North Carolina Division of Water Quality
Surface Water Protection Section
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Summary of Physical and Chemical Water Quality Data

Little Mountain, Mountain and Jacobs Creek Local Watershed Plan

Prepared for the

North Carolina Ecosystem Enhancement Program

Yadkin Pee Dee River Basin
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Report Background

This report provides a summary of the ambient water quality monitoring conducted by the North Carolina Division of Water Quality (December 2003 through August 2004) in support of the Little Mountain, Mountain and Jacobs Creek Local Watershed Plan.

Local watershed planning conducted by the North Carolina Ecosystem Enhancement Program (NCEEP) is a process designed to assist local governments and stakeholders with local watershed management to improve and maintain water quality benefits and assists the North Carolina Department of Transportation (NCDOT) in meeting future compensatory mitigation needs for stream, riparian buffer and wetland impacts resulting from highway improvements. The process involves determining major local watershed issues that are presently contributing to the degradation of water quality, predicting future watershed conditions under various land use and watershed management scenarios, identification of restoration and enhancement opportunities and developing a strategy for long-term follow-up to assist localities with the implementation of watershed protection recommendations proposed in the plan.

The information in this report is intended to supplement existing information in the watershed plan, to guide future watershed planning, monitoring and assessment work and to evaluate water quality impairment issues associated with Little Mountain Creek. Other assessment reports prepared by DWQ for this Plan were submitted to EEP in 2004 included fish and benthic macroinvertebrate surveys (NCBAU, 2004a) (NCBAU, 2004b); a summary of existing water quality data and a planning document for chemical/physical water quality monitoring (NCDWQ, 2003a) (NCDWQ, 2003b). EEP has also received The Watershed Characterization, Preliminary Findings and Recommendations Phase 1 Report (PFR) prepared by a private consulting firm (HDR, 2004). It provided detailed information relative to the entire study area but did not incorporate water quality data collected by DWQ nor did it discuss impairment of Little Mountain Creek.

While Phase 1 of the Watershed Plan was finalized in the spring of 2004, DWQ continued to collect water quality data through August in an effort to further discern water quality issues within the study area including impairment issues associated with Little Mountain Creek for future consideration by DWQ, EEP and other interested entities.

I. Water Quality Monitoring Overview

Chemical/physical water quality monitoring locations were established for five streams within the planning area: one each for Little Mountain, Mountain, Jacobs, Gum and Cedar Creeks. Three additional upstream locations were selected for Little Mountain Creek (two mainstem and one tributary). An upstream portion of Gum Creek was selected to serve as the local reference stream representing a minimally impacted drainage area within the study area (Figure 1, Table 1)

As presented in the fish and benthic assessment reports (NCBAU, 2004a & b), macroinvertebrate surveys were conducted at two locations in Little Mountain Creek (upstream and downstream of point discharges) and at one location on Jacobs Creek; fish surveys were conducted in Little Mountain, Mountain, and Jacobs Creeks. Water quality monitoring locations were selected with the following objectives in mind.

- Provide water quality data representative of the study area;
- Avoid water quality influences associated with Lake Tillery;
- Assess impairment of Little Mountain Creek;
- Correlate with fish and benthic macroinvertebrate collection sites;
- Identify upstream problem areas;
- Recommend areas for structural stormwater best management practices;
- Supplement existing water quality data;
- Develop baseline data for subwatersheds for which no data currently exists; and,
- Guide future local watershed monitoring, assessment and planning.

I. A. Site Selection

Sampling sites were chosen based on several criteria to meet objectives listed above: accessibility, proximity to potential sources of pollution and proximity to benthic and fish sampling sites. The sites are listed below.

<u>Little Mountain Creek at SR 1720 Valley Drive (LM-1)</u>. This site was chosen because it was downstream of the city of Badin, Alcoa and Badin's wastewater treatment plant. It was also a benthic sampling site for this study and for previous stream evaluations. This was where the most downstream data logger was deployed. Aquatic toxicity samples were collected at this location. This was at the most downstream end of the subwatershed integrating all upstream landuse activities.

<u>Little Mountain Creek at NC 740 (LM-2)</u>. This site was upstream of Badin, Alcoa and Badin's wastewater treatment plant but downstream of Alcoa's landfill seep discharge. It was chosen to assess water quality downstream of the landfill seep discharge. This site was also where the upstream data logger was deployed. Aquatic toxicity samples were collected at this location.

<u>Little Mountain Creek at Jackson Street Upstream of NC 740 (LM-3)</u>. This site was chosen because it was upstream of all known point discharges to Little Mountain Creek and was most accessible point downstream of an impoundment.

<u>UT to Little Mountain Creek at NC 740 (LM-4)</u>. This site was 200 feet downstream of one of Alcoa's stormwater outfalls and was selected to assess stormwater quality from Alcoa's facility.

<u>Little Mountain Creek at SR 1798 Morrow Mountain Road (LM-5).</u> Fish were surveyed here and it was also a Yadkin PeeDee River Basin Association Coalition stream monitoring site (No. Q6950000).

<u>Mountain Creek at SR 1720 Valley Drive (M-1).</u> This was at the most downstream end of the subwatershed integrating all upstream landuse activities in the Mountain Creek subwatershed. A portion of Albemarle is located within this drainage area. Fish community data were obtained at this location.

Jacobs Creek at SR 1740 Indian Mound Road (J-1). Fish and macroinvertebrates were surveyed here. This site was at the most downstream end of the subwatershed integrating all upstream landuse activities.

Cedar Creek at SR 1740 Indian Mound Road (C-1). This site was at the most downstream end of the subwatershed integrating all upstream landuse activities in the Cedar Creek subwatershed. A portion of Norwood is located within this drainage area.

Gum Creek at SR 1744 Snuggs Road (Ref-1). This site was selected to represent water quality minimally impacted by human activity. It is a mostly forested drainage area within the larger Gum Creek subwatershed.

I. B. Data Collection Methods

Stream samples were collected during baseflow conditions when no measurable precipitation occurred during the prior 48 hours of sample collection. Samples were collected in storm conditions during the rising stage of the hydrograph. Sample collection methods used were the grab sample technique (NCDWQ, 2004a) and the time weighted composite method using a battery operated, programmable automatic sampling device (used during storm events). Other sample collection details were described in the water quality monitoring plan (NCDWQ, 2003b).

Basic water quality parameters were selected for characterizing water physiochemical attributes. They included field parameters (dissolved oxygen, specific conductance, pH and water temperature), nutrients (total phosphorus, ammonia, TKN and nitrate-nitrate nitrogen), residue (suspended, fixed and volatile), turbidity, metals (total recoverable) and fecal coliform as pathogen indicators. A compilation of parameters and basic summary statistics are provided in Section VII, Tables 9 through 16.

Additional monitoring activities were conducted at Little Mountain Creek because it is unable to meet its designated uses of aquatic life propagation and maintenance of biological integrity as described in North Carolina's Draft 2004 Water Quality Assessment and Impaired Waters List (2004 Integrated 305(b) and 303(d) Report). The additional data were evaluated to address causes and sources of biological impairment. Chemical analyses were conducted upstream and downstream of discharges including metals, fluoride, cyanide and residual chlorine. Source discharge monitoring data from Alcoa and Badin were reviewed. Data sondes were deployed over an extended period to evaluate diurnal dissolved oxygen cycles; and, to address in-stream toxicity concerns, two types of ambient toxicity tests were conducted by NCDWQ's aquatic toxicology unit (ATU), a chronic *Ceriodaphnia dubia* pass/fail test and a 24-hour *Daphnia magna* feeding inhibition test (McWilliam et al., 2001).

Stream corridor assessments were performed along segments of Little Mountain and Cedar Creeks to judge stream stability, identify areas where pollutants may be entering the streams, conduct formal habitat assessments, provide photo documentation of key features and to identify specific areas that may be candidates for channel restoration or best management practices. Details of this assessment activity are presented in Section IV of this report.

I. C. Data Evaluation

Nutrient Screening. For this study, to estimate the extent of nutrient enrichment due to past and present land use activities, observed baseflow nutrient data were compared with ecoregional nutrient reference criteria developed by the USEPA for rivers and streams (USEPA, 2000a). These criteria were chosen because nutrient criteria for North Carolina are currently in development. Nutrient Ecoregions are areas within the United States of relative homogeneity with respect to ecological systems. Geographic phenomena such as soils, vegetation, climate and geology that shape the quantity and quality of ecosystem elements are relatively similar within each ecoregion. The criteria were developed using a 25th percentile statistical approach of water quality data collected throughout a particular aggregate ecoregion and subecogregion. The resulting criteria are to represent conditions of surface waters minimally impacted by human activities. Similarly, nutrient data collected during storm events for this study were compared with storm event nutrient data collected from undisturbed, forested drainage areas within the Slate Belt and Triassic basins in North Carolina as reported in a US Geological Survey surface water quality investigation prepared by Simmons and Heath (1982). These data comparisons will provide an estimate of the increase in nutrient levels caused by past and present land use activities.

Toxicant Screening. To estimate the extent to which aquatic organisms were exposed to toxic conditions, observed metals data were compared to toxicological screening benchmarks. When performing ecological risk assessments and water quality evaluations, contaminants are often compared to screening benchmarks to determine if the reported concentrations of those contaminants are high enough to warrant further consideration. Benchmark screening values denote thresholds of elevated risk, but do not predict actual impacts in particular situations. Actual site-specific and event-specific impacts depend upon the interaction of numerous factors, including the level, timing and duration of exposure; the form and bioavailability of the particular chemicals (often dependent on hardness or other variables); and simultaneous exposure to other stressors. For this study, laboratory metals analyses were conducted using the total extractable method. Screening benchmarks used for this study were based on total extractable metals and were adjusted for site specific hardness.

A detailed discussion of the many different sources of toxicological screening benchmarks can be found in Suter and Tsao (1996). The screening benchmarks used for this assessment were USEPA's acute (Criteria Maximum Concentration, CMC) and chronic (Criterion Continuous Concentration, CCC) National Recommended Water Quality Criteria (NRWQC) for freshwater (USEPA, 2002). Metals and other water quality data were also compared with North Carolina's Water Quality Standards (NCDWQ, 2004b).

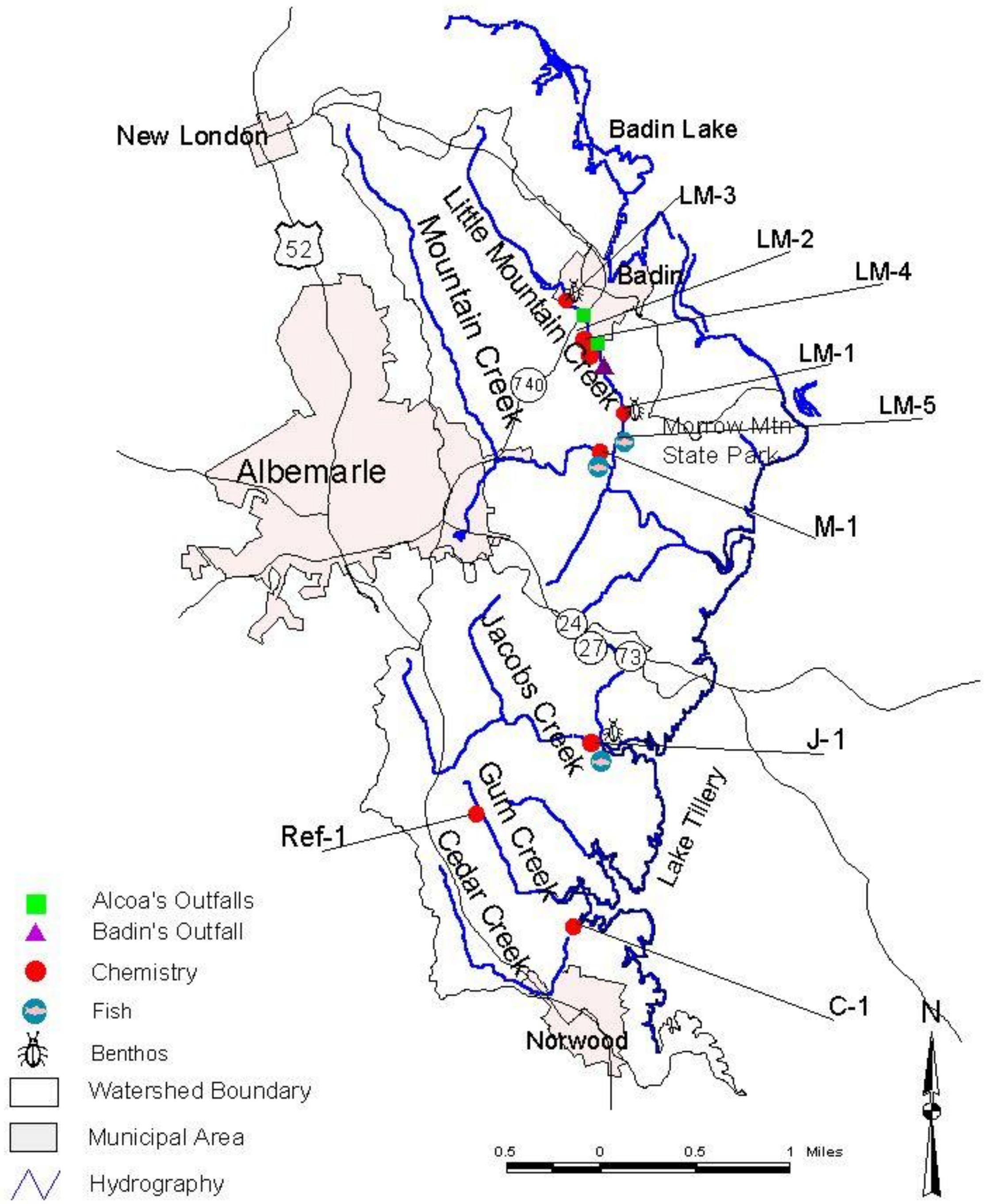

Figure 1. NCDWQ Monitoring sites for Mountain, Little Mountain and Jacobs Creeks Local Watershed Plan.

