regular sampling of the Chattahoochee River in the Lake Lanier basin. These data indicate that water quality is being affected by both point and nonpoint source pollution. The fecal coliform bacteria standard was exceeded at 30 tributary and 3 mainstem GA EPD monitoring stations due to nonpoint sources, including runoff from urban, agricultural, and forested areas (GA EPD, 1997a).

In Hall County water quality was sampled in Balus, Big, Hagen, Mud, Flat, Wahoo, Yellow, and Johnson Creeks, the Chestatee River, and the East and West Forks of the Little River. These tributaries show varying water quality. Results show that major contributors to stream degradation were related to land use and include sedimentation, erosion, certain metals, and fecal coliform bacteria. In most watersheds, fecal coliform bacterial levels were above the State Standard – 200 MPN/100 mL in the summer and 1,000 MPN/100 mL in winter (GA EPD, 2001). Sedimentation and elevated nutrients were identified as water quality concerns in nearly all the watershed streams. TSS was highest in Big, Flat, and Wahoo Creeks, and the West Fork of the Little River. Metals were also identified as a concern in the Flat Creek and Limestone Creek watersheds (CH2M HILL, 2000c).

In Forsyth County, water quality sampling included three tributaries to Lake Lanier: Six Mile, Four Mile, and Two Mile Creeks. Based on the sampling results, major contributors to stream degradation were sedimentation, erosion, and fecal coliform. Although water quality conditions varied throughout the county, exceedances of water quality criteria were limited. Fecal coliform bacteria and sedimentation levels were high in the Six Mile Creek watershed. Two Mile Creek is experiencing similar water quality problems, but to a lesser extent (CH2M HILL, 2000a).

Lake Lanier

The water quality in Lake Lanier is monitored by the GA EPD, The Upper Chattahoochee Basin Group (UCBG), the University of Georgia, the Upper Chattahoochee Riverkeeper, and others. The general purpose of these efforts has been to identify water quality problems and to determine the nature and extent of those problems. The UCBG (made up of a coalition of local governments surrounding Lake Lanier and the Lake Lanier Association) conducted a 2-year water quality assessment of the lake and its tributaries (UCBG, 1998) In addition, the University of Georgia, through an EPA grant under the Clean Lakes program (Section 314 of the Federal Clean Water Act), conducted a Phase 1 diagnostic/feasibility study of the water quality in Lake Lanier and its tributaries (UGA, 1998).

The results of these and other studies showed that the water quality in Lake Lanier is relatively good. Overall, the lake is mesotrophic, especially in the deeper open water areas. However, long-term EPA data show some increase in eutrophication (GA EPD, 1997a).Many of the embayments were mesotrophic to eutrophic, and the worst conditions appear to occur in the near-field embayments close to where tributaries enter the lake (UGA, 1998). Consequently, the main concern is possible water quality degradation from tributaries providing excessive sediment and nutrient loading. Nonpoint source loads account for about 80 to 90 percent of tributary-based nutrient loading to the lake. Other concerns include fecal coliform bacteria concentrations in some tributary streams and embayments, mercury and lead detected in some water samples, and stress to certain fish caused by low DO levels (GA EPD, 1997a).

Upper Atlanta Chattahoochee Basin

The Upper Atlanta Chattahoochee basin consists of watersheds in the City of Atlanta/Fulton County and Cobb, Forsyth, and Gwinnett Counties. In Forsyth County, aside from the Big Creek watershed, most watersheds (Dave's, Dick, James sub-basins) were moderately degraded to un-impacted (CH2M HILL, 2000a). Major contributors to stream degradation were identified in that report as sedimentation, erosion, certain metals, and

fecal coliform bacteria. Results indicated that although water quality levels varied throughout the basin, exceedances of water quality criteria were limited. However, fecal coliform bacteria levels frequently exceeded the State standard. Other chemical parameters that were measured include nutrients and metals and field parameters (DO, pH, turbidity, etc). These parameters were not a problem basin-wide, but levels were elevated at a few locations. These elevated levels of nutrients and metals appear to be primarily from point source discharges in these areas and concentrated urban runoff.

The Big Creek watershed, located in Fulton and Forsyth Counties, is undergoing changes due to widespread development. With continued growth, the principal concern in Big Creek is pollution caused by storm water runoff. All of the streams in the Big Creek watershed are impaired by sediment. Some tributaries to Big Creek also appear to be impaired by excessive nutrients and fecal coliforms (Camp Dresser and McKee, 2000). Within the Forsyth County portion of Big Creek, copper was also identified as a water quality stressor (CH2M HILL, 2000a). Monitoring data from 1970 to the present suggest that wet weather fecal coliform concentrations are increasing. The State of Georgia 303(d) list includes the lower mainstem of Big Creek, Foe Killer Creek, and Hog Wallow Creek on the non-attainment list for fecal coliform. DO appears to show a slightly decreasing DO trend, but all measurements are above the minimum in-stream DO requirement of 4.0 mg/L.

In the Dave's Creek and Dick Creek watersheds, water quality was moderately degraded. This degradation is primarily due to sedimentation associated with ongoing construction and development, the resulting increases in impervious surfaces, and associated increases in storm water runoff(CH2M HILL, 2000a).

Wet weather concentrations of pollutants are generally greater than the dry weather concentrations, particularly for TSS and fecal coliforms. However, there is an apparent trend of increasing concentration with decreasing stream flow for TKN, nitrate/nitrite nitrogen, TP, and dissolved phosphorus. Relatively constant loads from point sources and/or septic tanks are the likely cause of this trend, because those loads make up a larger percentage of the total stream flow under low flow conditions (CH2M HILL, 2000a).

Heavy metals have been collected in storm water discharge. Lead, copper, zinc, and cadmium are the metals that typically exhibit greater concentrations than other metals found in urban runoff. The presence of these heavy metals in tributary streams in the watershed may also be indicative of problems with a wide range of other toxic chemicals, such as synthetic organic compounds, which have been identified in previous field monitoring studies of urban runoff pollution (Camp Dresser and McKee, 2001).

Streams in Gwinnett County exhibit water quality problems similar to those identified in Big Creek. Crooked, Level, Richland, and Suwanee Creeks were found to have water quality impacts resulting from alterations in stream hydrology and sediment transport and deposition. Based on an analysis of TSS, Gwinnett watersheds in the Chattahoochee basin have been more affected by existing land development than those in the Oconee and Ocmulgee basins (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000a).

The level of fecal coliform bacteria is a ubiquitous water quality issue in Fulton County. Thirteen Fulton County streams and creeks are on the State of Georgia 303(d) list as a result of exceeding the state standard for fecal coliform bacteria in either drinking waters or

recreational waters. These exceedances are most often associated with CSOs and storm water runoff. While the values observed in Fulton County are in excess of the State standard, they are typical of urbanized watersheds around the country (CH2M HILL, 2001f).

High TSS concentrations have been measured in Fulton County streams, most often associated with rainfall events. Wet weather means were significantly higher than dry weather means. Major sources of sediment include construction sites, streambank erosion, and agricultural practices. The highest TSS concentrations in Fulton County were measured in the Camp Creek and Johns Creek watersheds. Elevated levels of nutrients and pesticides were measured during wet weather in the Sandy Springs basin. The Johns Creek and Sandy Springs basins both also contribute high levels of phosphorus and nitrogen to the Chattahoochee River (CH2M HILL, 2001f).

The City of Atlanta watershed, which drains into the Upper Atlanta Chattahoochee basin, includes highly urbanized portions of Fulton, DeKalb and Gwinnett Counties. An assessment performed for the City of Atlanta included several small basins that drain directly into the Chattahoochee River and the Nancy Creek sub-basins in the Upper Atlanta Chattahoochee basin. The streams in these watersheds receive pollution from a variety of sources, both point and nonpoint source.

Nonpoint sources contribute oil, metals, and other chemicals to nearby streams. In addition, scour and erosion from wet weather flows contribute sediment. Sanitary sewer overflows have also occurred in the Nancy Creek sub-basin (CH2M HILL, JJ&G Inc., Tetra Tech Inc., and R&D Environmental, 1998a).

GA EPD has recorded exceedances of standards for metals, including lead, copper, zinc, and cadmium, and exceedances of the standard for fecal coliform bacteria in Nancy Creek and other smaller sub-basins in Atlanta (GA EPD, 1997a).

Lower Atlanta Chattahoochee

Much of the City of Atlanta that drains into the Lower Atlanta Chattahoochee basin includes highly urbanized portions of Fulton and DeKalb Counties. The City of Atlanta assessment included several small basins, which drain directly into the Chattahoochee River, and the Peachtree Creek, Proctor, Sandy, and Utoy Creek sub-basins.

The discharges of the City's combined sewer system are the primary point sources of pollution in these watersheds. During heavy rainfall events, storm water runoff from impervious surfaces enters directly into receiving waters. In addition, scour and erosion from wet weather flows contribute sediment to the streams. Two large WPCPs discharge into the Chattahoochee River just below Peachtree and Utoy Creeks. Treated wastewater is also discharged to the river from two Atlanta WPCPs located outside the Chattahoochee River basin. Sanitary sewer overflows have occurred in all of the major sub-basins in Atlanta. Levels of pollutants such as BOD, TSS, nutrients, and some metals are elevated downstream of CSO locations and increase from upstream to downstream locations (CH2M HILL, JJ&G Inc., and R&D Environmental, 1998a; CH2M HILL, JJ&G Inc., and R&D Environmental, 1998b).

Data from the GA EPD indicate that water quality conditions are being negatively affected by both point and nonpoint source pollution below Peachtree Creek in Atlanta. Excursions of water quality standards in this portion of the Chattahoochee River basin include the DO standard in Sandy Creek in Fulton County and fecal coliform bacteria and lead standards on the Chattahoochee River mainstem. On the mainstem immediately downstream from two metropolitan Atlanta WPCPs and a coal-fueled electric power plant, the standard for temperature was exceeded. Tributaries in the sub-basin had exceedances of standards for metals, including lead, copper, cadmium, and mercury. Forty-five monitored tributaries exceeded the standard for fecal coliform (GA EPD, 1997a).

