Quality Assurance Project Plan (QAPP)
Oconaluftee Watershed Plan Development
2010

Eastern Band of Cherokee Indians (EBCI)
Office of Environment and Natural Resources (OENR)
Watershed Restoration & Protection Program

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Table of Contents

List of Figures

List of Tables

PROJECT MANAGEMENT

A3. DISTRIBUTION LIST

Official copies and subsequent revisions of this document will be provided to:

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A4. PROJECT/TASK ORGANIZATION

The task advisors and staff listed in Figure 1. below and Table 1. will implement the program

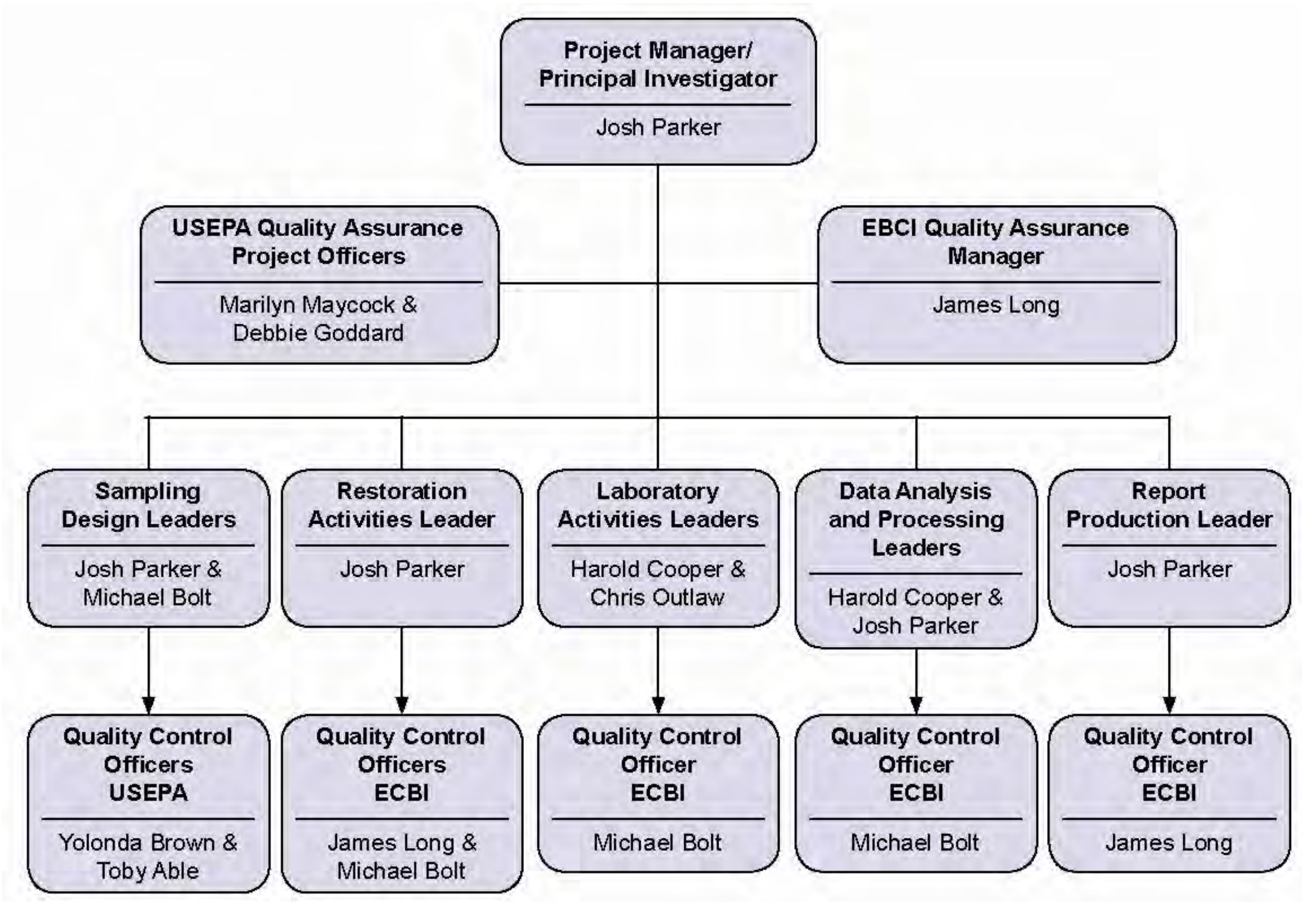

Figure 1. Task Organization

The principal users of data generated from this project will include Tribal environmental, natural resources, housing, and economic development staff, Bureau of Indian Affairs (BIA) Forestry and Realty Office staff, community leaders and members of the Birdtown community, the Tribal Natural Resources and Planning Boards and elected officials of the Tribe. Future resource management practices and decisions will ultimately be made by elected officials of the Tribe in conjunction with the Bureau of Indian Affairs and carried out by Tribal resource management and development programs. There is the possibility of volunteer monitoring to be carried out by community members with technical assistance from Tribal resource management programs.

Table 1. Task Team Members and Responsibilities* (from EPA, 1995)

Title	**Description of Duties/Responsibilities**
Project Manager/ Principal Investigator	Supervises the project personnel (scientists, technicians, and support staff) and ensures their efficient utilization by directing their efforts (directly or indirectly) on projects. Other specific responsibilities include: coordinate project assignments in establishing priorities and scheduling, ensure the completion of high-quality projects within established budgets and time schedules, provide guidance and technical advice to staff by evaluating performance, implementing corrective actions and providing professional development to staff, and prepare and/or review preparation of project deliverables, technical reviewers, and agencies to assure technical quality requirements meet contract or grant specifications. Other primary project-specific responsibilities include: having a sound understanding of project planning and design documents, being familiar with the biological and physical characteristics of project sites, identifying and complying with pertinent laws and regulations, and being able to facilitate and take the lead in communication between stakeholders and design and construction parties involved in projects.