Table 1. Descriptions, locations and types of NCDWQ monitoring for the Little Mountain, Mountain and Jacobs Creek Local Watershed Plan, December 17, 2003 through August 26, 2004.

Site Code	Monitoring Location	Latitude Longitude	Drainage Area (sq. miles)	Water Chemistry	Benthic Macro-invertebrates	Fish	Toxicity (water)	Data Sonde [1]	Stream Corridor [2]
LM-1	Little Mountain Creek at SR 1720 Valley Drive	35° 22' 52" 80° 06' 46"	8.5	✓	✓	-	✓	✓	✓
LM-2	Little Mountain Creek at NC 740	35° 24' 02" 80° 07' 22"	5.5	✓	-	-	✓	✓	✓
LM-3	Little Mountain Creek at Jackson Street Upstream of NC 740	35° 24' 15" 80° 07' 42"	5.0	✓	✓	-	-	-	✓
LM-4	UT to Little Mountain Creek at NC 740	35° 24' 03" 80° 07' 20"	0.1	✓ +	-	-	-	-	-
LM-5	Little Mountain Creek at SR 1798 Morrow Mountain Road	35° 22' 09" 80° 06' 41"	10.2	++	-	✓	-	-	-
M-1	Mountain Creek at SR 1720 Valley Drive	35° 21' 51" 80° 06' 57"	14.0	✓	-	✓	-	-	-
J-1	Jacobs Creek at SR 1740 Indian Mound Road	35° 17' 33" 80° 07' 08"	11.6	✓	✓	✓	-	-	-
C-1	Cedar Creek at SR 1740 Indian Mound Road	35° 14' 36" 80° 07' 29"	3.8	✓	-	-	-	-	✓
Ref-1	Gum Creek at SR 1744 Snuggs Road	35° 14' 37" 80° 07' 30"	0.9	✓	-	-	-	-	-

1. Data sonde -- programmable multi-probe and field data recorder.
2. Stream Corridor Assessments.

✓ Indicates that monitoring occurred.
- Indicates that monitoring did not occur.
+ LM-4 is downstream of Alcoa's stormwater outfall.
++ LM-5 is also YPDRBA Coalition site No. Q6950000.

II. Water Quality Data Summary

A. General Watershed Description

The planning area encompasses a total drainage area of approximately 68.0 square miles subdivided by nine named streams and several unnamed tributaries all of which empty into Lake Tillery/Pee Dee River. The area lies within Aggregate Nutrient Ecoregion IX, Southern Temperate Forest and Hills and Level III Ecoregion 45, Piedmont (USEPA, 2000a) and in the further divided Level IV subcategory 45c Carolina Slate Belt (Griffith et al., 2002).

The underlying geology is comprised of slate. It is thought that rock from this area formed from volcanic ash deposited on an ancient ocean floor forming very fine muds. Geologists theorize that after millions of years, heat and pressure metamorphosed the muds into slates and phyllites which were revealed upon ocean retreat (Beyer, 1991). Soils formed from this geology are varied and were discussed in detail in the Preliminary Findings Report (HDR, 2004). One important characteristic of the slate belt with respect to the study area is the low water storage capacity in upland areas. As a result, channels have less groundwater recharge and more frequent zero flow events, which in turn impact stream ecology and aquatic communities. For instance, USGS mean daily streamflow data from a nearby catchment (USGS gage 02123567) during January 2000 through October 2003 were charted in Figure 2. Low flows (due to the drought) were apparent during 2000 – 2002. More typical flow conditions returned during the latter part of 2002 and 2003.

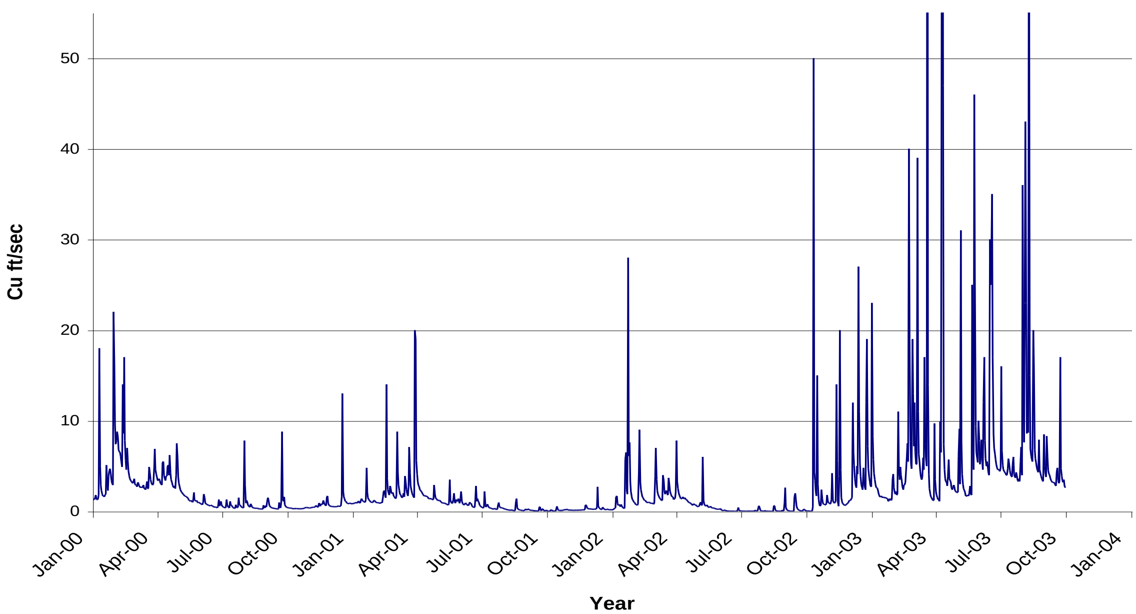

Figure 2. Daily mean streamflow for Dutchmans Creek drainage area (3.4 sq. mi.). USGS gage 02123567.

II. B. Subwatershed Water Quality Comparisons

Physical and chemical monitoring began in December 2003 and continued on a monthly basis until August 2004. These data were collected during baseflow conditions from each subwatershed on eight occasions. Samples were collected during one winter storm in December for each subwatershed. Summer storm samples were collected in June and August at Little Mountain Creek (LM-1), in May at Cedar Creek (C-1) and at a UT to Little Mountain Creek (LM-4) 200 feet downstream from one of Alcoa's stormwater outfalls in August. Summary statistics can be found in Section VII Tables 9 - 16.

Baseflow. Observed baseflow field readings for all subwatersheds were within reasonable values. Dissolved oxygen and pH measurements consistently met NCDWQ water quality standards (Table 2). As expected, median specific conductance was highest in Little Mountain Creek (LM-1) downstream of Badin and Alcoa's point discharges (154 μS/cm); however, it was unexpected to observe the relatively high median value (150 μS/cm) recorded for Cedar Creek (C-1) because no upstream point discharges were present (Table 2). The most upstream location on Little Mountain Creek (LM-3) was consistently lower in specific conductance than all other locations including Gum Creek (Ref-1; Figure 3). This was most likely due to influences of an upstream impoundment.

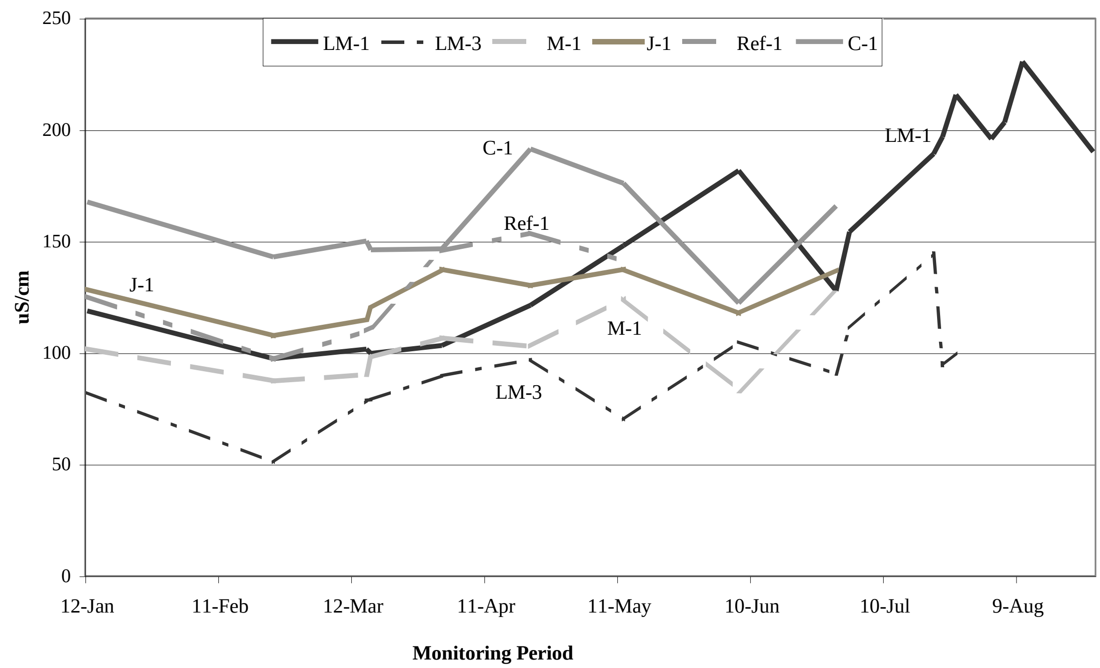

Figure 3. Baseflow specific conductance by subwatershed from January through August 2004.

Median baseflow nutrient data were compared with USEPA nutrient ecoregion reference criteria described in Section I and the local reference site (Gum Creek, Ref-1). Total nitrogen was below the criterion (0.69 mg/L) for all subwatersheds except for Little Mountain Creek (LM-1) and a UT to Little Mountain Creek (LM-4) where discharges were present (Table 2). Median total phosphorus at Mountain and Cedar Creeks exceeded ecoregion criterion (0.037 mg/L). As expected, total phosphorus and nitrogen were lowest at Gum Creek (Ref-1, Table 2) and at the most upstream location on Little Mountain Creek below the impoundment (LM-3).

Benthic periphyton was observed on bottom substrates in all streams where sunlight could penetrate resulting in slippery and hazardous walking conditions during the winter months. Quantitative measurements were not conducted. Periphyton growth is a response variable attributed to the ability of a functioning stream ecosystem to retain and process nutrients in response to upland disturbances (Bernhardt et al, 2003). Excessive periphyton growth may be an important indicator of nutrient enrichment (USEPA, 2000b).

Elevated nutrients in baseflow conditions also suggest somewhat polluted shallow groundwater throughout the study area as a result of upland nutrient inputs and watershed disturbances. Inputs from inorganic and organic fertilizer applications for agricultural production (present and past), lawn/turf management, septic systems and nutrient cycling disruptions as a result of forestry and land clearing operations all contribute to nonpoint source pollution and impairment of streams, rivers and reservoirs (USEPA, 1995). In North Carolina, agriculture is a source of impairment thought to contribute to the impairment of a third of the rated freshwater streams listed in the Draft 2004 North Carolina Water Quality Assessment and Impaired Waters List (NCDWQ, 2004c).

Table 2. Median values of selected parameters for monitoring locations in baseflow conditions.*

Parameter	LM-3	LM-4	LM-1	M-1	J-1	Ref-1	C-1	NCDWQ Standard	USEPA Criteria
Dissolved Oxygen (% Saturation)	82 (13)	90 (6)	91 (17)	94 (9)	107 (9)	93 (7)	98 (9)	-	-
Dissolved Oxygen (mg/L)	8.2 (13)	7.7 (6)	8.1 (17)	10.0 (9)	9.8 (9)	9.4 (7)	9.6 (9)	≥ 5.0	-
pH (s.u.)	7.2 (10)	7.8 (6)	7.3 (14)	7.1 (9)	7.2 (9)	7.1 (7)	7.2 (8)	6.0-9.0	-
Specific Conductance (µS/cm)	91 (13)	259 (6)	154 (17)	102 (9)	129 (9)	125 (7)	150 (9)	-	-
Turbidity (NTU)	5 (8)	-	3 (8)	4 (8)	4 (8)	3 (6)	3 (7)	50	6
Total Phosphorus (mg/L)	0.03 (8)	-	0.19 (8)	0.04 (8)	0.03 (8)	0.02 (6)	0.04 (7)	-	0.037
Total Nitrogen (mg/L)	0.41 (8)	1.25 (2)	2.00 (8)	0.54 (8)	0.54 (8)	0.42 (6)	0.61 (7)	-	0.69
Nitrate+Nitrite Nitrogen (mg/L)	0.16 (8)	1.05 (2)	1.50 (8)	0.30 (8)	0.32 (8)	0.20 (6)	0.41 (7)	-	-
Ammonia Nitrogen (mg/L)	0.02 (8)	< 0.02 (2)	0.05 (8)	0.02 (8)	< 0.02 (8)	< 0.02 (6)	< 0.02 (7)	-	-
Fecal Coliform (col/100 mls)	36 (7)	-	286 (7)	235 (8)	128 (8)	193 (6)	153 (7)	200	-
Copper (µg/L)	< 2 (8)	< 2 (2)	2 (8)	< 2 (8)	< 2 (8)	< 2 (6)	< 2 (7)	7	-
Zinc (µg/L)	< 10 (8)	12 (2)	< 10 (8)	< 10 (8)	< 10 (8)	< 10 (6)	< 10 (7)	50	-
Nickel (µg/L)	< 10 (8)	< 10 (2)	< 10 (8)	< 10 (8)	< 10 (8)	< 10 (6)	< 10 (7)	88	-
Aluminum (µg/L)	165 (8)	125 (2)	88 (8)	90 (8)	89 (8)	104 (6)	76 (7)		87

* Value for fecal coliform is geometric mean. Fecal coliform standard is based on five consecutive samples in a 30-day period or more than 20% of samples greater than 400 col/100 mls during such period. Numbers in parentheses represent the number of samples. USEPA nutrient and turbidity criteria are from Aggregate Ecoregion IX (USEPA, 2000).