The Chattahoochee River downstream of Atlanta carries high levels of nutrients, including TP (median concentration ranging from 0.5 to 0.75 mg/L). Nutrient levels decrease in the Chattahoochee River downstream of West Point Lake (median concentration of 0.09 mg/L), indicating that the lake acts as a sink for nutrients. Above West Point Lake, the phosphorus levels are typically elevated above 0.1 mg/L, especially during rainfall events. However, the phosphorus levels observed in the Little River and Camp Creek study areas were below this level (CH2M HILL, 2001f).

Many of the tributaries to the Chattahoochee River located generally south of Sweetwater Creek (Douglas County) appear to have better water quality than the mainstem along this stretch. In Douglas County, a water quality and biological monitoring program for the Anneewakee Creek watershed found elevated levels of fecal coliform throughout the basin. The monitoring included Slater Mill, Crooked, and Anneewakee Creeks as well as some unnamed tributaries. The water quality within the watershed was generally good otherwise (CH2M HILL, 2000b). Many chemical parameters, including conductivity and nutrients, were elevated downstream of the WPCP in the watershed, as might be expected.

Oconee River Basin

The Oconee River basin is located in Gwinnett and Hall Counties. General results from assessments for Hall County (CH2M HILL, 2000b), Gwinnett County (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000b), and GA EPD monitoring (GA EPD, 1998b) were used in the evaluation. In addition, data from one year of USGS records from Allen Creek (Station 02216968) were used to evaluate water quality conditions in water year 1999.

Overall, the surface-water quality in the Oconee River basin is good. However, surface-water quality problems due to nonpoint source pollution such as agricultural and storm water runoff are concerns. The contaminant of most concern is high turbidity due to erosion and sediment runoff. Concentrations of metals in excess of water quality standards have been detected in the Oconee River beyond District boundaries. The standard for fecal coliform bacteria has been exceeded in the mainstem and tributaries throughout the basin. These exceedances are attributed to a combination of urban runoff, septic systems, sanitary sewer overflows, rural nonpoint sources, and animal wastes (GA EPD, 1998b).

There has been a general upward trend in DO concentrations as point sources have been brought under tighter control. However, sediment loading remains a concern throughout the basin and is of greatest concern in developing metropolitan areas and along major transportation corridors (GA EPD, 1998b).

Allen Creek is one of the headwater tributaries to the Oconee River draining Hall County. Water quality data, although limited, indicate that water quality in the surface water from this area is generally good (Table 5-6). The DO, TP, BOD, and turbidity were not at levels which would indicate water quality problems. Fecal coliform average values were typical of relatively good water quality, but maximum values suggested that the stream was experiencing episodic elevations (geometric mean was 221 MPN/100 mL, maximum 5,400 MPN/100 mL).

TABLE 5-6
USGS Data Summary from Station 02216968 on Allen Creek
Metropolitan North Georgia Water Planning District Watershed Management Plan

Parameter	Min	Mean	Max
DO (mg/L)	7.7	9.1	11.8
Fecal (MPN/100 mL)	20	221	5400
TP (mg/L)	0.02	0.03	0.07
Turbidity (NTU)	1.8	8.9	34.0
BOD (mg/L)	0.6	1.0	1.8

The major streams with water quality monitoring programs such as watershed assessments reviewed in this report are listed in Table 5-7.

TABLE 5-7
Major Streams Sampled for Water Quality in Oconee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

Stream or Water body Name	County	Comments
North Oconee River	Hall	Water quality is generally good. Impacts are primarily the result of NPS pollution such as agricultural and storm water runoff.
Allen Creek	Hall	Water quality is generally good. Impacts are primarily the result of NPS pollution such as agricultural and storm water runoff.
Mulberry Creek	Hall	Water quality is generally good. Impacts are primarily the result of NPS pollution such as agricultural and storm water runoff.

In Hall County, a water quality assessment included sampling in Mulberry, Walnut, Allen, Candler, Pond Fork, and Caney Fork Creeks, as well as the North Oconee River (Table 5-5). Sampling included analysis during wet and dry weather conditions to evaluate the effects of storm water runoff. Based on the sampling results, major contributors to stream degradation were sedimentation, erosion, certain metals, and fecal coliform. Water quality within sub-watersheds varied in Hall County, with sub-basins exhibiting moderate to unimpacted water quality conditions. Fecal coliform contamination was identified as a concern in all basins. Sedimentation was identified as a water quality issue in Mulberry Creek, Allen Creek, and Pond Fork, as well as portions of the Upper Oconee River.

Aquatic integrity results from the Mulberry Creek watershed indicate minor to moderate degradation. Sedimentation and fecal coliform contamination were the primary concerns.

Sedimentation appears to be the result of construction associated with transitional land uses and new development, as well as historical agricultural practices. Although specific sources were not determined during this study, it appears that Walnut Creek and Caney Fork in this watershed appear to be relatively unimpacted. Sedimentation and habitat degradation (i.e., bank scour) from increased stream flows and sedimentation and erosion from development and rapid growth in the watershed were the primary sources of degradation (CH2M HILL, 2000c).

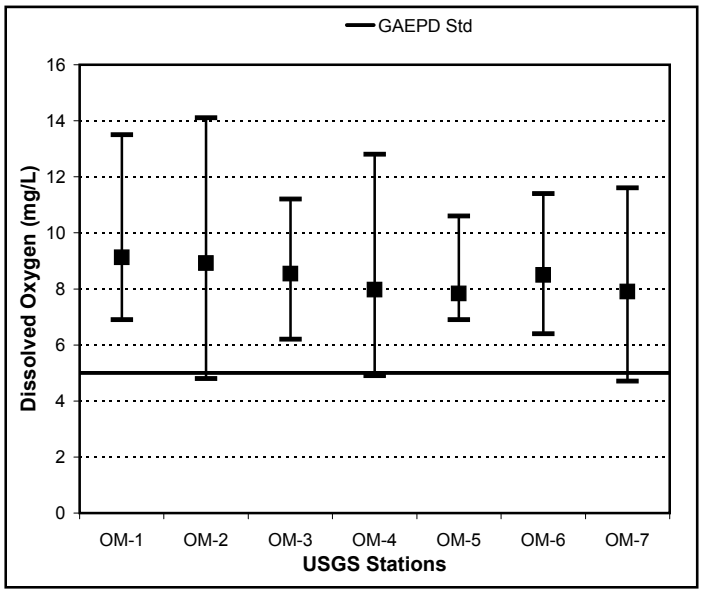
A Gwinnett County watershed assessment (CH2M HILL, JJ&G Inc., Tetra Tech Inc., and R&D Environmental, 2000b) identified similar water quality problems. The primary contributors to water quality degradation were found to be nonpoint source storm water runoff from both stabilized developed lands and historic agricultural lands. Changes in stream hydrology, sediment transport and deposition, and water quality were identified as specific aspects of the degradation. Other stressors include the clearing of riparian zone and streambank vegetation, which reduces natural retention and filtration of surface flows and associated chemical constituents, contributes to streambank erosion, sediment deposition, and flashy stream conditions, and reduces stream shading, thereby increasing water temperature.

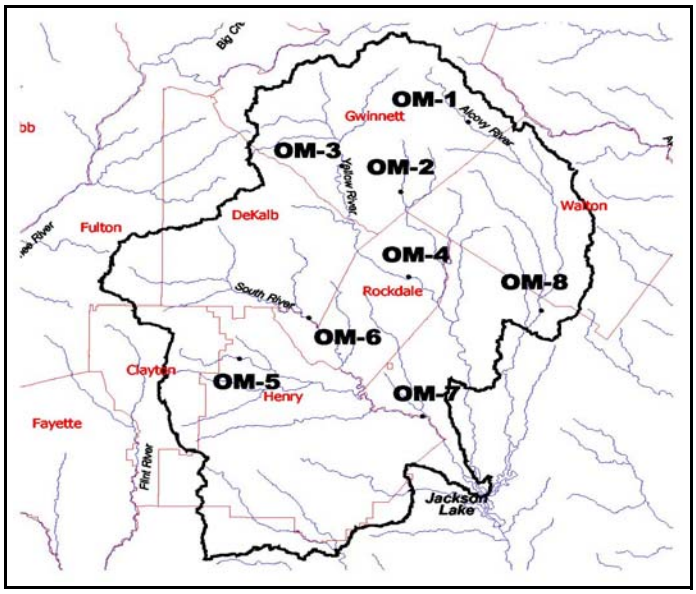
Ocmulgee River Basin

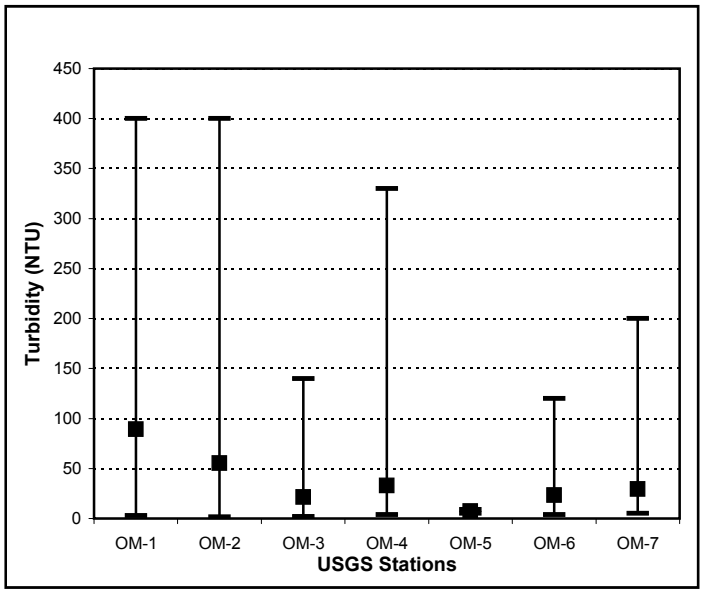
The Ocmulgee River basin includes portions of Gwinnett, DeKalb, Walton, Rockdale, Henry and Clayton Counties. The basin drains southeast to Lake Jackson and ultimately into the Ocmulgee River. USGS data from seven locations (Table 5-8, Figure 5-6: OM-1 through OM-7) were used in this evaluation. The data provided in Figure 5-6 were compiled from stations with available data during the period 1992 – 1999 and do not necessarily reflect data from equal sample sizes or concurrent years.