Project Quality Assurance (QA) Officer	Reports to the Project Manager and is independent of the field, laboratory, data, and reporting staff. Major responsibilities include monitoring quality control (QC) activities to determine conformance, distributing quality related information, training personnel on QC requirements and procedures, reviewing QA/QC plans for completeness and noting inconsistencies, and signing-off on the QA plan and reports.
Sampling Design Leader	Completes the sampling design by coordinating resources from the statistician, senior contributing personnel and the needs of the user or contacts that are relative to the sample design.
Sampling Design QC	Performs QC evaluations to ensure that quality control is maintained throughout the sampling design process.
Restoration Activities Leader(s)	Ensures on-schedule completion o f assigned-fieldwork-and-adherence-to-Standard - Operating Procedure (SOP) and documentation requirements. Supervises all field activities, including implementation of the QA/QC program.
Restoration Activities QC Officer	Performs QC evaluations to ensure that quality control is maintained throughout the entire field sampling procedure.
Laboratory Manager/ Leader	Ensures on-schedule completion of assigned laboratory analyses and adherence to laboratory SOPS. Supervises all lab activities, including implementation of the QA/QC program.
Laboratory QC Officer	Performs QC evaluations to ensure that quality control is maintained throughout the sample analysis process in the laboratory.
Data Analysis and Processing Leader	Ensures on-schedule completion of assigned data processing work and complete documentation. Supervises all data processing activities, including implementation of the QA/QC program.
Data QC Officer	Performs QC evaluations to ensure that quality control is maintained throughout the data analysis process.
Report Production Leader	Ensures on-schedule completion of assigned writing, editing and data interpretation work. Directs all reporting activities, including in-house and outside review, editing, printing, copying, and distributing or journal submission.
Reporting QC Officer	Performs QC evaluations to ensure that quality control is maintained throughout the entire reporting and document production process.