Geometric means for fecal coliform bacteria collected during baseflow conditions were above the NCDWQ standard (200 col/100 ml) in Mountain Creek (M-1) and Little Mountain Creek (LM-1) indicating that harmful pathogenic organisms could be present in these streams (Table 2; USEPA, 2001). The source of the bacteria is unclear although cattle were observed to have access at various locations along both stream corridors and manure was observed on stream banks at Mountain Creek. Badin's monthly calculated discharge monitoring reports (DMRs) for 2001 through 2004 indicated that treated effluent discharged to Little Mountain Creek contained fecal coliform counts well below 200 cols/100 ml.

Storm flow. Chemical and physical samples were collected during one winter storm in December for each subwatershed and at one upstream location in Little Mountain Creek (LM-2). Summer storm samples were collected in June and August from Little Mountain Creek (LM-1) and in May from Cedar Creek (C-1). Storm samples were also collected once from a UT to Little Mountain Creek (LM-4) in August. In general, results were as expected with increases (compared with baseflow conditions) in suspended residue, nutrients, some metals and fecal coliform. Storms result in runoff from upland sources (urban and agriculture) that carry nutrients, metals, soil particles, pathogens and other pollutants to streams as nonpoint source pollution (USEPA, 1997). Impervious surfaces exacerbate the problem. Monitoring studies and modeling studies have indicated that urban pollutant loads are directly related to watershed imperviousness (CH2M Hill, 2000; Schueler, 1994). Increased stream flow scours bottom substrates and erodes vulnerable stream banks, which in turn increases sediment loads contributing additional pollutants to the stream system. As pollutant concentrations and flow increase, downstream pollutant loadings to Lake Tillery increase as well.

Table 3 presents selected stormflow data for comparisons with North Carolina water quality standards and stormwater data for undisturbed, forested watersheds within the Slate Belt and Triassic basins in North Carolina (Simmons and Heath, 1982). Mean values for total nitrogen and total phosphorus exceeded reference data at all locations except for Mountain Creek (M-1) where total phosphorus was less than reference conditions. The highest total nitrogen values were from Little Mountain Creek (LM-1), the UT to Little Mountain Creek (LM-4) and Cedar Creek (C-1), (2.6, 1.9 and 2.0 mg/L respectively). Average suspended residue concentrations were highest in Little Mountain Creek (LM-1, 340 mg/L) and Cedar Creek (C-1, 317 mg/L). All locations were within water quality standards for turbidity. As expected, fecal coliform bacteria were elevated at all locations except for Gum Creek (Ref-1).

Table 3. Observed values of selected parameters in storm conditions by monitoring location compared with NCDWQ Standards and reference stream data (mg/L).*

Parameter	LM-1	LM-4	C-1	M-1	J-1	Ref-1	NCDWQ Standard	Reference stream data
Total Nitrogen	2.56 (3)	1.90 (1)	2.03 (2)	0.84 (1)	0.92 (1)	0.66 (1)	-	0.55 (9)
Total Phosphorus	0.92 (3)	0.09 (1)	0.27 (2)	0.02 (1)	0.03 (1)	0.03 (1)	-	0.03 (9)
Suspended Residue	340 (3)	43 (1)	318 (2)	< 2.5 (1)	3 (1)	< 5 (1)	-	-
Turbidity	12 (1)	-	13 (1)	5.7 (1)	10 (1)	7.7 (1)	50	-
Fecal Coliform (cols/100 ml)	360 (1)	-	440 (1)	200 (1)	810 (1)	120 (1)	200	-

* Reference stream data are from storm events in undisturbed watersheds in North Carolina as described in Simmons and Heath, (1982). NCDWQ Standards per 15A NCAC 2B .0200 (NCDWQ, 2004b). Numbers in parentheses represent number of samples. Mean value is presented where number of samples exceeded one.

The Preliminary Findings Report predicted nutrient export potential by subwatershed qualitatively (low – medium – high) based on nutrient export values obtained from literature sources and landuse/landcover datasets (HDR, 2004). The predictions were as follows.

- Mountain Creek – high;
- Little Mountain Creek – medium;
- Jacobs Creek – low; and
- Cedar Creek – high.

Comparing the above ratings with data from Table 3 indicated that export predictions were fairly accurate except for Little Mountain (LM-1) and Mountain Creeks (M-1). Predictions for Little Mountain Creek most likely failed to account for Badin's point discharge. The prediction for Mountain Creek was higher than data suggested but since storm data were limited for this stream (n = 1) the prediction may be accurate. Urban landuse associated with Albemarle was most likely responsible for the higher prediction. Data for Jacobs and Cedar Creeks concurred with predictions presented in the Preliminary Findings Report. The UT to Little Mountain Creek (LM-4) was not rated but the data suggested that export potential would be high.

Stream flow data from each subwatershed would provide more relevant information allowing calculations of pollutant loadings leaving each stream over time. Assuming flows were proportional to drainage area, nutrient exports associated with the larger subwatershed areas would be higher depending on pollutant concentrations. To gain further insight of the degree watershed disturbances have altered the ability of the stream ecosystem to conduct nutrient retention and cycling functions, flow and nutrient data unique to these particular subwatersheds would be needed.

III. Impairment Assessment of Little Mountain Creek

Little Mountain Creek is listed in North Carolina's Draft 2004 Water Quality Assessment and Impaired Waters List (NCDWQ, 2004c) due to impaired biological integrity. To address this status, additional monitoring work was conducted and results are presented in this section. For this work, samples were collected at locations within Little Mountain Creek to identify major chemical and physical stressors to which aquatic biota were exposed, evaluate toxicity and assess major sources.

Stressors and Source Evaluation. Chemical analyses were conducted upstream and downstream of discharges including metals, fluoride, cyanide and residual chlorine. Metals data were compared with USEPA toxic screening benchmarks (as described in Section I). Source discharge monitoring data from Alcoa and Badin were reviewed. Data sondes were deployed over an extended period to evaluate diurnal dissolved oxygen cycles; and, to address in-stream toxicity concerns, two types of ambient toxicity tests were conducted by NCDWQ's aquatic toxicology unit (ATU), a chronic *Ceriodaphnia dubia* pass/fail test and a 24-hour *Daphnia magna* feeding inhibition test (McWilliam et al, 2001). These data plus data collected for the entire planning were evaluated to address biological impairment.

III. A. Metals

Metals data were compared with USEPA's chronic (criterion continuous concentration – CCC) and acute (chronic maximum criteria – CMC) criteria for toxic pollutants (screening benchmarks) to determine the extent to which toxic conditions may exist in baseflows and during storm events. The uses of USEPA's criteria for toxic pollutants were described in Section I. Baseflow metals data were also compared with North Carolina Water Quality Standards to determine whether standards were met.

Baseflow median observations for arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc at all locations were less than detection limits and were below NCDWQ water quality standards. At times, copper and zinc were measured slightly above detection limits but were below NCDWQ water quality standards and USEPA toxic screening benchmarks (Tables 9 – 16 in Section VII). Iron was detected in all samples but concentrations were below NCDWQ water quality standards and USEPA benchmarks. Aluminum was also pervasive throughout the planning area. Median aluminum values were above the USEPA screening benchmark of 87 μg/L at all locations except for Cedar Creek (C-1) (Table 2).

Because aluminum processing occurred at Alcoa's Badin Works facility during this study, aluminum concentrations from the Alcoa drainage area in the UT to Little Mountain Creek (LM-4) were expected to be higher than in other streams, however this was not the case. Median baseflow aluminum for the Alcoa drainage area was typical for this region; aluminum was actually higher in Little Mountain Creek (LM-3) upstream of the Alcoa drainage (Tables 11 and 12 in Section VII).

Most metal concentrations increased during storm events. Spring and summer events resulted in the largest metals increase compared with winter monitoring in December most likely due to the increased storm intensity (in rate and amount) in May, June and August. This may explain why copper, zinc, lead and nickel were not observed above detection limits in the winter storm event. Table 4 presents metals data associated with storm event monitoring at each location compared with USEPA toxic metals screening benchmarks.

Screening benchmarks were exceeded at both subwatersheds for zinc, copper and aluminum. May aluminum in Cedar Creek (C-1) was five times higher than August aluminum in the UT to Little Mountain Creek (LM-4) (Table 4). Elevated aluminum was most likely related to sediment concentration since suspended residue in the UT to Little Mountain Creek (LM-4) was 43 mg/L compared with Cedar Creek where it was 630 mg/L (Tables 12 and 16 in Section VII).

The screening benchmark for lead was exceeded at the most downstream location on Little Mountain Creek (LM-1) on one occasion; lead was detected once at Cedar Creek (C-1) but below the screening benchmark. Nickel was detected in both subwatersheds at concentrations below the benchmark (Table 4).

Table 4. Selected metal concentrations per storm event compared with USEPA Criteria Maximum Concentration (CMC) screening values (μg/L).*

Parameter	**LM-1**			**LM-4**	**C-1**		**M-1**	**J-1**	**Ref-1**
	12/03	*6/04*	*8/04*	*8/04*	*12/03*	*5/04*	*12/03*	*12/03*	*12/03*
Copper	3	**44**	**17**	**17**	< 2.0	**27**	< 2.0	< 2.0	< 2.0
Zinc	< 10	**120**	44	**48**	< 10	**100**	< 10	< 10	< 10
Lead	< 10	**46**	13	< 10	< 10	33	< 10	< 10	< 10
Nickel	< 10	24	< 10	18	< 10	17	< 10	< 10	< 10
Iron	610	1700	5500	2100	650	28000	570	610	850
Aluminum	370	**16000**	**5000**	**4600**	270	**26000**	150	260	210
Hardness as $CaCO_3$ (mg/L)	33		39	18	56	51	31	41	35
CMC Screening Values (μg/L)									
Copper	5		6	3	8	7	5	6	5
Zinc	47		54	28	73	68	44	56	49
Lead	20		25	9	39	35	18	26	22
Nickel	184		212	110	287	265	174	221	193
Aluminum	750								

* Bolded values exceed screening values. Screening values were adjusted for hardness. CMC values are from NRWQC (USEPA, 2002).

Increased metal concentrations are frequently detected in stormwater throughout North Carolina. A portion of the observed metals increase, including those of nickel and lead, could be the result of nonpoint source pollution from upland sources such as agriculture, golf courses, parking lots, industrial properties and rail lines known to exist in the study area. A portion of the increase could be attributed to higher turbidity and suspended sediment concentrations as aluminum, iron, copper and zinc are elemental components of the underlying geology and soil. USEPA is aware that certain waters will exceed toxic criteria for aluminum and that elevated concentrations in some waters may be due to aluminum associated with soil particles rather than the more toxic aluminum hydroxide (USEPA, 2002).

Acute toxicity tests were not conducted at these locations.

III. B. Alcoa's Landfill Seep Discharge Data Summary

The Badin Landfill is located within the Town of Badin, adjacent to the Alcoa facility on SR 1566 northeast of Little Mountain Creek comprising an area of approximately 13.0 acres. The Town of Badin and Alcoa historically used the landfill for final disposal of a variety of waste products generated by Alcoa and the Town. It is currently capped and leachate is discharged to Little Mountain Creek under NPDES Permit No. NC0004308. DWQ has recently given permission for Alcoa to connect this waste stream to Badin's WWTP. Aloca provided the following monitoring data at the request of DWQ's Watershed Assessment Team staff. The summary is based on a report that Aloca conducted voluntarily and not at the request of a regulatory agency.

The outfall is located approximately 1400 feet upstream of NC 740. Landfill leachate is collected by a serious of collection pipes near the bottom of the landfill that feed into one pipe and eventually discharge to the stream. Flow is measured using a free flowing 90º V-notch weir. The downstream location (LMC-2) is at NC 740 and the upstream location (LMC-1) is a few feet upstream of the discharge.

Shield Engineering, Inc., on the behalf of Alcoa, collected and analyzed water samples on three occassions from Little Mountain Creek upstream and downstream of the discharge (Table 5). Samples were analyzed for total cyanide, cyanide (amenable), fluoride, biochemical oxygen demand and total organic carbon. On one occasion in March 2003 samples collected from the discharge were analyzed for the following additional chemical parameters: carbonate, sulfate, chloride, nitrate, iron, bromide, iodide, calcium, potassium, sodium, magnesium, manganese, aluminum and strontium. Field measurements (DO, specific conductance, oxidation-reduction potential (ORP), temperature, pH and alkalinity) were made at each location along with cross sectional profiles and flow data. Flow data measured at the stream locations were collected using commercially available flow meters. Landfill leachate flow data were calculated based on a v-notch weir discharge equation.

Dissolved oxygen, pH, and temperature at each location were within expected ranges. Specific conductance, alkalinity, cyanide and fluoride measurements from the landfill discharge were significantly higher than upstream measurements. Cyanide exceeded the standard once in November 2002. Fluoride exceeded the standard by more than one order of magnitude during each of the monitoring periods. Downstream data suggested that the discharge was diluted as specific conductance, alkalinity and cyanide recovered to upstream levels. Fluoride levels remained slightly elevated at the downstream location but were within the standard.