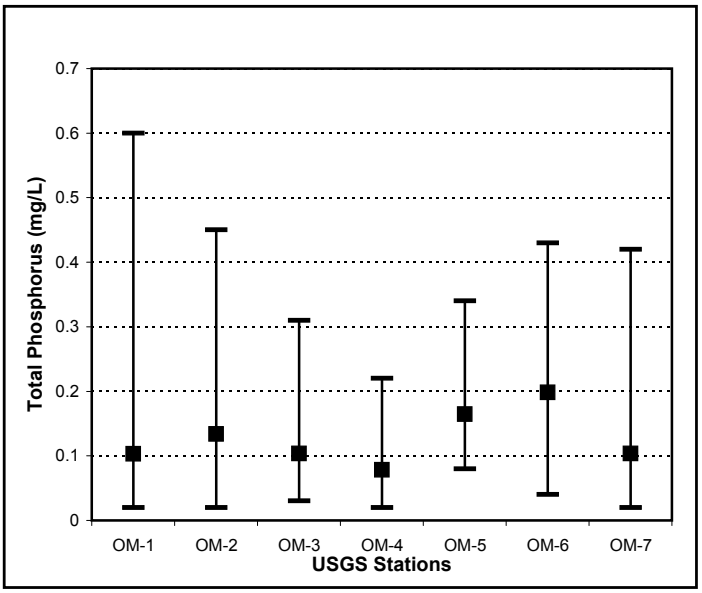
TABLE 5-8
USGS Stations Analyzed in the Ocmulgee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

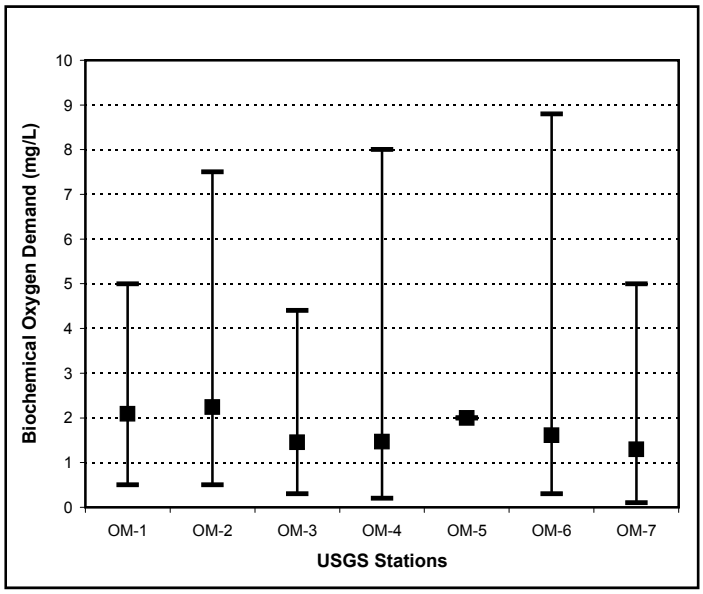
Stream	Station Name	USGS Station CODE
Alcovy River	OM-1	02208150
Big Haynes Creek	OM-2	02207385
Yellow River/Snellville	OM-3	02206500
Yellow River/Milstead	OM-4	02207300
South River/Klondike	OM-6	02204070
Big Cotton Indian Creek	OM-5	02204222
South River/Snapping Shoals	OM-7	02204520

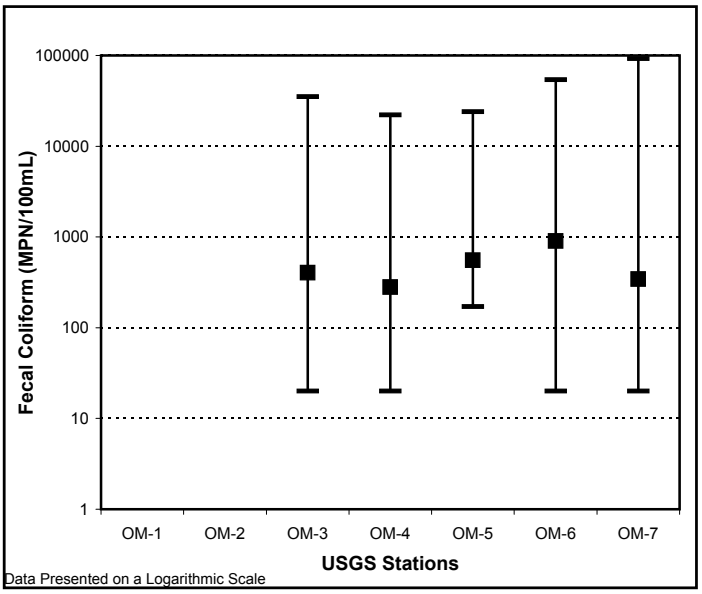












Legend

(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-6

Water Quality Data Summaries for the Ocmulgee River Basin

Metropolitan North Georgia Water Planning District Watershed Management Plan

Water quality in the Ocmulgee basin is somewhat degraded. Average DO concentrations were almost always above the state standard of 5 mg/L. Several minimum values (Stations OM-2 on Big Haynes Creek, OM-4 on the Yellow River, and OM-7 on the South River) were below the standard.

The average BOD levels at the seven stations were generally below 2.0 mg/L. This level should not exert a demand on DO that would be detrimental to the biota. However, spikes in BOD values, which were greater than 4 mg/L, observed at all the stations except OM-5 on Big Cotton Indian Creek (about 14 mg/L), may exert localized pressure on biota.

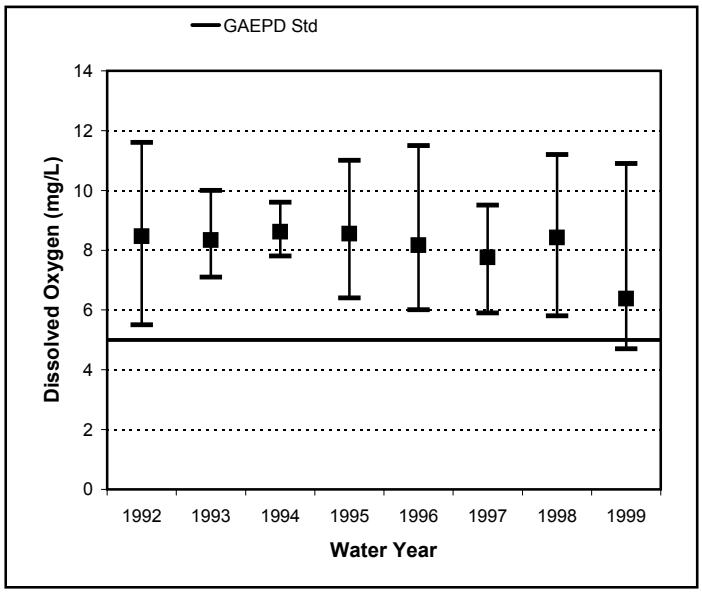
The average turbidity levels at all stations except OM-5 on Big Cotton Indian Creek are relatively high (i.e., greater than 20 NTU), indicating potential long-term problems and potential stressors to aquatic integrity. Similar to others stations, the high turbidity values (i.e., ranging form 120 NTU to 400 NTU) may be due to the flashy nature of these systems. Prolonged high turbidity and TSS have been shown to degrade stream systems and reduce biotic integrity (Mulvey and Hamel, 1998; David, 1995; Herricks, 1995; Omernick, 1976; Schueler, 1994).

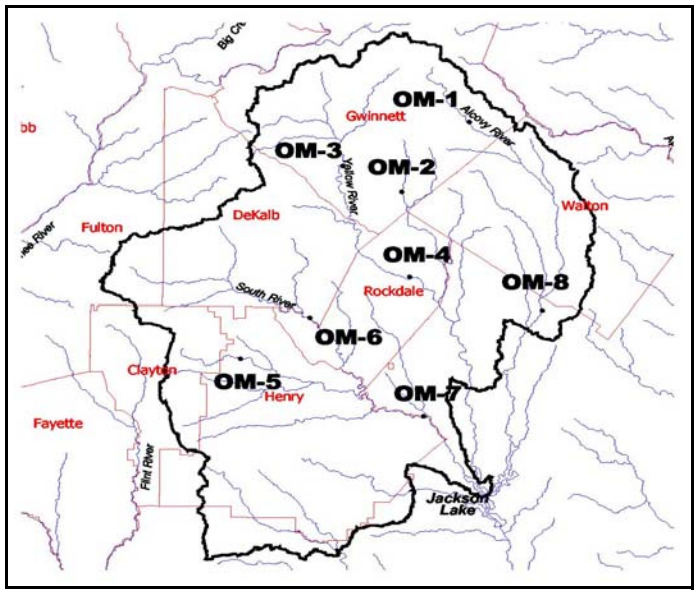
The average concentrations and range of TP values measured at the seven stations, with a maximum of 0.6 mg/L, were not exceptionally high. These values do not indicate a water quality concern from this nutrient.