Note: * a sole staff member is NOT required for each of these positions; an individual may be called upon to perform one, two, or several of these sets of responsibilities

A5. PROBLEM DEFINITION AND BACKGROUND

The Tribal Office of Environment and Natural Resources (OENR) primary objective in this project is to develop a watershed-level planning document by which the Birdtown community, EBCI Office of Environmental and Natural Resources and other partners can initiate future natural resource management strategies and restoration activities. This watershed plan will be used to guide monitoring strategies, stream restoration efforts, BMP implementation and other nonpoint pollutant source related activities occurring in the portion of the Oconaluftee River that flows through the Qualla Boundary, downstream of Oconaluftee Island Park. This document, along with water quality data and other watershed level information will ultimately be used to facilitate watershed restoration and protection efforts through the involvement of stakeholders identified in this document.

The Oconaluftee River drains lands within the Great Smoky Mountain National Park and the north-northwestern portion of the Qualla Boundary (Figure 2). The portion of the Oconaluftee watershed located on Tribal land is accessible along US 19 throughout the Quall Boundary. The Lower Oconaluftee watershed, a major tributary to the Tuckaseegee River, drains approximately 8.6 square miles (sq mi.) within it's boundary and receives flow from upstream watersheds that total approximately 177.75 square miles. Almost all of the Lower Oconaluftee watershed is within U.S. Geological Survey Hydrologic Unit Code (HUC) 06010203030040. A small portion is within 06010203030030. Elevations in the watershed range from 1,879 feet above mean sea level at the Reservation's boundary at the Oconaluftee River to 4,066 feet above mean sea level at Mount Noble, at the Reservation's boundary with Great Smoky Mountains National Park. Slope ranges from 0 to 55 degrees with a mean slope of 20 degrees (Std dev 9.92). Goose and Adams creeks are the Oconaluftee River's main tributaries inside the watershed.

In the early `90s, the Tribe began routinely monitoring water quality using USEPA approved physical and chemical parameters. Other entities including the USEPA, USF WS, and North Carolina Wildlife Resources Commission (NCWRC), have assisted with biological surveys. Data collection and analysis methods utilized by the Tribe in the development of its environmental programs were developed by the USEPA, other federal programs, or the state of North Carolina's Division of Water Quality (NCDWQ), and have been modified to meet the needs of the Tribe. The Tribe's decision to develop sample collection and data interpretation protocols similar to the NCDWQ's facilitates data comparison between State and Tribal monitoring programs. The OENR is also equipped to compare the present and future conditions of the streams to historical conditions by reviewing data collected by the USEPA and other agencies who have worked on Tribal lands.

Since the late `90s, Tribal environmental staff have continued developing the capacity within the OENR Water Quality Section to enhance both its water monitoring efforts as well as its ability to carry out watershed restoration activities. Staff from the United States Environmental Protection Agency (USEPA), United States Fish and Wildlife Service, Natural Resources Conservation Service (NRCS), North Carolina Department of Environment and Natural Resources (NCDENR), and the Tennessee Valley Authority (TVA) have provided technical assistance to Tribal staff in watershed restoration efforts across the Qualla Boundary and outlying portions of Tribal lands in Graham and Cherokee County. These efforts have primarily involved assisting the OENR to develop a Unified Watershed Assessment (UWA) process and installing stream restoration and enhancement measures and various best management practices (BMPs).