Table 5. Monitoring data provided by Alcoa for Alcoa Badin landfill seep discharge to Little Mountain Creek. *

Field Parameters	November 2002			March 2003			July 2003			DWQ WQS
	LMC-1	LMC-2	BL-EFF	LMC-1	LMC-2	BL-EFF	LMC-1	LMC-2	BL-EFF	
DO (mg/L)	9.9	9.9	6.6	11.2	10.5	7.2	8.5	9.3	6.7	5.0
Specific Cond. (µS/cm)	74	84	1250	47	61	1610	72	96	1500	-
Oxidation Reduction Potential (mV)	205	189	35	2.6	274	-8	249	205	-45	-
Temperature ºC	8.7	8.4	12.3	15.6	15.1	13.9	24.3	23.4	21.4	-
pH (s.u.)	6.6	6.5	7.3	6.6	6.4	7.5	7.0	7.1	7.2	6.0-9.0
Alkalinity (mg/L)	-	-	-	13.3	19.1	564	-	-	-	-
Laboratory Parameters (mg/L)										
Cyanide	nd	nd	0.0099	nd	nd	nd	nd	nd	nd	0.005
Amenable Cyanide	nd	nd	nd	nd	nd	nd	nd	nd	nd	-
Fluoride	nd	0.27	21	nd	0.30	21	nd	0.47	21	1.8
BOD	nd	nd	nd	nd	nd	nd	nd	nd	nd	-
TOC	3.2	3.2	3.7	2.3	2.3	5.3	3.1	2.9	5.4	-
Alkalinity as $CaCO_3$	-	-	-	-	-	690	27	37	650	-
Carbonate	-	-	-	-	-	5.1	-	-	-	-
Sulfate	-	-	-	-	-	130	-	-	-	-
Chloride	-	-	-	-	-	16	-	-	-	230
Nitrate	-	-	-	-	-	2.3	-	-	-	10
Iron	-	-	-	-	-	0.18	-	-	-	1
Bromide	-	-	-	-	-	nd	-	-	-	-
Iodide	-	-	-	-	-	nd	-	-	-	-
Calcium	-	-	-	-	-	38	-	-	-	-
Potassium	-	-	-	-	-	9.1	-	-	-	-
Sodium	-	-	-	-	-	360	-	-	-	-
Magnesium	-	-	-	-	-	11	-	-	-	-
Manganese	-	-	-	-	-	1.4	-	-	-	200
Strontium	-	-	-	-	-	0.17	-	-	-	-
Aluminium	-	-	-	-	-	0.34	-	-	-	-
Flow (cfs)	11.2	11.5	0.01	4.0	4.9	0.02	0	2.3	0.02	-

*NCDWQ Standards are from Class C except for manganese and nitrate which apply to surface waters in water supply watersheds (WS Classes) per 15A NCAC 2B .0200 (NCDWQ, 2004b). LMC-1 is upstream. LMC-2 is downstream. BL-EFF is landfill outfall (NPDES No. NC0004308). nd = not detected above lab detection limits.

III. C. Fluoride and Cyanide Monitoring

Alcoa collected fluoride and cyanide data from stormwater outfalls on an annual basis from 1996 through 2003 as part of their NPDES monitoring requirements. The monitored outfalls pertaining to Little Mountain Creek included the landfill seep (018), an on-site stormwater outfall (004) and an outfall (017) discharging to a UT to Little Mountain Creek at NC 740.

For this study, fluoride and cyanide were monitored in baseflow and storm conditons at four locations on Little Mountain Creek (LM-3, LM-2, LM-4 and LM-1) upstream and downstream of the outfalls (cyanide data was not collected at LM-4).

Alcoa's data. A review of Alcoa's stormwater monitoring data indicated that cyanide was detected (5.9 μg/L) once at outfall 017 in September 1998 above the water quality standard of 5.0 μg/L. All other cyanide observations over this period (1996 through 2003) were below detection limits.

Stormwater fluoride data during the same period (1996 – 2003) are presented in Figure 4. Monitoring associated with the on-site outfall (004) revealed elevated fluoride concentrations well above the water quality standard of 1.8 mg/L every year. These flows were apparently combined with other on-site stormwater as fluoride concentrations were diluted prior to entering Little Mountain Creek. However, according to the data from outfall 017, dilution to below the standard occurred only during the first four years (1996 through 1999) and the last (2003). For a three-year period (2000 – 2002) coinciding with drought conditions during those years, the fluoride standard was exceeded.

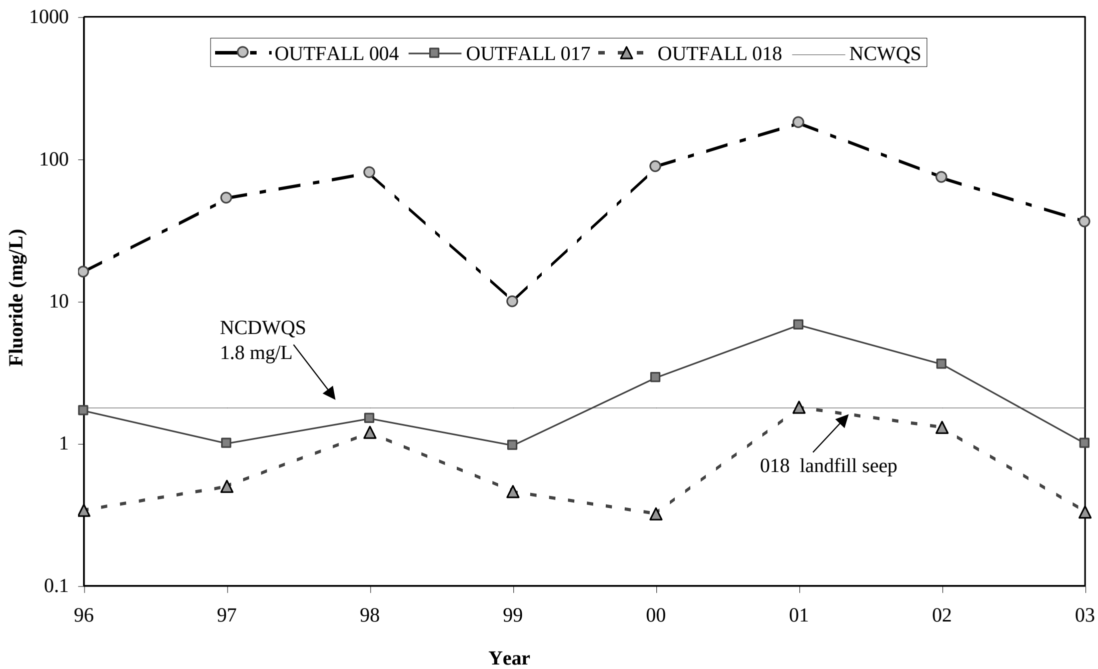

Figure 4. Alcoa's stormwater fluoride.

<u>NCDWQ data</u>. Fluoride data collected for this study is presented below in Figure 5. In the UT to Little Mountain Creek (LM-4), fluoride was detected above the standard five times out of six baseflow-monitoring events and in stormwater monitoring. At the most downstream location in Little Mountain Creek (LM-1) fluoride concentrations were, for the most part, diluted to below the standard. Fish and macroinvertebrates were collected at this location.

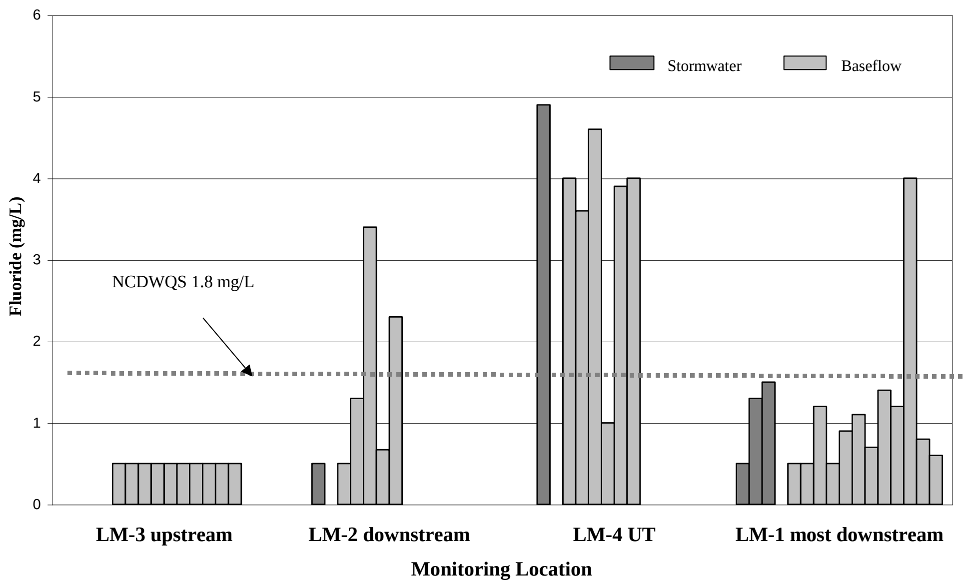

Figure 5. NCDWQ fluoride at Little Mountain Creek December 2003 - August 2004 (baseflow and stormwater).

Cyanide was below the detection limit for all seventeen monitoring events conducted for this study (Tables 9, 10 and 11 in Section VII).

It is clear that Alcoa discharged fluoride to Little Mountain Creek, at times exceeding water quality standards. According to a 1986 fluoride report prepared by water quality planning staff (DEM, 1986), aquatic insects were fairly resistant to fluoride. The report was prepared in an effort to determine if the existing standard was protective to aquatic life, in light of what was then recent new scientific research involving fluoride and because several mining companies in the Appalachian Mountains that discharged fluoride requested a review (DEM, 1986). The report presented aquatic toxicity data from several tests relative to the effects of fluoride and sodium fluoride on a variety of freshwater vertebrates, invertebrates, plankton and others. They found that the most sensitive species were trout with an average 96-hr LC_{50} of 27.0 mg/L fluoride. Invertebrates were more resistant to fluoride; 21 day no effect concentrations for *Daphnia magna* growth and reproduction ranged between 30.4 and 5.2 mg/L fluoride; and, 48 hour LC_{50} tests conducted at varying hardness ranged between 122 – 385 mg/L fluoride. No change in the standard was recommended until further acute and chronic studies were completed that met USEPA guidelines for standard calculations. Presently, the standard remains at 1.8 mg/L.

III. D. Badin's Wastewater Discharge Monitoring Summary

Badin's monitoring and inspection reports from 2001 through 2004 were reviewed (NPDES Permit No. NC0074756). Flow violations were frequently reported throughout the period. In 2004, ammonia and flow violations were reported on several occasions. Total suspended solids (TSS) and biochemical oxygen demand (BOD) concentrations were within limits. In response to violations, DWQ staff from the Mooresville region met with the plant operator in November 2004 to provide technical guidance with respect to process adjustments and monitoring protocols. Badin has recently received funding to initiate collection system rehabilitation.

DWQ has recently given permission for Alcoa to connect its landfill seep discharge (< 7500 gpd) to Badin's WWTP. In May 2004, Badin began effluent monitoring for fluoride, cyanide and quarterly toxicity testing. Cyanide has not been detected. Mean fluoride for the period June through August was 0.65 μg/L. Chronic toxicity tests conducted in July and October passed.

For this study, monitoring for residual chlorine was conducted four times upstream and downstream of Badin's discharge in Little Mountain Creek using a Hach field test kit. The presence of residual chlorine was unclear due to manganese or some other unknown substance that interfered with test reagents. Further testing using alternative lab methods detected no residual chlorine at the downstream location.

III. E. Aquatic Toxicity Testing

Alcoa's NPDES permit required quarterly *Ceriodaphnia* chronic toxicity testing on effluent that discharged from outfall 005 to a UT to Little Mountain Creek at NC 740. A review of the data indicated that there were toxicity problems in 1994 but water quality improved in subsequent years. Alcoa reported four failures in 1994, one in 1995, two in 1996 and one in 1999. The most recent failure was in 2002.

For this study, aquatic toxicity was evaluated by both the common *Ceriodaphnia* chronic procedure that measures reproduction and survival as a result of exposure to test waters over six to seven days and a procedure that evaluates acute sub-lethal effects using a more sensitive endpoint related to test organism feeding rates (McWilliam et al, 2002). Toxicity test data are summarized in Table 7. Samples were collected for both tests in August 2004 in baseflow conditions from Little Mountain Creek upstream and downstream of Alcoa and Badin's discharges. Both the 3-Brood *Ceriodaphnia dubia* pass/fail test and the *Daphnia magna* multi-concentration feeding inhibition test indicated that water quality, at the time of sample collection, had not been negatively impacted. However some uncertainty exists with respect to the *Ceriodaphnia* pass/fail tests due to control organism performance failing to meet quality control criteria.

Table 7. NCDWQ aquatic toxicity testing summary for Little Mountain Creek, August 2004*

Test Type	Parameters, Endpoints	LM-2 Upstream	LM-1 Downstream	Results
Feeding Inhibition (acute sub-lethal)	Treatment Concentration (% of test water)	12.5, 25, 50, 80, 100	12.5, 25, 50, 80, 100	Pass
	Result, LC50	> 100 %	> 100 %	
	Lowest EC50, Toxicant Exposure	> 100 %	> 100 %	
	Lowest EC50, Feeding Period	> 100 %	> 100 %	
	Control Survival	100 %	100 %	
	Treatment Survival	100 % in 100 % test water	100 % in 100 % test water	
Chronic pass/fail	Treatment Concentration (% of test water)	100	100	Pass
	Control Survival	41.7 %	50.0 %	
	Control Mean Reproduction	12.8 neonates	16.3 neonates	
	Treatment Survival	100 %	100 %	
	Treatment Mean Reproduction	24.4 neonates	26.6 neonates	

* LC50 is concentration of sample causing 50% mortality in test organisms. Sub-lethal feeding depression is reported as the "lowest EC50", the lowest concentration of test waters that results in a 50% reduction of the feeding rate or algal concentration as compared to controls. EC50s are determined for both the test water exposure (toxicant) period and the post-exposure feeding. Control organism performance did not meet quality control criteria for chronic test.