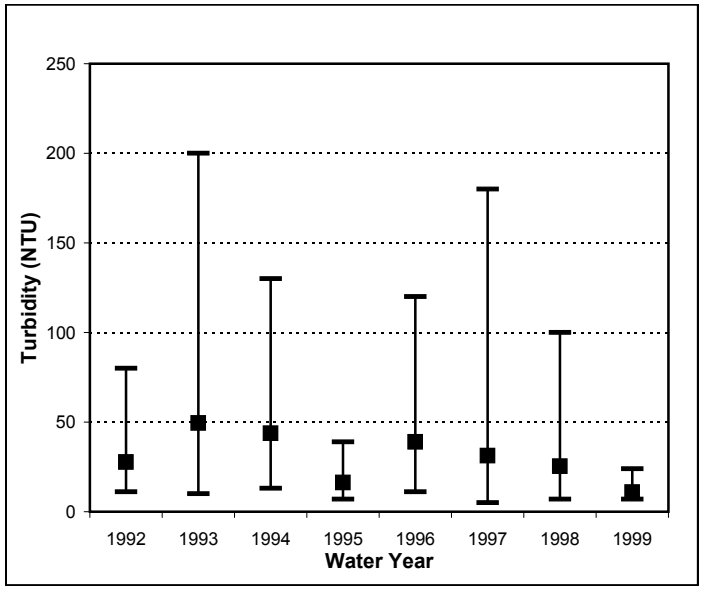
As in other developed basins such as the Chattahoochee, the average fecal coliform bacteria data show wide variability among the seven stations, with values exceeding 500 MPN/ 100 mL at Station OM-5 (554 MPN/100 mL) and OM-6 (899 MPN/100 mL). Both of these stations are located downstream of a municipal WPCP. The maximum values at all these stations, which are within Atlanta and other large metropolitan areas, exceeded 10,000 MPN/100 mL. In addition to wildlife, probable contributors to the elevated fecal coliform bacteria levels include urban runoff, sewer line problems, and CSOs.

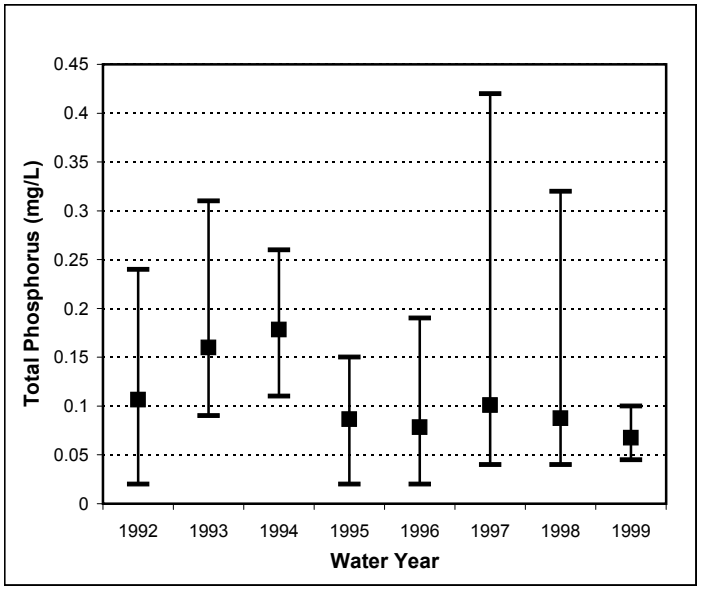
Station OM-7 on the South River near Snapping Shoals Creek was evaluated for any obvious trends in water quality over a 7-year period (Figure 5-7). The strongest trend was the steady increase in BOD levels over the period of record. Turbidity and TP values declined over the period, and there was no evident trend in fecal coliform levels. Although the TP values were variable, the decrease observed in these data may be attributed to improvements at WPCPs, which are more restrictive in this area to meet phosphorus loading standards for Lake Jackson (GA EPD, 2001). The slight decreases in turbidity levels may be attributed to a number of factors, including improved treatment at WPCPs. The increase in BOD is indicative of increased organic loading, possibly due to development in the area. In addition to these trends, there is evidence of episodic high levels of contaminants, as shown by the maximum values reported for each parameter during each year (Figure 5-7).

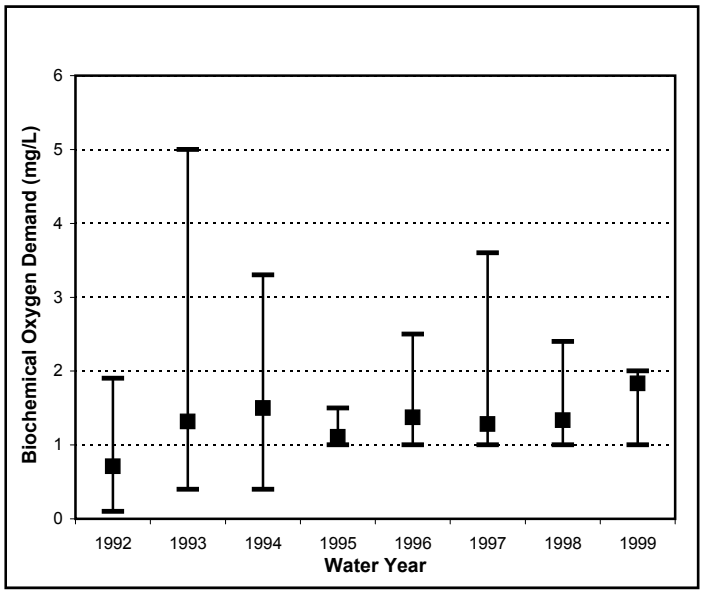
Many counties and municipalities have also conducted monitoring in the Ocmulgee River basin (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000b; Team Alcovy, 2002; Brown and Caldwell, 2002; Tetra Tech, Inc., 2000; DCWSD and CH2M HILL, 2001; CH2M HILL, 1998; CCWA and CH2M HILL, 2001a). Primary observations concerning the water quality of the major streams assessed are summarized in Table 5-9.

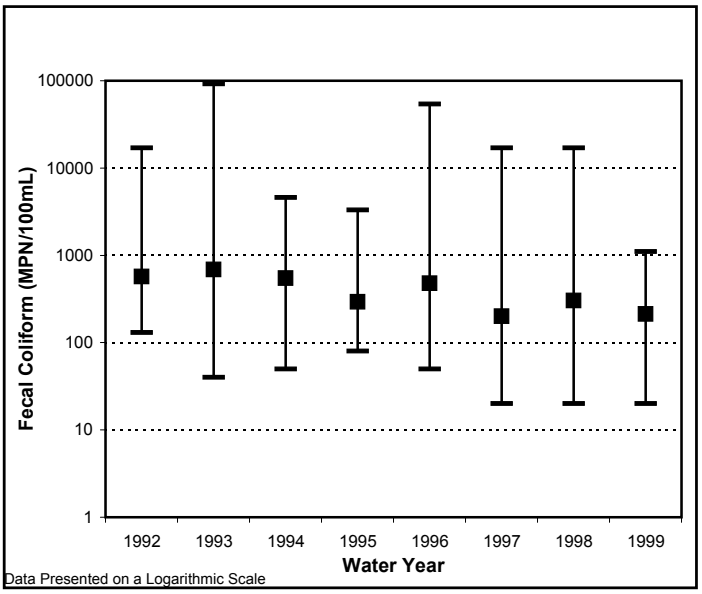












Legend

(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-7

Annual Water Quality Trend Analysis for Station OM-7 (Located in the Ocmulgee River Basin)

Metropolitan North Georgia Water Planning District Watershed Management Plan

TABLE 5-9
Major Streams Sampled for Water Quality in Ocmulgee Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

Stream or Water Body Name	County	Comments
Alcovy	Gwinnett, Walton	Water quality in the Alcovy is primarily affected by NPS runoff from developed lands and agricultural operations.
Big Haynes Creek	Gwinnett, Walton	Urban runoff and WWTPs are affecting water quality in this river.
Yellow River	Gwinnett, DeKalb, Rockdale	Urban runoff and WWTPs are affecting water quality in this river.
South River	DeKalb, Rockdale, Henry	The South River is heavily impacted by urban and suburban point and NPS pollution.
Big Cotton Indian Creek	Henry, Clayton	Water quality is good in general.

Watershed assessments have been conducted on the Alcovy River watershed and on portions of the Yellow and South Rivers and Big Cotton Indian and Big Haynes Creeks (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000b). Average TSS levels were low during base flow sampling events in the mainstem Alcovy River and its tributaries. Wet weather results, however, varied widely. The highest TSS levels were observed at three sites: East Bear Creek, West Bear Creek, and Mountain Creek. TSS concentrations showed the greatest variation in the upstream portions of the Alcovy basin in Gwinnett County. This variation is likely due to fluctuations in flow in the headwater region of the watershed. Average TSS concentrations exceeded the screening levels established for the Alcovy assessment during both dry and wet weather by an order of magnitude (Team Alcovy, 2002; Brown and Caldwell, 2002).

The various assessments done in the Alcovy River utilized differing methods, total phosphorus (TP) and soluble reactive phosphorus (SRP), to characterize the amount of phosphorus in the watershed. TP levels were elevated during base flow conditions in Big Flat Creek, East and West Bear Creek, Cornish Creek, and the upper Alcovy River. Most elevated TP levels were reported during wet weather and were likely associated with TSS. In another assessment, soluble reactive phosphorus (SRP) concentrations were also consistently high in the Alcovy River. In addition to TP, ammonia, nitrate, and total nitrogen concentrations were elevated at the Big Flat Creek station and frequently exceeded EPA screening levels in that stream. Elevated ammonia levels were also measured on the Alcovy in Gwinnett County and nitrate-nitrogen levels were elevated during occasional rainfall events (Team Alcovy, 2002; Brown and Caldwell, 2002).

Fecal coliform bacteria levels were responsible for most designated use violations in the Ocmulgee basin (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000b). Concentrations were highly variable but elevated at most sites, particularly during rainfall events. Levels were consistently high during rainfall events at monitoring sites on the Alcovy River. Fecal coliform counts were frequently higher than the state water quality

standards. For example, in the Alcovy River the highest concentrations were reported in Gwinnett County and were an order of magnitude higher than the state criteria for a single sample. High fecal coliform concentrations were also measured in Big Flat Creek. Similar to fecal coliform, *E. coli* concentrations varied significantly across most monitoring sites.

Receiving waters downstream of the Loganville WWTP on Big Flat Creek showed depressed oxygen levels with some measurements the state standard of 5 mg/L. Average ammonia levels increased significantly downstream and were above the chronic toxicity level of 1.4 mg/L (CH2M HILL, JJ&G Inc., Tetra Tech Inc. and R&D Environmental, 2000b). Elevated BOD levels were also measured downstream of the plant. Fecal coliform levels were variable; however, average downstream concentrations were generally higher than average upstream concentrations (Team Alcovy, 2002; Brown and Caldwell, 2002).