III. F. Benthic Macroinvertebrate and Fish Surveys

<u>*Benthic macroinvertebrates.*</u> As mentioned in the benthic macroinvertebrate report, Little Mountain Creek at SR 1720 (the same site evaluated for this study) was listed in the 1998 and 2002 303(d) impaired stream reports (fair rating) as a result of impaired biological communities dominated by tolerant species. Low Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa richness values were attributed to possible low dissolved oxygen, nonpoint source pollution and point discharges from Alcoa and Badin's WWTP (NCBAU, 2004). No other streams in the study area were previously rated.

Collected benthic macroinvertebrate communities and bioclassifications provided for this study are presented in Table 8 below. They indicated a benthic community in Little Mountain Creek at SR 1720 (LM-1) in decline with a rating of Poor while the upstream location in Little Mountain Creek at Jackson Street upstream of NC 740 (LM-3) scored higher earning a rating very close to Good-Fair (an official rating of Fair). The Jacobs Creek subwatershed (J-1) earned a Good-Fair rating. Habitat scores were generally high for all rated locations, which seemed to discount a lack of habitat as a contributor to the impaired community collected at the downstream location on Little Mountain Creek (LM-1).

Table 8. Benthic macroinvertebrate results (full scale samples) January 20, 2004.

Biological Community	LM-3 Upstream	LM-1 Downstream	J-1
Ephemeroptera	6	2	6
Plecoptera	2	1	3
Plecoptera (seasonally corrected)	2	1	0
Trichoptera	5	2	4
Total Taxa Richness	51	41	52
EPT Richness	13	5	13
EPT Richness (seasonally corrected)	13	5	10
EPT Abundance	59	32	84
Biotic Index	6.14	6.85	5.57
Biotic Index (seasonally corrected)	6.24	6.95	5.67
EPT Biotic Index	5.15	6.43	4.49
Bioclassification	Fair	Poor	Good-Fair
Habitat			
Stream Width (m)	5	6	6
Drainage Area (square miles)	~5.0	8.5	11.5
Depth – Average (m)	0.2	0.2	0.2
Canopy (%)	70	60	50
Substrate (%)			
Boulder	25	15	5
Rubble	30	35	30
Gravel	20	40	30
Sand	10	10	0
Silt	0	0	0
Physiochemical			
Water Temperature ºC	4	2	4.1
Dissolved Oxygen (mg/L)	13.7	13.0	12.0
Specific Conductance (µS/cm)	96	124	132
pH (s.u.)	6.9	6.7	7.1
Habitat Scores	78	84	75

Interpretations of collected benthic macroinvertebrate taxa suggested that low dissolved oxygen conditions could have been present in Little Mountain and Jacobs Creeks. However, field data recorded for this study did not provide clear evidence of low dissolved oxygen. For instance, all field measurements for dissolved oxygen at Little Mountain Creek (LM-1) during this study were above 5.0 mg/L; the lowest measurement was 6.7 mg/L (Table 9 in Section VII). Field observations were above 5.0 mg/L at Jacobs Creek as well. Dissolved oxygen measurements recorded by BAU biologists at each location during macroinvertebrate sampling were well above 5.0 mg/L. There was some evidence of low dissolved oxygen at one upstream location in Little Mountain Creek (LM-2) where concentrations below 5.0 mg/L were observed three times in July and once in August.

To further evaluate dissolved oxygen at Little Mountain Creek, data sondes were simultaneously deployed for a 72-hour period in August 2004 in Little Mountain Creek upstream and downstream of Badin and Alcoa's outfalls at LM-1 and LM-2. Probes were programmed to record readings every 15 minutes. Dissolved oxygen followed a typical diurnal pattern with minimal values occurring overnight. Upstream recordings fell below 4.0 mg/L during the last 24-hour period but recovered during daylight hours. Observations downstream remained above 4.0 mg/L throughout the period (Figure 6).

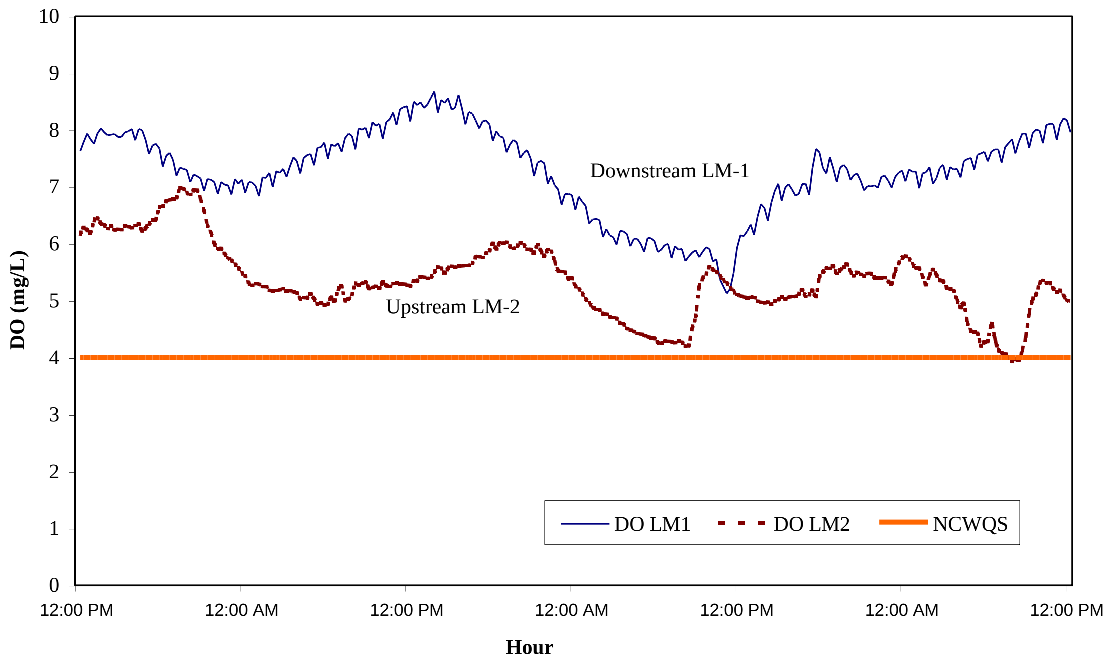

Figure 6. Dissolved oxygen over 72 hours at two locations in Little Mountain Creek August 6 through August 9.

It is unclear why dissolved oxygen measurements conducted for this study did not correlate well with biological indicators. Perhaps low dissolved oxygen existed during periods when personnel were not in the watershed or that low dissolved oxygen was more prevalent prior to the study and the macroinvertebrate community has not fully recovered.

While there was no visual evidence of excessive organic enrichment (other than periphyton) downstream of Badin's discharge, interpretations of the taxa data suggested this problem existed as well. Wastewater flows above permit limits may have flushed activated sludge and other waste constituents through the system into the stream channel. There was no visual evidence in stream substrates or on top of banks during stream surveys most likely because storm events moved solids further downstream beyond the study area.

Interpretations of the macroinvertebrate taxa also suggested that zero surface flow conditions (series of pools and dry riffle sections) existed in the upstream segment of Little Mountain Creek (LM-3). Field observations concur with this evidence. Organism survival would be difficult in these conditions although the hyporheic zone and stable habitats provide refuge for organisms during these periods (Sedell et al., 1990). The degree to which zero surface flow impacted the macroinvertebrate population is uncertain because no previous surveys were conducted at this location. There clearly was some impact since the rating here was lower than the rating for Jacobs Creek where stream flow was continuous.

More consistent stream flow in the upstream portions of Little Mountain Creek (LM-3) could improve aquatic insect abundance and subsequently provide increased numbers for downstream recolonization. However, an upstream impoundment coupled with less groundwater recharge associated with slate belt geology would make stream flow improvements unlikely unless a feasible method was engineered to manipulate releases of impounded water.

Aquatic insect assessments from Jacobs Creek suggested that low dissolved oxygen may exist but as explained above for Little Mountain Creek field measurements recorded during staff visits to the watershed did not concur. Assuming that the low dissolved oxygen stressor was present in both Jacobs and Little Mountain Creeks and that periods of zero flow provided additional stress to upstream benthic communities in both streams, the impacts were not as severe as the macroinvertebrates indicated at the downstream location in Little Mountain Creek (LM-1).

It is reasonable to conclude that in addition to zero flow and low dissolved oxygen, other stressors were contributing to the impairment in Little Mountain Creek (LM-1). It is plausible that the poor rating was the result of a cumulative effect of several factors (periodic zero flow, low dissolved oxygen, organic enrichment, reduced numbers of drift organisms, toxicants from point and nonpoint sources and other unknown stressors) that impacted the macroinvertebrate community to the degree observed. These combinations of conditions were not present in Jacobs Creek or at the upstream location in Little Mountain Creek (LM-3).

Fish. Fish assessments conducted for this study suggested a slightly depressed community at Little Mountain Creek compared with other locations within the study area; Jacobs (J-1) and Mountain Creeks (M-1) both earned Good ratings while Little Mountain Creek rated Good-Fair (Table 9). Intolerant species were not collected from any location which is not uncommon due to the lack of upstream recolonization sources and the series of dams and impoundments associated with Lake Tillery that serve to short circuit recolonization patterns and create inhospitable migratory conditions (BAU, 2004). However, an insectivore species of darter that has a tolerance rating of intermediate was collected at Mountain and Jacobs Creeks but not at Little Mountain Creek, which was partly responsible for its lower rating.

Table 9. Electroshocking data, NCIBI scores and ratings for Little Mountain Creek Local Watershed Plan, March 22, 2004.*

Site Number	1 (M-1)	2 (downstream of LM-1)	3 (J-1)
Waterbody	**Mountain Creek at SR 1720**	**Little Mountain Creek at SR 1798**	**Jacobs Creek at SR 1740**
Shocking duration (seconds)	7,006	4,451	5,421
No. fish/100 seconds shocking time	6.7	7.4	5.6
Number of species	16 (5)	16 (5)	16 (5)
Number of fish	472 (5)	328 (5)	306 (5)
Number of species of darters	1 (3)	0 (1)	1 (3)
Number of species of sunfish+bass	6 (5)	6 (5)	6 (5)
Number of species of suckers	1 (3)	2 (5)	2 (5)
Number of intolerant species	0 (1)	0 (1)	0 (1)
Percentage of tolerant fish	27 (3)	27 (3)	14 (5)
Percentage of omnivores+herbivores	33 (5)	36 (3)	15 (5)
Percentage of insectivores	64 (5)	64 (5)	82 (5)
Percentage of piscivores	2.54 (5)	0.61 (3)	2.61 (5)
Percentage of diseased fish	0.64 (5)	0.91 (3)	3.27 (1)
Percentage of species w/multiple age groups	56 (5)	69 (5)	56 (5)
NCIBI Score	50	44	50
NCIBI Rating	Good	Good-Fair	Good

* Values within parentheses are the metric score for corresponding parameter (NCBAU, 2004a).

IV. Stream Corridor Assessments

During the course of this study, project staff walked approximately 5.0 miles of mainstem and tributaries of Little Mountain Creek and Cedar Creek. To investigate water quality impairment issues, most of the stream walking was done in the mainstem and a tributary of Little Mountain Creek. Segments of Cedar Creek were investigated for comparison purposes and to investigate water quality issues.

Project staff walked the identified sections of channel while carrying out the following tasks:

- Observing overall channel, noting specific areas of sediment deposition, severe bank erosion, evidence of channelization and similar attributes;
- Conducting basic field measurements and calculations of stream channel morphology at representative segments to approximate the degree of stability (Rosgen, 1996);
- Observing overall riparian area condition and the nature of surrounding land use;
- Identifying wastewater discharge pipes, stormwater outfalls, other piped inputs or withdrawals, and tributary inflows;
- Observing visual water quality conditions (odors, surface films, low flows, etc);
- Noting specific areas where pollutants are or may be entering the stream (livestock access areas, dump sites, land clearing adjacent to the stream, etc);
- Identifying specific areas that may be candidates for channel restoration or BMPs;
- Providing digital photo documentation of key features;
- Conducting formal habitat assessments at representative reaches, as appropriate.

The present condition of the Little Mountain Creek and Cedar Creek subwatersheds (and others in planning area) is the result of watershed management activities and land uses that have occurred over the past 200 years. Early watershed activities continue to influence how these channel networks react to ongoing land use practices. Several historical watershed disturbances that contributed to and continue to influence natural fluvial geomorphology in these subwatersheds included the following.

- ✓ Land clearing for agriculture and other activities;
- ✓ Relocation/realignment of stream channels;
- ✓ Golf course construction;
- ✓ Rail corridors;
- ✓ Lake Tillery and other smaller impoundments;
- ✓ The Alcoa/Badin landfill;
- ✓ Imperviousness associated with Albemarle, Badin and Norwood; and,
- ✓ Alcoa's Badin Works complex.

Ecoregional characteristics also contribute to the condition of stream channels. The Carolina Slate Belt provides the geologic foundation of the entire watershed study area. Generally, this ecoregion is characterized by soils with low water storage capacity. Therefore channels have less groundwater recharge and more frequent zero flow. This characteristic influences aquatic life cycles more heavily than geomorphology; although, slate does influence channel pattern and profile in that it directs water flow during bankfull and higher storm events.

IV. A. Evaluated Stream Segments

<u>Little Mountain Creek at SR 1720 Valley Drive.</u> Landuse adjacent to this 4000 feet mainstem segment was predominantly comprised of small livestock operations, pasture/hay, mature hardwood forest and scattered single-family homes on large, predominately rural lots. Two paved roads (SR 1723 to the west and SR 1720 to the east) paralleled the stream in a northerly direction upstream to NC 740 and carried mostly local traffic. For the most part these two roads did not encroach within the riparian area except at one location where SR 1723 came to within 20 feet of the stream for a distance of approximately 300 feet. The stream channel within this segment was 17 feet wide (top of bank), 12 feet wide (wetted width) and water depth was 0.3 feet (on the day measurements were taken). This was a mostly straight or slightly sinuous segment with a riffle/run/pool bed morphology. A slate cobble, boulder substrate predominated and provided a natural grade control preventing significant downcutting and incision. As a result, channel adjustments in response to disturbances, were most likely accomplished by high energy storm flows that widened the channel. The stream segment was more likely straightened/moved to its present location rather than having undergone significant dredging and channelization.
Field measurements conducted for incision (entrenchment ratio) indicated that the stream had access to a wide floodplain (entrenchment ratio > 2.2) and therefore was not incised. In a few areas, cattle trampled banks were observed which continues to exacerbate local instability.