Studies by Tetra Tech, Inc. (2000), and CH2M HILL, JJ&G Inc., Tetra Tech Inc., and R&D Environmental, (2000b) showed that the Yellow River in Gwinnett County is impacted by fecal coliform and copper. The source of these constituents was identified as urban runoff. Municipal POTWs are impacting the Yellow River in Rockdale County and fecal coliform, copper, and lead were shown to be at elevated levels in the mainstem of the river. No Business Creek is impacted by fecal coliform and lead. Lead and zinc are impacting Beaver Ruin Creek and cadmium, copper, lead, and zinc are causing impairment on Jackson Creek. Beaver Ruin Creek and other tributaries, such as Shoal Creek and Big Haynes Creek, have high levels of fecal coliform (Tetra Tech, Inc., 2000; CH2M HILL, JJ&G Inc., Tetra Tech Inc., and R&D Environmental, 2000b).

Both point source and nonpoint source pollutants affect water quality and aquatic integrity in the South River study area. Point sources in the South River basin include WPCPs, CSOs, and a number of industrial/commercial sites located in the headwaters of the river. Water quality sampling performed by DeKalb County (DCWSD and CH2M HILL, 2001) identified nutrients, sedimentation, and fecal coliform bacteria as parameters of concern throughout the South River watershed. The pH values at many locations were below the minimum State standard (GA EPD, 2001). In addition, TP and ammonia levels were elevated in the headwaters of the South River as well as below the Snapfinger Creek and Pole Bridge Creek WPCPs. Nitrate-nitrite levels were elevated in the tributaries to the South River and were higher than the drinking water standard. BOD concentrations were elevated in the headwaters of the South River and below the Pole Bridge Creek LAS. Residual chlorine, while not a pervasive problem in the watershed, was detected at two of the five locations sampled. Fecal coliform levels were high, particularly in the headwaters of the South River and in Intrenchment Creek. One of the potential reasons for the high fecal coliform bacteria levels, as well as elevated levels of some of the other parameters, such as nitrogen and phosphorus, are the discharges from the City of Atlanta CSO facilities into the headwater streams in the South River watershed (DCWSD and CH2M HILL, 2001).

Water quality impacts were also evident in the South River in Rockdale County, primarily associated with urban runoff from DeKalb County and the City of Atlanta. Fecal coliform levels were elevated in the Snapping Shoals and Honey Creek sub-basins, the major tributaries to the South River in Rockdale County, due to both urban and nonpoint source runoff. Downstream of the Almand Branch WPCP, copper, zinc, low DO, and toxicity have been identified as water quality problems in this stream (Tetra Tech Inc., 2000). Impairment in the Snapping Shoals Creek watershed was predominantly due to erosion, high metal

levels, and sedimentation as a result of surface runoff from urban and suburban development. The southern portion of the watershed is expected to develop rapidly. Negative impacts to aquatic integrity and designated uses associated with storm water point and nonpoint sources related to urbanization are expected to increase (CH2M HILL, 1998).

Streams in Clayton County, such as Big Cotton Indian, Panther, Reeves, and Upton Creeks, have good water quality in general. Fecal coliform values, however, exceeded standards at least once in each stream. Elevated conductivity was measured on Panther Creek. Panther Creek also had higher nitrogen and phosphorus concentrations relative to other streams in Clayton County. Total recoverable lead values exceeded state standards at least once on Big Indian Cotton Creek and Upton Creek. However, dissolved lead concentrations in those creeks were below the water quality standard (CCWA and CH2M HILL, 2001a).

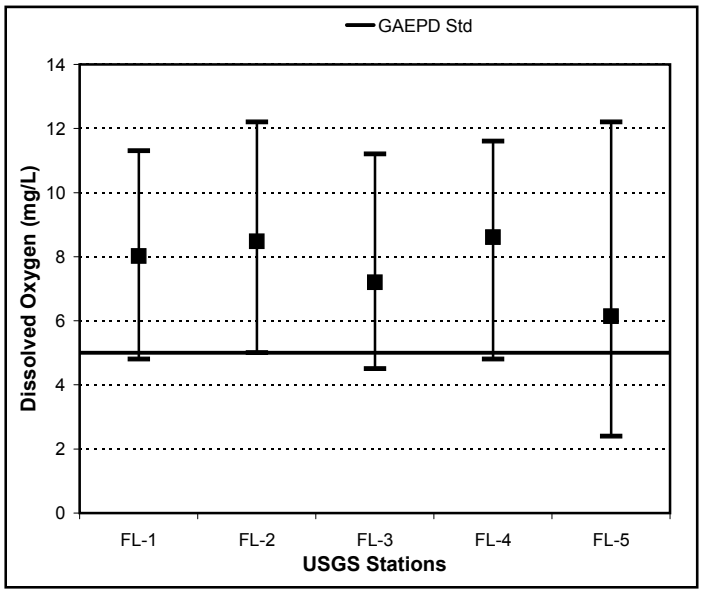
Flint River Basin

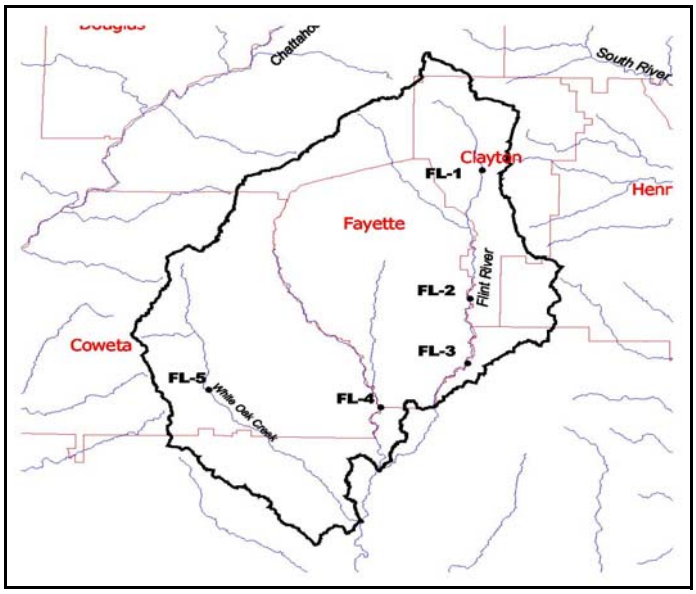
The Flint River basin is a primarily suburban area located just south of Atlanta. Within the District boundaries, the basin includes Fulton, Clayton, Fayette, and Coweta Counties. The five USGS monitoring stations listed in Table 5-10 and depicted in Figure 5-8 were evaluated to document long-term water quality conditions for selected parameters. The data provided in Figure 5-8 were compiled from stations with available data during the period 1992 – 1999 and do not necessarily reflect data from equal sample sizes or concurrent years. The densely developed headwaters of the Flint River watershed in Clayton County include the HAIA and the Cities of Hapeville and College Park. The headwaters of the other creek systems originate in rural areas of Fayette and Coweta Counties.

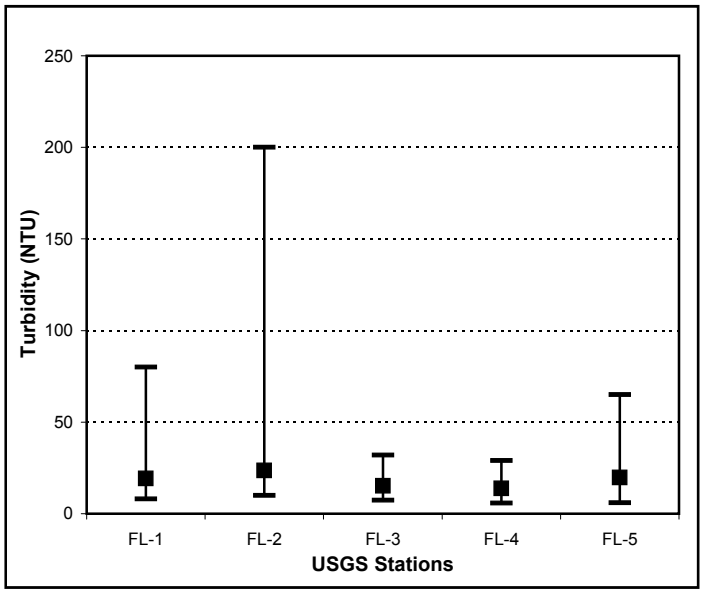
TABLE 5-10
USGS Stations Analyzed in the Flint Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

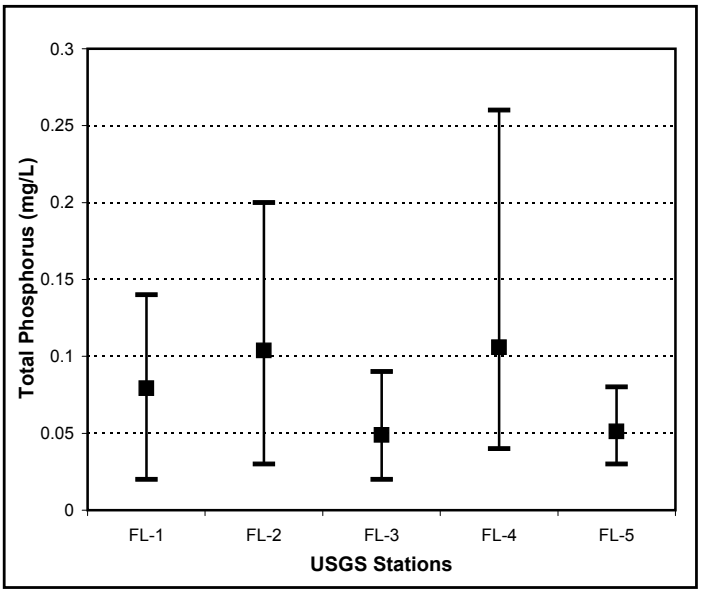
Stream	Station Name	USGS Station CODE
Flint River near Jonesboro	FL-1	02344180
Flint River near Inman	FL-2	02344380
Flint River near Griffin	FL-3	02344500
Line Creek	FL-4	02344752
White Oak Creek	FL-5	02344804

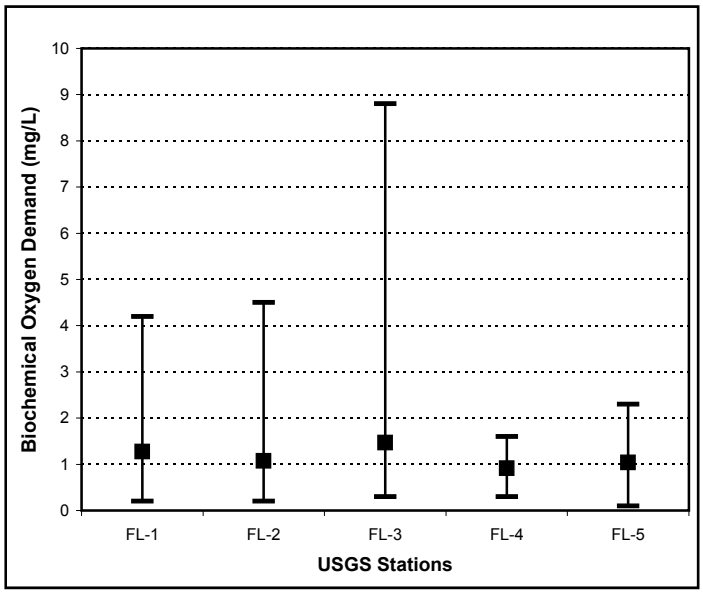
Water quality data in the Flint River portion of the District indicate generally fair to good conditions. The average DO concentrations were above the state standard of 4 mg/L for warm water species. The range of average DO values shown in Figure 5-8 is highly variable and essentially due to seasonal variation. The lowest DO value (2.4 mg/L) measured at Station FL-5 on White Oak Creek was below the state standard for warm water species. The land uses in this watershed are predominantly agricultural and forest. Typically when DO values are depressed in areas with a predominance of agricultural use, there is a

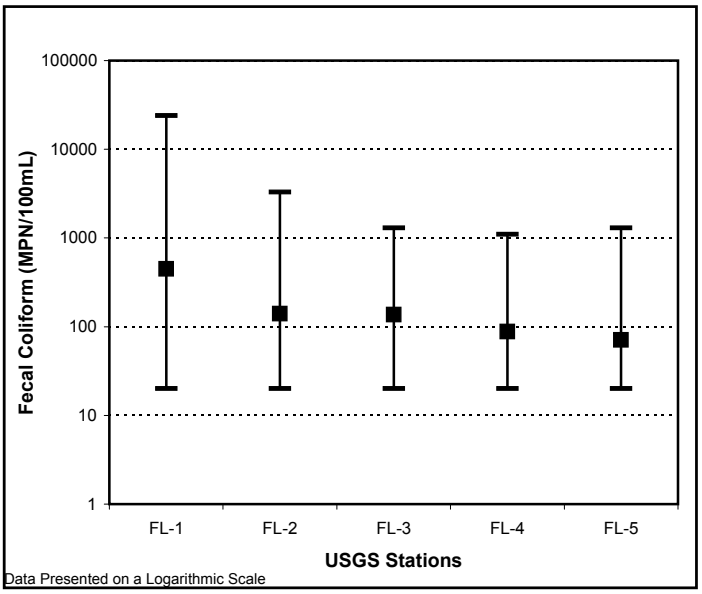












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(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-8

Water Quality Data Summaries for the Flint River Basin

Metropolitan North Georgia Water Planning District Watershed Management Plan

corresponding increase in BOD, turbidity, and TP. However, this relationship was not observed in the USGS data collected at Station FL-5 (Figure 5-8: DO).

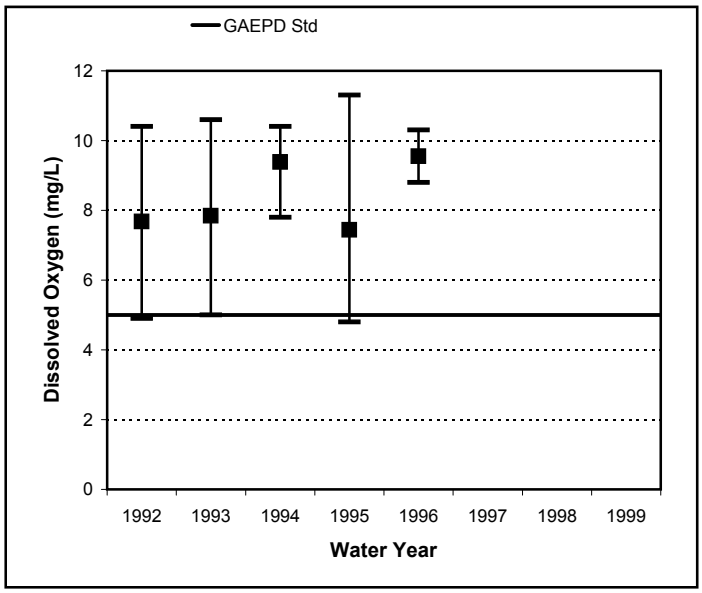
The average BOD levels at the 5 stations were below 2.0 mg/L. These average levels should not exert a demand on DO that would be detrimental to the biota. The spikes in BOD at Station FL-1, FL-2 and FL-3, which were greater than 4 mg/L, indicates a potential for localized stress on biota due to oxygen depletion (Figure 5-8).

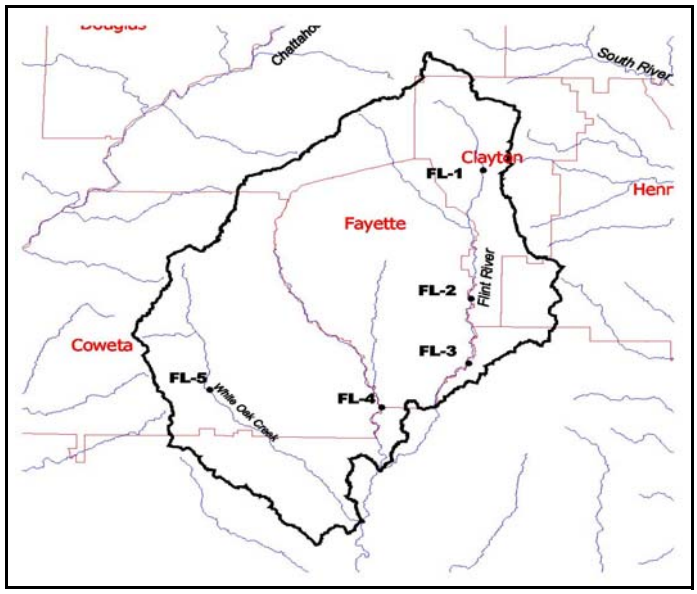
The average turbidity levels at the 5 stations was relatively low (i.e., less than 25 NTU), indicating no substantial long-term problems or potential stress to aquatic integrity. The maximum turbidity values at Station FL-1 (80 NTU) and FL-2 (200 NTU) in Clayton County downstream from the HAIA are likely due to the flashy nature of these systems (Figure 5-8). Prolonged high turbidity in this range and TSS have been shown to degrade stream systems and reduce biotic integrity (Mulvey and Hamel, 1998; David, 1995; Herricks, 1995; Omernick, 1976; Schueler, 1994).

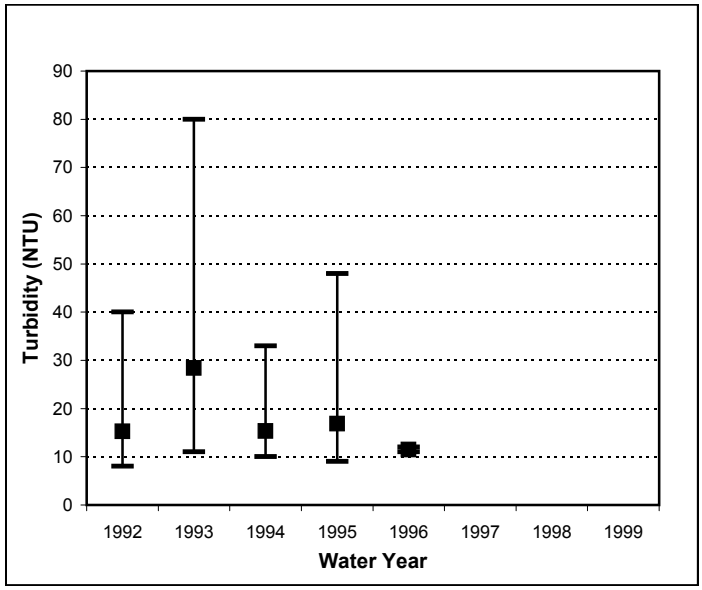
Similar to other developed basins in the District, the average fecal coliform bacteria data showed wide variability among the five stations (Figure 5-8). The highest average value (450 MPN/100 mL) was calculated for Station FL-1 on the Flint River near Jonesboro. Also, Station FL-1 and the nearest downstream station on the Flint River (FL-2) near Inman exhibited the widest range of fecal concentrations. The maximum fecal coliform levels at the two Flint River stations exceeded 3,000 MPN/100 mL. The fact that neither of these stations is downstream of a WWTP suggests that the source of the fecal coliform is natural or possibly septic systems. Samples collected by HAIA and CCWA have identified high fecal coliform bacteria levels north of the airport (CH2M HILL, 2001b). There was a slight increase in the BOD, but the average values were low (less than 1.5 mg/L) and not indicative of a long-term effect (Figure 5-8).