Stream banks ranged from 0.5 to 1.5 feet in height and were mostly 90 degrees vertical. Bankfull height was at or near bank height resulting in a bank height ratio approaching 1.0. One area of bank instability was observed near SR 1723 where the road comes to within 30 feet of the stream (Figure 7). An evaluation of the area using Rosgen's bank erosion hazard index (BEHI) resulted in an index value of moderate; near bank stress was judged to be high (stream velocity vectors pointing at bank). High flows during storm events may eventually erode the outside bank to a point at which SR 1723 could become compromised.

Figure 7. Moderate bank erosion at Little Mountain Creek at SR 1723.

In general, the stream segment at this location did appear to be capable of moving its sediment load; pools were not filled in with sediment and midchannel aggradational bars were non existent. Bankfull height was at or near bank height. Overall, this stream segment was moving towards stability or is stable and appeared to have morphologically recovered from previous alterations.

Riparian Zone. The riparian area along both sides of the stream consists mainly of areas of mature hardwood forests (> 50 feet wide) with minimal breaks, pasture/hayland and scattered single family homes on large lots. Dense areas of privet (most likely *Ligustrum sinense*) were also observed in the riparian areas of both sides of the stream and along stream banks. The stream had substantial tree canopy with some breaks for light penetration. An area of the riparian zone near the termination of the evaluated stream segment was impacted by an overhead high voltage transmission line. All the trees were removed along a 300 – 400 feet length of stream for right of way access. Canopy and shading were nonexistent resulting in excessive benthic periphyton growth at this location.

Habitat. The habitat evaluation conducted as part of this stream corridor assessment scored an 87 which concurred with a habitat score of 84 recorded as part of the benthic macroinvertebrate assessment conducted near this location (NCBAU, 2004). Instream field measurements were recorded at several locations along the assessment and were similar to baseflow median values recorded at LM-1. A downstream, lower gradient segment of this stream evaluated by staff from DWQ's fish community assessment unit (NCBAU, 2004a) indicated more riffle embeddedness and pool areas filled with silt, sand and gravel. The habitat score for this segment was 55. In general though, aquatic habitat throughout the assessed segments of the Little Mountain Creek subwatershed tended to score high.

Little Mountain Creek from UT to Little Mountain Creek at Stanly County Country Club upstream to NC 740. This 3200 feet stream segment was walked and found to possess similar channel, riparian and geomorphology characteristics as those that were observed at the downstream segment. Stream channel dimensions substrates and degree of stability were not unlike those observed downstream. Stream planform was mostly straight. Stream bank heights were equal to bankfull heights resulting in a bank height ratio of 1.0 indicating that the stream had access to its floodplain.

Badin's WWTP outfall was observed 1000 feet downstream from NC 740; nothing unusual associated with the discharge was observed. One of Alcoa's stormwater outfalls discharges to the stream at NC 740 (Figure 8). It was observed discharging during each visit (30 observations) to the subwatershed; nothing unusual with respect to the discharge was observed other than there was flow during dry periods. A county recycling facility is located across NC 740 could provide land for an appropriate structural stormwater best management practice.

Figure 8. Alcoa's stormwater outfall.

Riparian Zone. The riparian area was divided equally between two dominate land use types: wide (> 50 feet) mature hardwood forest buffers and related understory with few breaks; and, managed livestock pastures with narrow (< 50 feet) buffers of mature hardwood forest and related understory with few breaks. The invasive plant species *Ligustrum sinense* was dominant along the entire stream segment. Areas where cattle have access to the stream and trampled stream banks were observed. The golf course lies along the right bank and encroaches to within the riparian zone for a short distance (100 feet) a one location. A mature deciduous forest as described above buffers the golf course from the stream for a majority of its length.

Habitat. Aquatic habitat was also similar to downstream segments, characterized by little to no riffle embeddedness, a variety of pool size and propitious microhabitat which consisted of rocks, sticks and leafpacks, snags and logs, undercut banks and root mats.

UT to Little Mountain Creek at Stanly County Country Club. This tributary was essentially a concrete, rock lined ditch surrounded by a golf course throughout most of its length of 4000 feet. The last 1000 feet were surrounded by single family homes within a neighborhood of Badin. At several points along the length of the ditch, walls were crumbled and failing. Long stretches where the bottom had eroded to bedrock material were observed as well. Field measurements were not recorded at this location due to limited flow. However, stream pattern, profile and dimension were greatly disturbed. The purpose of the concrete channel was most likely to maximize course playing area and move storm flows through the course as rapidly as possible. The stream appeared to have made some adjustments to its new channel, but it would need channel enhancement or restoration to return to a functioning aquatic ecosystem.

Habitat. Habitat was not assessed but based on ocular estimations it is doubtful that this stream would score above 30. Abundant aquatic insects and high species richness could not be supported by the available habitat. The channel was completely rip rapped resulting in only one type of microhabitat and substrate. There were no pools, riffles, shading or buffer zones.

Although a benthic macroinvertebrate survey was not conducted here, in all likelihood, dispersal and recolonization by drift organisms (Smock, 1996) in downstream segments of the mainstem of Little Mountain Creek would be limited as well.

Little Mountain Creek at NC 740. Landuse along this 2000 foot mainstem segment was predominantly mature upland hardwood forest. The first 1000 feet was dominated by a capped hazardous waste landfill to the northeast, adjacent to Alcoa's Badin Aluminum Works facility. A well-established and maintained turf cover crop was present and it appeared to stabilize the cover material. Leachate collected from the landfill was observed discharging from a six-inch diameter pipe to Little Mountain Creek approximately 1000 feet upstream of NC 740 (Figure 9). Field water quality measurements (dissolved oxygen-73.8% and 6.44 mg/L, temperature 21.9°C, specific conductance-1317 μS/cm) were not unusual except for an elevated specific conductance. Instream specific conductance (111 μS/cm) appeared to equilibrate at approximately 50 feet downstream from discharge. Chemical and physical water quality data associated with the landfill seep discharge were discussed in the impairment section of this report.

The stream channel within this segment averaged 18 feet in width and depth of water averaged two inches. This segment was mostly straight with a riffle/run bed morphology. A slate cobble, boulder substrate predominated. This stream segment was most likely moved to its present location.

Major upstream watershed disturbances included an impoundment and an underground utility line that crosses the stream. A 50-foot long portion of stream near the end of the stream walk appeared to have been dredged or dug out forming a long pool of about three feet deep by fifteen feet long.

Estimations of bankfull height and flood prone width suggested that the stream segment was not incised. Bankfull height was at or near bank height. Stream banks ranged from 0.5 to 2.0 feet in height and were mostly 90 degrees vertical and undercut in some places. Few of the most downstream pools and runs (near NC 740) consisted of a thin layer of silt/clay.

Figure 9. Alcoa's landfill seep discharge.

Riparian Zone. The riparian area along both sides of the stream consisted of mainly mature upland hardwood forest and associated understory shrubs and trees. Riparian width was greater than 50 feet. Alcoa's landfill was observed to be at a distance of approximately 100 feet to the northeast of the stream and was buffered by a hardwood forest.

Habitat. Habitat assessements at the most downstream point of this segment (LM-3 Little Mountain Creek above NC 740) were conducted by NCBAU staff during benthic macroinvertebrate surveys and received a score of 78.

Little Mountain Creek at Jackson Street Upstream of NC 740. This stream corridor assessment began at the most upstream monitoring location on Little Mountain Creek (LM-3) and continued for 2000 feet upstream to the impoundment. Landuse adjacent to the stream corridor along this segment was comprised of mature hardwood trees and understory vegetation. A right of way break for an underground natural gasline transected the stream at one location 200 feet upstream from where the assessment began.

Upstream of the utility crossing, the main stream channel was altered since several channels were seen in a braided pattern approximating a Rosgen DA channel (Rosgen, 1996). Some channels were filled with stagnant ponds, others were dry and another where very low flow was observed. The channels were about the same depth (1.5 – 2.0 feet) but their widths varied from 10.0 to 3.0 feet and were mostly straight. Stream banks were mostly vertical and appeared to be stable although some channels appeared to still be forming and somewhat downcutting as they had not yet reached bedrock. Other channels appeared to be stable with a bottom substrate that consisted of slate cobbles, gravel and boulders. Most likely these channels developed in response to disruptions in normal flow regimes (storm and base flow) cause by the dam/impoundment. High water indicators were observed within the floodplain.

A gravel road ran the length of the earthen dam. The impoundment was not assessed but covered approximately 15 acres in area (Figure 10). The original stream channel was at one end of the dam; an emergency spillway at the other. The spillway was essentially a dug out channel 300 feet north of the original channel and was not discharging at the

on Little Mountain Creek.

time of this assessment. The elevation of the impounded water is maintained by an overflow pipe (12-inch diameter) which removes water from the surface down through the dam about 50-75 feet to a concrete culvert and then to the original channel. Field measurements of water quality were recorded (dissolved oxygen-78.4% and 6.4 mg/L, water temperature-21.9° C, specific conductance-93.8 μS/cm), and were not unusual for this stream and were similar to baseflow measurements recorded downstream in Little Mountain Creek (LM-3). It appeared also that several large dump truck loads of spoil material (mostly slate bedrock gravel and pebbles) left over from spillway construction were deposited within the original channel which in turn modified stream flow.

Habitat. Habitat was not formally evaluated as part of the assessment of this segment. However, based on ocular estimations of substrate, undercut banks, root mats, other instream habitat and riparian areas habitat scores would have been high.

Cedar Creek at US 52. Cedar Creek was the southern-most stream within the study area. It was chosen for stream corridor assessments because it was observed that most of the stream was impacted by a rail line and initial water quality field readings and chemistry data indicated upstream disturbances. The assessment began at US 52 and continued upstream for approximately 3400 feet. In general, this stream segment appeared to be unstable and would continue to erode until it finds equilibrium.

Landuse adjacent to this segment was predominantly urban consisting of commercial areas along US 52, an industrial complex, a rail line, a city park and a few single family homes. The city park may provide enough land for an appropriate structural stormwater best management practice. The first 300 feet of channel was straight and banks that measured 6 feet in height and were 90 degree vertical. Banks of this height were not observed in other subwatersheds within the study area. It appeared that this length of channel was was not original and that the stream banks were most likely formed from fill soil associated with adjacent property grading and leveling for the railroad, utility line, and commercial buildings. The original channel was most likely filled. Bottom substrate was hard bedrock

Riparian Zone. The left riparian area was an empty overgrown lot of sparse weeds and *Ligustrum sp*. The right riparian area consisted of an industrial building and sewer right or way < 20 feet from top of bank. A concrete outfall was observed (source unknown) to have previously discharged a thick black substance. The outfall discharge was a source of scour, erosion and a headcut was developing (Figure 11).

Further upstream (100 feet) Cedar Creek makes a 90 degree turn to the north. Stream velocity vectors at this point were high. If allowed to continue, stream bank erosion would most likely result in impacts to adjacent property(s). The stream continued in a mostly straight pattern paralleled by a rail line along the right bank and continued under SR 1922. The channel associated with the segment upstream of SR

Figure 11. Concrete outfall on Cedar Creek.

1922 appeared to have been relocated to accommodate surrounding land use as well. The original channel was most likely filled. An overhead high voltage utility line impacted this portion of the stream as well.

Habitat. Scores were judged upstream and downstream of SR 1922. Total scores of 68 and 55 were earned. Both locations scored highest for instream habitat (microhabitats of rocks, undercut banks, root mats, snags and logs, sticks and leaf packs) and for a good mix of bottom substrates (gravels and boulders). Riparian buffer scores were low.

The stream was judged to be moderately entrenched (entrenchment ratio = 1.9) and therefore somewhat incised and was further adjusting itself by undercutting its banks and widening. Bankfull depth was below actual stream bank height which contributed to bank erosion during bankfull storm events. A BEHI was judged and calculations resulted in an index range of very high to extreme. Observations of bottom substrate and pools indicated that although bank erosion was very high, the stream was capable of moving its sediment load within the segment assessed.

Summary. In general, the Little Mountain Creek mainstem from SR 1720 upstream to the impoundment had adjusted to previous watershed-scale disruptions and evolved to stable conditions or was moving towards stability. Observed channel conditions throughout the Little Mountain Creek subwatershed suggested that recent and historic disturbances contributing to stream instability were compensated for and that for the most part equilibrium was achieved through channel widening. Major channel adjustments such as extreme bank erosion and incision were not observed. The stream appeared to be able to transport sediment loads, very few riffles were embedded with sediments and pool bottoms were hard. However, a few areas of localized instability (i.e. unstable banks and livestock trampling the stream banks) were observed. These isolated disturbances if left unchecked may contribute to further localized instability. One problem area within the Little Mountain Creek watershed which could be improved was the UT at the Stanly County Country Club which was essentially a concrete lined ditch with very little to no auspicious habitat for aquatic insects and impacted riparian zones with no woody vegetation.

The Cedar Creek watershed was more unstable than Little Mountain Creek characterized by eroding banks and riparian zone impacts. Two critical areas need to be investigated further to prevent continued water quality degradation, headcutting, bank erosion and possible property damage. These include the outfall described above and the unstable bank where Cedar Creek makes its turn to the north.

V. Summary and Conclusions

Summary

- To estimate the level of watershed disturbance, nutrient data were compared with nutrient data that are to represent conditions of surface waters of minimal human impact. USEPA ecoregion criteria and a local minimally impacted stream were used for baseflow comparisons. Stormwater data were compared with stormwater data from unforested drainage basins in the Carolina Slate Belt.