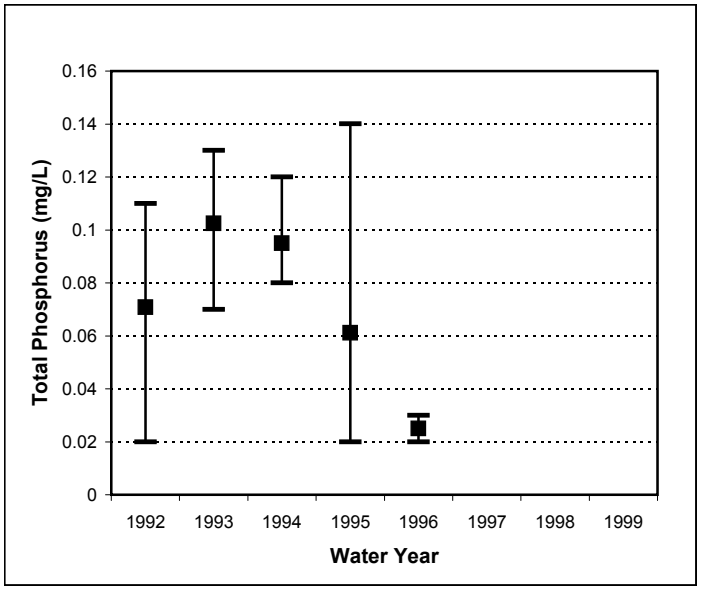
Station FL-1 on the Flint River near Jonesboro was evaluated for any obvious trends in water quality over a 5-year period, 1992 through 1996 (Figure 5-9). The data variability in the final year of the data set was much reduced from previous years. There was evident improvement in the parameter averages except for BOD.

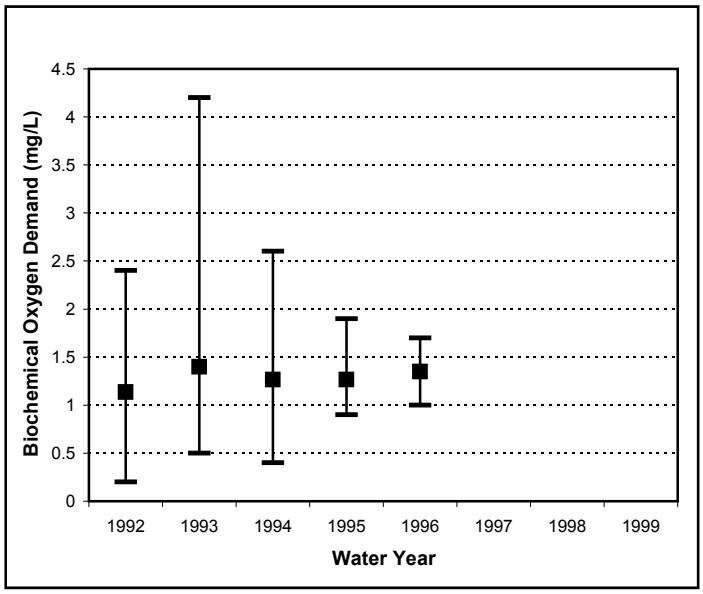
The Clayton County Water Authority and the Fayette County Water System have conducted long-term monitoring in the Flint River basin. Results of these other monitoring programs were used to summarize general water quality conditions at a number of locations throughout the Flint River basin (Table 5-11).

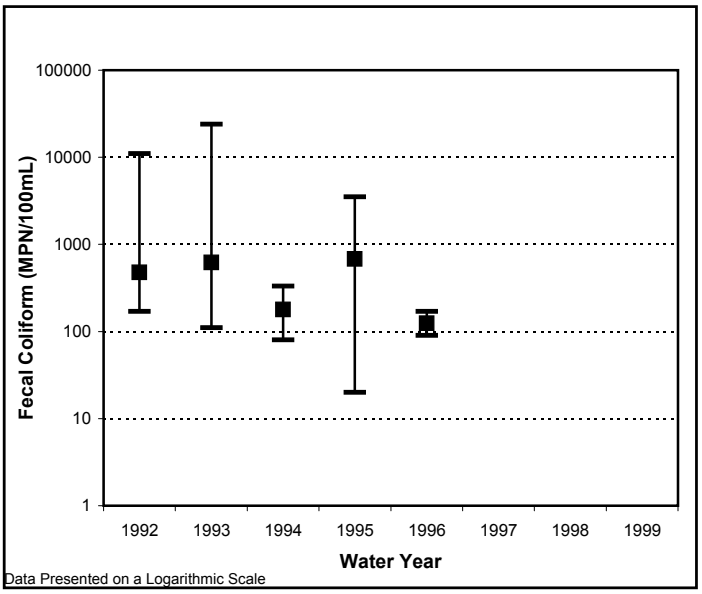












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(Geomean instead of Arithmetic Mean presented for Fecal Coliform.)

Max
Mean
Min

Figure 5-9

Annual Water Quality Trend Analysis for Station FL-1 (Located in the Flint River Basin)

Metropolitan North Georgia Water Planning District Watershed Management Plan

TABLE 5-11
Major Streams Sampled for Water Quality in Flint Basin
Metropolitan North Georgia Water Planning District Watershed Management Plan

Stream or Water body Name	County	Comments
Flint River	Clayton, Fayette	Water quality is variable, with some tributaries and segments affected by development and resulting NPS pollution.
Line Creek	Fayette, Coweta	Water quality is affected primarily by fecal coliform bacteria and storm water runoff.
Shoal Creek	Fayette, Coweta	Water quality is affected primarily by fecal coliform bacteria and storm water runoff.

New roads and the growth of metropolitan Atlanta have been the catalyst for accelerated development in the Flint River basin during the last 15 years. Another contributor to this growth is HAIA, a portion of which is located in the northwest corner of Clayton County. The HAIA is expanding and is building a fifth runway in the headwaters of the Flint River in Clayton County; continued development and redevelopment are expected in this area. Development, without measures to minimize the associated impacts from runoff, including pollutants and altered hydrology, will result in degraded surface-water quality, loss of stream habitat and aquatic integrity, and the level of service expected for local reservoirs.

Water quality in the Flint River basin reflects the land use characteristics of different locations in the basin. The headwater system below the airport in Clayton County has been substantially impacted by development. Water quality data from watershed assessments (CCWA and CH2M HILL, 2001b) and other studies demonstrate that a few stream segments in the Flint River watershed do not currently meet State water quality standards; these stream segments are on the 305(b) list of impaired waters (see Section 2). Water quality sampling data, in conjunction with existing data on watershed characteristics, were compared to State water quality standards and used to identify primary factors causing stream impairment. Results of the chemical analyses indicate that although water quality levels vary throughout the District, they are typical of urban developed areas.

The water quality ranges form poor near to just to the south of the airport to good further downstream, with some elevated levels of nutrients, metals, fecal coliform, TSS, and turbidity, as well as low levels of DO and pH. Specifically, a few pH, fecal coliform, DO, and metals (dissolved zinc and lead) measurements exceeded the State standards at the ambient and watershed study water quality stations.

GA EPD monitoring found violations of the DO water standard due to urban runoff at three sites between the headwaters at HAIA and Flat Shoals Creek. Violations of the DO standard were also measured in Flat Creek near Peachtree City, Camp Creek in Fulton County, and Beaver Creek in Crawford County, due mainly to nonpoint sources. Two stations on the mainstem between HAIA and Flat Shoals Creek had violations of the lead standard as a result of urban runoff. Three monitored tributaries draining the metropolitan Atlanta area of the sub-basin had violations of the standard for lead, and one of these had additional

violations of copper and zinc standards. Twelve monitored tributaries had violations of the standard for fecal coliforms due to nonpoint sources in metropolitan Atlanta and the cities of Thomaston and Griffin (GA EPD, 1997b).

The average pH levels in Sullivan, Mud, Morning, Murphy, Nash, Jester, Camp, and Beaverdam Creeks were within the State standard of 6.0 and 8.5 standard units (SU). However, some stations, including one on White Oak Creek, exhibited low pH readings and a few measurements were below the lower limit of the State standard of 6.0 SU. The low pH values are likely due to a combination of runoff and natural conditions existing during the study (CCWA and CH2M HILL, 2001b).

Fecal coliform levels, which are typically problematic throughout metropolitan Atlanta, exceeded State standards at stations in the Blalock Reservoir and Shamrock Lake sub-basins in Clayton County. High fecal coliform levels were identified north of the HAIA, indicating a potential source in Fulton County. Generally, high levels of fecal coliform were observed throughout this District.

Zinc and copper exceedances were recorded near the headwaters of the Flint River in highly developed commercial, industrial, and residential areas. Concentrations of copper and zinc exceeded State standards for the acute conditions in Mud Creek and the Flint River. Acute copper standards were also exceeded in Sullivan Creek (CCWA and CH2M HILL, 2001b).

The nutrient levels varied throughout the project areas, but were typical of urban and rural developed land uses. TP levels were elevated slightly downstream of wetlands in the Camp and Jester Creek systems of the Flint River watershed. During fall and winter, nutrients may be released as part of the natural vegetation decay process, particularly from wetlands (Mitsch and Gosselink, 1993) and from developed and natural landscapes. These released nutrients are washed downstream to creeks, causing elevated nutrient levels–particularly during rainfall events. TSS and turbidity results showed similar trends; the peak levels were associated with runoff from the respective study areas. The average turbidity and TSS levels in Clayton County were highest in the Blalock Reservoir sub-basin and in the upper portion of the Flint River basin.

The average DO levels ranged between 6 and 10 mg/L for the six study areas. The lowest values were observed in the Lower Cotton Indian Creek, Blalock Reservoir, and J.W. Smith Reservoir sub-basins. Although none of the low measurements exceeded the minimum standard of 5.0 mg/L, a few measurements were at or near this level. Based on the water quality results, major contributors to stream degradation were certain metals, fecal coliform, turbidity, and TSS. The occasional low DO levels may also contribute to stream degradation. Although fecal coliform levels exceeded State standards in a few samples, these were not contributing to stream degradation; however, the exceedances are considered a human health concern (CCWA and CH2M HILL, 2001a and 2001b).

The Line Creek sub-basin includes portions of Fayette and Coweta Counties. Standards for fecal coliform were violated at the most downstream location on Line Creek during normal flow conditions. DO and pH exceeded standards in one sample on Flat Creek before the confluence with Line Creek during normal flow conditions. During rainfall events several sampling locations in Line, Flat, and Shoal Creeks exceeded fecal coliform and dissolved zinc standards (ARCADIS Geraghty and Miller Inc., 2000).