- Median nutrient levels in Little Mountain Creek downstream of Alcoa and Badin's discharges exceeded baseflow and stormflow criteria. All other streams were below baseflow criteria. Stormwater median total nitrogen for all other streams exceeded criteria as well. Little Mountain Creek was the highest, Cedar Creek the second highest and a UT to Little Mountain Creek downstream from Alcoa was the third highest. Periphyton growth on stream substrate was evident throughout most of the planning area. The Preliminary Findings Report predicted nutrient export potential for each subwatershed based on literature and landcover/landuse data sets. Their predictions matched closely with actual collected data except for Mountain and Little Mountain Creeks subwatersheds. The Mountain Creek subwatershed was rated high for potential nutrient export while actual data (although limited) suggested a lower rating. The prediction for Little Mountain Creek was probably too low. Collected nutrient data provided evidence that nutrient export potential would most likely be high.

- Potential disease causing bacteria or other organisms may be present throughout the planning area. While other sources may be responsible, cattle manure was observed in stream and along stream corridors on several occasions.

- Five miles of mainstem and tributaries of Little Mountain and Cedar Creek were assessed by walking sections of stream channel noting specific areas of severe bank erosion, evidence of channelization, sediment deposition and overall channel instability. Areas where pollutants are or were entering the stream were identified along with areas that may be candidates for channel enhancement/restoration and stormwater structural best management practices.

- The UT to Little Mountain Creek at the Stanly County Country Club was a concrete lined ditch 4000 feet long surrounded by a golf course. Zero flow was observed during spring and summer months. Evidence of cattle trampled stream banks along Little Mountain and Mountain Creeks were observed. Areas of stream bank instability that could threaten property were noted for both Little Mountain and Cedar Creeks.

- Stormflow metals were detected at times above toxic benchmarks in Little Mountain at LM-1 and LM-4 and in Cedar Creeks (C-1). Aluminum was pervasive throughout the study area and exceeded baseflow toxic benchmarks.

- Alcoa's fluoride inputs to Little Mountain Creek at (LM-4) often exceeded water quality standards. There were toxicity failures upstream of this location during the past ten years. The most recent failure was in 2002. Alcoa's landfill seep discharged toxicants to Little Mountain Creek 1400 feet upstream of NC 740 but loadings were not significant. Recently, DWQ has given Alcoa permission to connect the landfill seep discharge to Badin's WWTP at flows less than 7500 gallons per day.

- Badin reported repeated flow violations during 2001 through 2004. In 2004 repeated ammonia violations were reported. Biochemical oxygen demand and total suspended sediment limits were not exceeded during this period. In May 2004, Badin began to monitor for fluoride, cyanide and toxicity. Two toxicity tests conducted in 2004 passed. Cyanide has not been detected and fluoride was detected but well below the standard. Residual chlorine was not detected downstream of Badin's outfall in Little Mountain Creek (LM-1). In November 2004, DWQ provided the operator with technical guidance in plant operations and monitoring protocols. Badin has identified collection system problems and has recently received funding to begin collection system repairs.

- Both the 3-Brood *Ceriodaphnia dubia* pass/fail and *Daphnia magna* multi-concentration feeding inhibition test conducted in August indicated no adverse water quality impacts upstream or downstream of Aloca and Badin's discharges in Little Mountain Creek at LM-1 and LM-2 at the time of sample collection. However, some uncertainty exists with the *Ceriodaphnia* test due to control organism failure to meet quality control criteria.

- Based on impaired biological integrity, Little Mountain Creek at SR 1720 was listed in the 1998, 2002 and the Draft 2004 Integrated 305(b) and 303(d) Impaired Waters Report. Little Mountain Creek was assessed again for this study (at the same location) and received a rating of Poor. Also for this study, an upstream location in Little Mountain Creek (LM-3) was rated and received a Fair and Jacobs Creek (J-1) received a Good-Fair rating. Aquatic habitat scores were high throughout the planning area.

- Fish community assessments conducted for this study suggested a slightly depressed community in Little Mountain Creek compared with Jacobs and Mountain Creeks.

- Aquatic insects collected from each location suggested that low dissolved oxygen was a contributing stressor throughout the study area; however, field data did not strongly support this evidence. Assuming that low dissolved oxygen was a stressor to aquatic insects, the impacts to the macroinvertebrate communities at Jacobs Creek (J-1) and upstream in Little Mountain Creek (LM-3) were not as severe as the macroinvertebrates indicated at the downstream location in Little Mountain Creek (LM-1).

- Aquatic insect taxa downstream in Little Mountain Creek (LM-1) provided evidence of organic enrichment. Visual evidence of excessive organic material was not observed on stream banks or on bottom substrates during stream walks. Periphyton growth was observed on bottom substrates.

- Zero flow periods common in slate belt geology were also evidenced by collected aquatic insect taxa. Field observations concurred with this evidence. The most upstream monitoring site in Little Mountain Creek (LM-3) experienced the most direct impact from zero flow but the degree of impact was unclear since previous surveys were not conducted at this location. There was likely some impact since there was continuous stream flow at Jacobs Creek which received a better rating than Little Mountain Creek (LM-3).

Conclusions.
Slate belt geology within the study area is both beneficial and detrimental to aquatic communities. Favorable stable habitats provide refugia for benthic communities during periods

of zero surface flow that would otherwise decimate populations. Low dissolved oxygen related to organic/nutrient enrichment along with periodic zero surface flow were stressors impacting the aquatic insect community throughout the study area but these stressors alone did not result in the poor rating for Little Mountain Creek. It is plausible that a cumulative effect of natural background stress combined with additional stressors (toxicants) from point and nonpoint sources (and unknown stressors) unique to Little Mountain Creek were responsible for impacting the benthic community to the degree observed.

Slate geology also partly influenced stream channel adjustments that occurred as a result of upstream watershed activities. Large adjustments to channel form such as extreme bank erosion, incision and sediment deposition were limited (which maintained favorable habitat) due to the extensive and shallow depth to bedrock that prevented the streams from downcutting. Channel adjustments were accomplished through channel widening. Generally, upstream watershed activities resulted in localized problems that could be addressed easily.

Some improvements to improve water quality have already begun. Badin's planned collection system repairs and improved wastewater treatment plant operations should improve downstream water quality. The improvements may also address downstream organic enrichment issues and lessen potential disease causing organisms in the stream.

Other problem areas identified in the study area along with possible solutions are listed below.

- Localized stream bank instability in Little Mountain Creek at SR 1723 and Cedar Creek 100 feet upstream of US 52 need to be stabilized to prevent adjacent property and infrastructure damage.
- Fencing to keep cattle out of Mountain and Little Mountain Creeks would reduce nutrients and potential disease causing organisms and improve local aquatic habitat in those streams.
- The UT to Little Mountain Creek at the Stanly County golf course may be able to contribute drift organisms for downstream colonization if habitat was improved along its entire length and woody vegetation planted streamside to improve riparian conditions.
- More study of the impoundment on Little Mountain Creek is needed to determine if it would be feasible to schedule releases of water periodically during spring and summer dry periods to maintain stream flow. This may subsequently improve the aquatic insect community and become a source of drift organisms for downstream colonization.
- Stormwater nutrients and toxicants entering Little Mountain Creek from the Alcoa facility could be reduced if stormwater treatment was installed. A Stanly County waste recycling facility across from the Alcoa facility may be a suitable location for a retention/treatment pond. Further investigation is needed to determine if the identified locations are feasible.
- Cedar Creek could also benefit from stormwater treatment. City parkland at US 52 in Norwood may be a suitable site for a retention/treatment pond. Further investigation is needed to determine if the identified locations are feasible.

VII. Data Tables

The following Tables 9 through 16 summarize the physical and chemical data collected at the sampling locations described in the text. Column headings for these tables are given below:

N number of samples or measurements
Max maximum value
Min minimum value
Med median
Mean mean (geometric mean, in the case of fecal coliform)

Values below the minimum analytical reporting limit (not detected above the reported practical quantitation limit (PQL) are shown in the table as less than the specified reporting limit (e.g. "< 2.0"). The PQL is defined and proposed as the "lowest level achievable among laboratories within specified limits during routine laboratory operations". The PQL is about three to five times the calculated Method Detection Limit (MDL) and represents a practical and routinely achievable detection limit with a relatively good certainty that any reported value is reliable.

In calculating means, values below the PQL were assigned a value equal to the specified reporting limit. Metals concentrations are as total recoverable not as dissolved.

Hardness calculated using the formula, 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L]. Additional laboratory information on detection limits, methods and links to other related websites is available on the DWQ Laboratory Section web site at: http://h2o.enr.state.nc.us/lab.

Table 9. Water quality summary for Little Mountain Creek at SR 1720 Valley Road (LM-1).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	17	24.8	5.6	21.1	18.9		2	22.2	8.2	15.2	15.2
Specific Cond. (µS/cm)	17	231	97	154	157		3	129	98	101	110
DO (mg/L)	17	13.8	6.7	8.1	8.8		2	10.0	6.6	8.3	8.3
DO (% saturation)	17	123	76	91	92		2	85	75	80	80
pH (s.u.)	14	8.2	6.8	7.3	7.3		3	7.2	6.7	6.8	6.9
Nutrients (mg/L)											
Ammonia Nitrogen	8	0.33	< 0.02	0.05	0.09		3	0.68	0.10	0.30	0.36
Total Kjeldahl Nitrogen	8	0.83	0.40	0.46	0.52		3	1.60	0.51	1.40	1.17
Nitrate+Nitrite Nitrogen	8	3.90	0.76	1.50	1.79		3	2.40	0.67	1.10	1.39
Total Phosphorus	8	0.29	0.09	0.19	0.18		3	1.80	0.10	0.85	0.92
Inorganics (mg/L)											
Hardness as $CaCO_3$	8	57	26	39	40		3	39	33	33	35
Suspended Residue	8	4	< 2.5	2.8	3.0		3	620	200	200	340
Fixed Residue	8	2.5	< 2.5	< 2.5	2.5		3	520	12	160	231
Volatile Residue	8	all < 2.5					3	190	34	100	108
Fluoride	12	4.0	< 0.5	0.9	1.1		3	1.5	< 0.5	1.3	1.1
Cyanide	7	all < 0.02					2	all < 0.02			
Turbidity (NTU)											
-	8	5.2	< 1	2.8	2.8		1	12			
Metals (µg/L)											
Calcium (mg/L)	8	15.0	5.5	9.1	9.8		3	10.0	7.1	7.6	8.2
Magnesium (mg/L)	8	4.8	3.0	4.0	3.8		3	3.6	3.4	3.5	3.5
Aluminum	8	310	< 50	88	119		3	16000	370	5000	7123
Arsenic	8	all < 10					3	10	< 10	< 10	10
Cadmium	8	all < 2.0					3	all < 2.0			
Chromium	8	all < 25					3	all < 25			
Copper	8	3.0	< 2.0	2.3	2.4		3	44	2.5	17	21
Iron	8	350	73	230	220		3	5500	610	1700	2603
Lead	8	all < 10					3	46	< 10	13	23
Manganese	8	51	11	39	35		3	3000	58	1400	1486
Mercury	7	all < 0.2					3	all < 0.2			
Nickel	8	all < 10					3	24	< 10	< 10	15
Zinc	8	all < 10					3	120	< 10	44	58
Fecal Coliform Bacteria (cols per 100 mL)											
-	7	640	12	51	45		1	360			

Table 10. Water quality summary for Little Mountain Creek at NC740 (LM-2).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	8	24.7	21.0	23.8	23.4		1	7.3			
Specific Cond. (µS/cm)	8	254	100	163	173		1	92			
DO (mg/L)	8	7.4	3.9	5.1	5.3		1	10.7			
DO (% saturation)	8	88	44	58	63		1	89.1			
pH (s.u.)	6	7.7	7.1	7.5	7.4		1	7.2			
Nutrients (mg/L)											
Ammonia Nitrogen	-	-					1	< 0.02			
Total Kjeldahl Nitrogen	-	-					1	0.33			
Nitrate+Nitrite Nitrogen	-	-					1	0.27			
Total Phosphorus	-	-					1	0.04			
Inorganics (mg/L)											
Hardness as $CaCO_3$	1	75					1	28			
Suspended Residue	-	-					1	6			
Fixed Residue	-	-					1	< 2.5			
Volatile Residue	-	-					1	6			
Fluoride	5	3.4	< 0.5	1.3	1.6		1	< 0.5			
Cyanide	-	-					1	< 0.02			
Turbidity (NTU)											
-	-	-					1	16			
Metals (µg/L)											
Calcium (mg/L)	1	19.0					1	6.1			
Magnesium (mg/L)	1	6.8					1	3.2			
Aluminum	1	80					1	620			
Arsenic	1	< 10					1	< 10			
Cadmium	1	< 2.0					1	< 2.0			
Chromium	1	< 25.0					1	< 25			
Copper	1	< 2.0					1	2.4			
Iron	1	220					1	880			
Lead	1	< 10					1	< 10			
Manganese	1	200					1	65			
Mercury	1	< 0.2					1	< 0.2			
Nickel	1	< 10					1	< 10			
Zinc	1	< 10					1	12			
Fecal Coliform Bacteria (cols per 100 mL)											
-	-	-					1	300			

Table 11. Water quality summary for Little Mountain Creek at Jackson Street upstream of NC 740 (LM-3).