Tallapoosa River Basin

Only a small portion of the District, the southwest corner of Paulding County, is within the Tallapoosa River basin. Water quality data from the Tallapoosa River were reported as part of a GA EPD study (GA EPD, 1998c). While water quality was found to be generally good, portions of the mainstem and some tributaries are threatened by nonpoint source pollution and altered hydrology. The pollutants are generally associated with pockets of urban development and include nutrients, metals, and bacteria. In addition, altered hydrology in the watershed due to the conversion of forest lands to other uses has contributed to erosion and sediment loading in the streams, which alters stream morphology, impacts habitat, and reduces water clarity (GA EPD, 1998c).

All major tributaries and the mainstem of the Tallapoosa River are meeting their designated fishing use in Paulding County. Beyond the Paulding County line, lead water quality standards were exceeded in the Tallapoosa River mainstem due to nonpoint sources. During monitoring conducted by GA EPD, the standard for fecal coliform bacteria was not met in one Tallapoosa River mainstem segment downstream of Paulding County. This was attributed to a combination of urban runoff, septic systems, sanitary sewer overflows, rural nonpoint sources, and animal wastes. This region has a high concentration of poultry operations, and spreading of poultry waste on fields may be a potential source (GA EPD, 1998c).

TP concentrations are relatively low in this basin, reflecting the low population and low level of development in the basin. TP concentrations in the mainstem Tallapoosa River have remained relatively constant over time. DO concentrations in the Tallapoosa basin are generally in excess of both the state instantaneous minimum of 4.0 mg/L and the state daily average minimum of 5.0 mg/L. DO concentrations have generally shown a slight increase with time and have remained relatively stable in the Tallapoosa River. Synthetic organic chemicals have not been detected through GA EPD monitoring in the surface waters of the Tallapoosa River basin at problem concentrations.

Some portions of the basin show stress from altered hydrology and increases in sedimentation. This is primarily associated with the increased ground disturbance and impervious surfaces around smaller streams in developing areas of the watershed (GA EPD, 1998c).

References

ARCADIS Geraghty & Miller, Inc. 2000. Draft Watershed Assessment Line Creek and Flat Creek. Prepared for Peachtree City Water and Sewerage Authority.

Beck, J, K. Fleming, A. Mullally, S. Randolph, 1999. Federal, State, and Local Water Quality Control, An Assessment of the Current Laws Affecting the Etowah River and Suggestions for Local Proactive Planning. Etowah Initiative.

Brown and Caldwell. 2002. Alcovy River Watershed Protection Plan.

Camp Dresser & McKee. Big Creek Watershed Study Master Plan. Prepared for the cities of Alpharetta, Cumming and Roswell as well as Cherokee, Forsyth and Fulton Counties.

CH2M HILL, JJ & G Inc., Tetra Tech Inc., and R&D Environmental Inc. 2000a. Gwinnett County Watershed Assessment and Modeling: Chattahoochee Basin Impacts Assessment.

CH2M HILL, JJ & G Inc., Tetra Tech Inc., and R&D Environmental Inc. 2000b. Gwinnett County Watershed Assessment and Modeling: Ocmulgee/Oconee Basins Impacts Assessment.

CH2M HILL, JJ & G Inc., Tetra Tech Inc., and R&D Environmental Inc. 2000. Gwinnett County Watershed Protection Plan.

CH2M HILL, W.L. Jorden, and R&D Environmental. 1998a. West Watershed Impacts Assessment: Metro Atlanta Urban Watersheds Initiative.

CH2M HILL, W.L. Jorden, and R&D Environmental. 1998b. East Watershed Impacts Assessment: Metro Atlanta Urban Watersheds Initiative.

CH2M HILL. 1997a. Pumpkinvine Creek Watershed Assessment. Prepared for Paulding County.

CH2M HILL. 1998. Integrated Biological and Water Quality Evaluation for the Snapping Shoals Creek Watershed.

CH2M HILL. 2000a. Forsyth County Watershed Assessment and Management Plan.

CH2M HILL. 2000b. Anneewakee Creek Watershed Assessment Study. Prepared for Douglasville-Douglas County Water and Sewer Authority and R.J. Wood Company.

CH2M HILL. 2000c. Community Watershed Assessment and Watershed Management Plan: Hall County and the City of Gainesville.

CH2MHILL. 1999. Gwinnett County Watershed Characterization – Biological Monitoring. Prepared for the Gwinnett County Watershed Assessment Steering Committee.

CH2MHILL. 2001a. Watershed Assessment and Management Plan. Watershed Assessment Blalock Reservoir and J.W. Smith Reservoir Watershed. For Clayton County Water Authority.

CH2MHILL. 2001b. Watershed Assessment and Management Plan. Watershed Assessment Flint River Watershed. For Clayton County Water Authority.

CH2MHILL. 2001c. Watershed Assessment and Management Plan. Watershed Assessment Little Cotton Indian Creek Watershed. For Clayton County Water Authority.

CH2MHILL. 2001d. Watershed Assessment and Management Plan. Watershed Assessment Northeast and Shoal Creek WRF Watersheds. For Clayton County Water Authority.

CH2MHILL. 2001e. Watershed Management Plan. For Clayton County Water Authority.

CH2M HILL, 2001f. Fulton County Watershed Management Plan.

Cobb County Water System (CCWS) and CH2M HILL. 1997. Noonday Creek Watershed Study. Prepared for Water Protection Branch, Georgia Environmental Protection Division.

David, Allan, J. 1995. Stream Ecology: Structure and Function of Running Waters. New York: Chapman & Hall.

DeKalb County Water & Sewer Division (DCWSD) and CH2M HILL. 2001. South River Watershed Assessment and Management Plan.

Dirnberger, J., W. Ensign, D. McGarey, and H. Sutton. 2001. Status of water quality and biological integrity in major watersheds in Bartow County, Georgia. Department of Biological and Physical Sciences, College of Science and mathematics, Kennesaw State University. Kennesaw, GA.

Frick, E.A., Hippe, D.J., Buell, G.R., Couch, C.A., Hopkins, E.H., Wangness, D.J., and Garrett, J.W. 1998. Water Quality in the Apalachicola-Chattahoochee-Flint River Basin, Georgia, Alabama, and Florida, 1992-95. U.S Geological Survey Circular 1164, updated 1998.

GA EPD, 2001. Rules And Regulations For Water Quality Control Chapter 391-3-6 Georgia Department of Natural Resources Environmental Protection Division Atlanta, Georgia Revised - October 2001

Georgia Environmental Protection Division (GA EPD). 1997a. Chattahoochee River Basin Management Plan 1997. Environmental Protection Division, Georgia Department of Natural Resources.

Georgia Environmental Protection Division (GA EPD). 1997b. Flint River Basin Management Plan 1997. Environmental Protection Division, Georgia Department of Natural Resources.

Georgia Environmental Protection Division (GA EPD). 1998a. Coosa River Basin Management Plan 1998. Environmental Protection Division, Georgia Department of Natural Resources.

Georgia Environmental Protection Division (GA EPD). 1998b. Oconee River Basin Management Plan 1998. Environmental Protection Division, Georgia Department of Natural Resources.

Georgia Environmental Protection Division (GA EPD). 1998c. Tallapoosa River Basin Management Plan 1998. Environmental Protection Division, Georgia Department of Natural Resources.

Georgia Environmental Protection Division (GA EPD). 1998d. 305b Report. epa.gov/305b/98report/ga.html

Georgia Public Policy Foundation and Pacific Research Group (GPPF). 1999. The Georgia Index of Leading Environmental Indicators.

Herricks, E. E. 1995. Storm water Runoff and Receiving Systems: Impacts, Monitoring, and Assessment. Lewis Publishers, Boca Raton, FL. Pp. 44.

Laenen, A. and Dunnette, 1997. D. *River Quality: Dynamics and Restoration*. Lewis Publishers. Boca Raton, FL.

Lake Allatoona Preservation Authority (LAPA). 2001. Lake Allatoona Comprehensive Watershed Management Plan.

LAPA: Lake Allatoona Preservation Authority. 2001. Draft Lake Allatoona Comprehensive Management Plan.

Mitsch, William J. and James G. Gosselink. 2000. *Wetlands.* John Wiley and Sons, New York.

Mulvey, Michael and Allen Hamel. 1998. Winter storm turbidity and biological integrity of Oregon coast streams, Oregon Department of Environmental Quality, Laboratory Division, Biomonitoring Section, 1712 SW Eleventh Avenue, Portland, OR 97201

Omernick, J.M. 1976. The Influence of Landuse on Stream Nutrient Levels. U.S. Environmental Protection Agency, Office of Research and Development: Corvallis, Oregon.

Schueler, T. 1994. "The Importance of Imperviousness". *Watershed Protection Techniques*. Vol. 1(3).

Team Alcovy website. 2002. The Alcovy River Watershed Assessment. teamalcovy.com.

Tetra Tech, Inc. 2000. Preliminary Watershed Assessment and Management Plan to protect Water Quality in Rockdale County, Georgia through 2020.

United States Environmental Protection Agency (USEPA). 1983. Results of the Nationwide Urban Runoff Program. Vol. I Final Report, Water Planning Division, U.S. EPA, Washington, DC.

United States Geological Survey (USGS), http://www.water.usgs.gov

University of Georgia (UGA). July 1998. *Clean Lakes Study*. K. Hatcher, editor. Draft prepared for GA EPD. Prepared by the Carl Vinson Institute of Government.

Upper Chattahoochee Basin Group (UCBG). 1998.Water Quality Study of Lake Sidney Lanier. http://www.epa.gov/region4/water/nps/projects/ga98-3.htm

USEPA 1998, Water Quality Criteria And Standards Plan -- *Priorities For The Future* United States Environmental Protection Office of Water EPA 822-R-98-003

Welker and Associates, Inc., Cherokee County Water and Sewerage Authority (CCWSA), Eco Tech, Inc. and Limno-Tech, Inc. 2001. Cherokee County Water and Sewerage Authority Draft Comprehensive Report-Little River (Cherokee County) Watershed Assessment and Watershed Protection Implementation Plan.