Parameter	Baseflow					Stormflow				
	N	Max	Min	Med	Mean	N	Max	Min	Med	Mean
Field Parameters										
Water Temperature (ºC)	13	26.1	5.3	20.9	18.4	-	-	-	-	-
Specific Cond. (µS/cm)	13	145	51	91	92	-	-	-	-	-
DO (mg/L)	13	12.3	5.3	8.2	8.4	-	-	-	-	
DO (% saturation)	13	124	64	82	87	-	-	-	-	-
pH (s.u.)	10	7.8	6.7	7.2	7.2	-	-	-	-	-
Nutrients (mg/L)										
Ammonia Nitrogen	8	0.03	< 0.02	< 0.02	0.02	-	-	-	-	-
Total Kjeldahl Nitrogen	8	0.37	< 0.20	0.21	0.23	-	-	-	-	-
Nitrate+Nitrite Nitrogen	8	0.24	0.05	0.16	0.15	-	-	-	-	-
Total Phosphorus	8	0.04	< 0.02	0.03	0.03	-	-	-	-	-
Inorganics (mg/L)										
Hardness as $CaCO_3$	8	41	21	32	32	-	-	-	-	-
Suspended Residue	8	7	< 2.5	5	4.9	-	-	-	-	-
Fixed Residue	8	6	< 2.5	4	3.9	-	-	-	-	-
Volatile Residue	8	5	< 2.5	< 2.5	3.1	-	-	-	-	-
Fluoride	10	all < 0.5				-	-	-	-	-
Cyanide	7	all < 0.02				-	-			
Turbidity (NTU)										
-	8	11	< 2.3	5.3	5.9	-	-			
Metals (µg/L)										
Calcium (mg/L)	8	9.0	4.4	6.7	6.8	-	-	-	-	-
Magnesium (mg/L)	8	4.5	2.4	3.7	3.6	-	-	-	-	-
Aluminum	8	410	57	165	195	-	-	-	-	-
Arsenic	8	all < 10				-	-	-	-	-
Cadmium	8	all < 2.0				-	-			
Chromium	8	all < 25.0				-	-			
Copper	8	all < 2.0				-	-	-	-	-
Iron	8	750	250	605	543	-	-	-	-	-
Lead	8	all < 10				-	-	-	-	-
Manganese	8	370	26	70	110	-	-	-	-	-
Mercury	7	all < 0.2				-	-			
Nickel	8	all < 10				-	-	-	-	-
Zinc	8	all < 10				-	-	-	-	-
Fecal Coliform Bacteria (cols per 100 mL)										
-	7	140	13	45	36	-	-			

Table 12. Water quality summary for UT to Little Mountain Creek at NC 740 (LM-4).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	6	26.0	21.3	22.3	22.9		1	26.1			
Specific Cond. (µS/cm)	6	275	230	259	254		1	62			
DO (mg/L)	6	8.6	7.1	7.7	7.7		1	8.1			
DO (% saturation)	6	98	82	90	90		1	82.0			
pH (s.u.)	5	7.9	7.4	7.8	7.7		1	6.5			
Nutrients (mg/L)											
Ammonia Nitrogen	2	all < 0.02					1	0.56			
Total Kjeldahl Nitrogen	2	all < 0.20					1	0.92			
Nitrate+Nitrite Nitrogen	2	1.10	1.00	1.05	1.05		1	0.98			
Total Phosphorus	2	all < 0.02					1	0.09			
Inorganics (mg/L)											
Hardness as $CaCO_3$	2	73	68	71	71		1	18			
Suspended Residue	-	-					1	43			
Fixed Residue	-	-					1	37			
Volatile Residue	-	-					1	6			
Fluoride	6	4.6	1.0	4.0	3.5		1	4.9			
Cyanide	-	-					-	-			
Turbidity (NTU)											
-	-	-					-	-			
Metals (µg/L)											
Calcium (mg/L)	2	19.0	17.0	18.0	18.0		1	6.0			
Magnesium (mg/L)	2	6.3	6.1	6.2	6.2		1	0.83			
Aluminum	2	150	100	125	125		1	4600			
Arsenic	2	all < 10					1	< 10			
Cadmium	2	all < 2.0					1	< 2.0			
Chromium	2	all < 25.0					1	< 25			
Copper	2	all < 2.0					1	17			
Iron	2	all < 50					1	2100			
Lead	2	all < 10					1	< 10			
Manganese	2	all < 10					1	75			
Mercury	2	all < 0.2					1	< 0.2			
Nickel	2	all < 10					1	18			
Zinc	2	13	< 10	12	12		1	48			
Fecal Coliform Bacteria (cols per 100 mL)											
-	-	-					-	-			

Table 13. Water quality summary for Mountain Creek at SR 1720 Valley Drive (M-1).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	9	24.9	3.1	18.9	16.1		1	8.0			
Specific Cond. (µS/cm)	9	127	83	102	102		1	89			
DO (mg/L)	9	18.9	5.8	10.0	10.9		1	11.3			
DO (% saturation)	9	125	66	94	95		1	95.0			
pH (s.u.)	9	7.8	6.8	7.1	7.3		1	7.2			
Nutrients (mg/L)											
Ammonia Nitrogen	8	0.03	< 0.02	0.02	0.02		1	< 0.02			
Total Kjeldahl Nitrogen	8	0.32	< 0.20	0.29	0.26		1	0.24			
Nitrate+Nitrite Nitrogen	8	0.47	0.14	0.30	0.30		1	0.60			
Total Phosphorus	8	0.05	< 0.02	0.04	0.04		1	0.02			
Inorganics (mg/L)											
Hardness as $CaCO_3$	8	49	27	38	38		1	31			
Suspended Residue	8	5	< 2.5	3.5	3.4		1	< 2.5			
Fixed Residue	8	5	< 2.5	< 2.5	3		1	< 2.5			
Volatile Residue	8	5	< 2.5	< 2.5	3		1	< 2.5			
Fluoride	6	4.6	1.0	4.0	3.5		-	-			
Cyanide	-	-					-	-			
Turbidity (NTU)											
-	8	6.4	2	3.7	3.8		1	5.7			
Metals (µg/L)											
Calcium (mg/L)	8	12.0	6.0	9.5	9.3		1	7.0			
Magnesium (mg/L)	8	4.6	2.8	3.6	3.7		1	3.2			
Aluminum	8	140	< 50	90	93		1	150			
Arsenic	8	all < 10					1	< 10			
Cadmium	8	all < 2.0					1	< 2.0			
Chromium	8	all < 25					1	< 25			
Copper	8	all < 2.0					1	< 2.0			
Iron	8	550	270	450	404		1	570			
Lead	8	all < 10					1	< 10			
Manganese	8	74	12	51	45		1	16			
Mercury	-	-					-	-			
Nickel	8	all < 10					1	< 10			
Zinc	8	25	< 10	< 10	12		1	< 10			
Fecal Coliform Bacteria (cols per 100 mL)											
-	7	640	21	440	235		1	200			

Table 14. Water quality summary for Jacobs Creek at SR 1740 Indian Mound Road (J-1).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	9	24.4	3.6	19.9	16.3		1	7.8			
Specific Cond. (µS/cm)	9	138	108	129	126		1	107			
DO (mg/L)	9	15.8	6.3	9.8	10.6		1	11.4			
DO (% saturation)	9	129	72	107	105		1	95.5			
pH (s.u.)	9	8.9	7.0	7.2	7.5		1	7.3			
Nutrients (mg/L)											
Ammonia Nitrogen	8	0.02	< 0.02	< 0.02	0.02		1	0.02			
Total Kjeldahl Nitrogen	8	0.44	< 0.20	0.26	0.27		1	0.27			
Nitrate+Nitrite Nitrogen	8	0.61	0.03	0.32	0.30		1	0.65			
Total Phosphorus	8	0.05	< 0.02	0.03	0.03		1	0.03			
Inorganics (mg/L)											
Hardness as $CaCO_3$	8	59	36	52	50		1	41			
Suspended Residue	8	6	< 2.5	3.3	3.6		1	3			
Fixed Residue	8	5	< 2.5	< 2.5	3.2		1	< 2.5			
Volatile Residue	8	5	< 2.5	< 2.5	2.8		1	< 2.5			
Fluoride	-	-					-	-			
Cyanide	-	-					-	-			
Turbidity (NTU)											
-	8	10	1.3	3.5	3.7		1	10			
Metals (µg/L)											
Calcium (mg/L)	8	13.0	7.5	11.0	10.8		1	8.4			
Magnesium (mg/L)	8	6.7	4.3	5.9	5.7		1	4.8			
Aluminum	8	490	< 50	89	141		1	260			
Arsenic	8	all < 10					1	< 10			
Cadmium	8	all < 2.0					1	< 2.0			
Chromium	8	all < 25					1	< 25			
Copper	8	2.1	< 2.0	< 2.0	2.0		1	< 2.0			
Iron	8	520	160	285	313		1	610			
Lead	8	all < 10					1	< 10			
Manganese	8	41	11	23	26		1	25			
Mercury	-	-					-	-			
Nickel	8	all < 10					1	< 10			
Zinc	8	12	< 10	< 10	10		1	< 10			
Fecal Coliform Bacteria (cols per 100 mL)											
-	7	550	27	160	128		1	810			

Table 15. Water quality summary for Gum Creek at SR 1744 Snuggs Road (Ref-1).

Parameter	Baseflow						Stormflow				
	N	Max	Min	Med	Mean		N	Max	Min	Med	Mean
Field Parameters											
Water Temperature (ºC)	7	22.7	5.3	15.5	14.6		1	8.8			
Specific Cond. (μS/cm)	7	154	97	125	126		1	92			
DO (mg/L)	7	15.5	6.9	9.4	10.5		1	10.1			
DO (% saturation)	7	119	80	93	97		1	86.6			
pH (s.u.)	7	7.8	7.0	7.1	7.2		1	7.3			
Nutrients (mg/L)											
Ammonia Nitrogen	6	0.02	< 0.02	< 0.02	0.02		1	0.07			
Total Kjeldahl Nitrogen	6	0.44	< 0.20	0.26	0.27		1	0.34			
Nitrate+Nitrite Nitrogen	6	0.29	0.10	0.20	0.20		1	0.32			
Total Phosphorus	6	0.03	< 0.02	0.02	0.02		1	0.03			
Inorganics (mg/L)											
Hardness as $CaCO_3$	6	75	35	56	55		1	35			
Suspended Residue	6	3	< 2.5	2.8	2.8		1	< 5			
Fixed Residue	6	all < 2.5					1	< 5			
Volatile Residue	6	3	< 2.5	< 2.5	2.6		1	< 5			
Fluoride	-	-					-	-			
Cyanide	-	-					-	-			
Turbidity (NTU)											
-	6	4.2	1.1	3.2	3.0		1	7.7			
Metals (μg/L)											
Calcium (mg/L)	6	17.0	7.1	12.0	11.9		1	7.1			
Magnesium (mg/L)	6	8.0	4.1	6.3	6.1		1	4.2			
Aluminum	6	210	< 50	104	117		1	210			
Arsenic	6	all < 10					1	< 10			
Cadmium	6	all < 2.0					1	< 2.0			
Chromium	6	all < 25					1	< 25			
Copper	6	3.4	< 2.0	< 2.0	2.0		1	< 2.0			
Iron	6	340	140	175	197		1	850			
Lead	6	all < 10					1	< 10			
Manganese	6	42	< 10	16	20		1	28			
Mercury	-	-					-	-			
Nickel	6	all < 10					1	< 10			
Zinc	6	all < 10					1	< 10			
Fecal Coliform Bacteria (cols per 100 mL)											
-	5	370	73	200	193		1	120			

Table 16. Water quality summary for Cedar Creek at SR 1740 Indian Mound Road (C-1).

Parameter	Baseflow					Stormflow				
	N	Max	Min	Med	Mean	N	Max	Min	Med	Mean
Field Parameters										
Water Temperature (ºC)	9	23.1	3.2	13.3	14.7	1	8.3			
Specific Cond. (µS/cm)	9	191	122	150	157	2	145	113	129	129
DO (mg/L)	9	15.2	5.6	9.6	10.1	1	10.8			
DO (% saturation)	9	129	64	98	97	1	91.7			
pH (s.u.)	8	7.5	6.9	7.2	7.2	1	7.3			
Nutrients (mg/L)										
Ammonia Nitrogen	7	0.03	< 0.02	0.02	0.02	2	0.30	0.25	0.28	0.28
Total Kjeldahl Nitrogen	7	0.35	< 0.20	0.26	0.26	2	1.20	0.70	0.95	0.95
Nitrate+Nitrite Nitrogen	7	0.70	0.20	0.41	0.43	2	1.30	0.86	1.08	1.08
Total Phosphorus	7	0.07	0.02	0.04	0.04	2	0.48	0.05	0.27	0.27
Inorganics (mg/L)										
Hardness as $CaCO_3$	7	75	42	66	62	2	56	51	54	54
Suspended Residue	7	5	< 2.5	< 2.5	3.1	2	630	5	318	318
Fixed Residue	7	5	< 2.5	< 2.5	2.9	2	560	3	282	282
Volatile Residue	7	< 5	< 2.5	< 2.5	< 2.9	2	70	2.5	36	36
Fluoride	-	-				-	-			
Cyanide	-	-				-	-			
Turbidity (NTU)										
-	7	5.7	1.3	3.2	3.6	1	13			
Metals (µg/L)										
Calcium (mg/L)	7	18.0	10.0	15.0	14.6	2	13.0	11.0	12.0	12.0
Magnesium (mg/L)	7	7.4	4.2	6.7	6.3	2	5.8	5.8	5.8	5.8
Aluminum	7	220	< 5	76	98	2	26000	270	13135	13135
Arsenic	7	all < 10				2	all < 10			
Cadmium	7	all < 2.0				2	all < 2.0			
Chromium	7	all < 25				2	all < 25			
Copper	7	2.4	< 2.0	< 2.0	2.1	2	27.0	< 2.0	14.5	14.5
Iron	7	510	78	400	364	2	28000	650	14325	14325
Lead	7	all < 10				2	33	< 10	22	22
Manganese	7	80	13	58	50	2	3400	77	1739	1739
Mercury	-	-				-	-			
Nickel	7	all < 10				2	17	< 10	13.5	13.5
Zinc	7	12	< 10	< 10	10	2	100	< 10	55	55
Fecal Coliform Bacteria (cols per 100 mL)										
-	6	240	71	155	153	1	440			

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