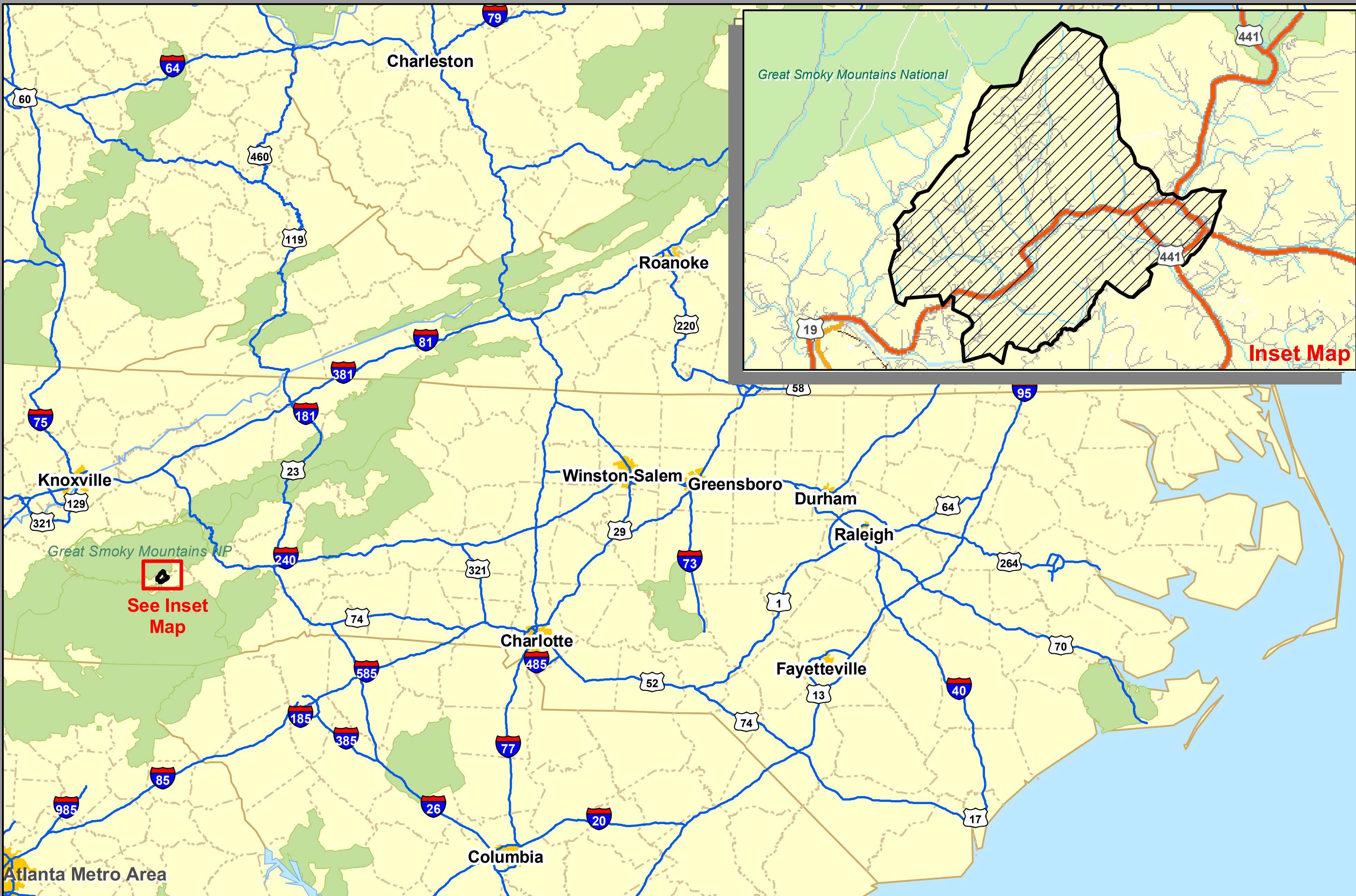

Figure 1.

Lower Oconaluftee River Watershed Location Map

Based on land use coverage, the Lower Oconaluftee watershed is primarily composed of deciduous forest, while the second most common land use type has been identified as mixed hardwood/conifer forest. Currently the Lower Oconaluftee River watershed is experiencing a rapid increase in residential development. Road access into house sites and houses themselves are often located on very steep slopes. OENR staff have worked with Tribal housing programs to improve the site review process and use of better erosion control practices for house sites located on Tribal lands. Periodic timber harvesting and rock gathering activities also occur within the watershed. In cooperation with the BIA Forestry Department, the OENR has alerted members to the negative impacts on the Lower Oconaluftee watershed that result from insufficient use of best management practices (BMPs) during harvesting activities. Both agencies are working with loggers to implement better practices. Historically, logging sites and access roads have been a major source of sediment to streams within the Lower Oconaluftee watershed.

The Birdtown community has expressed a strong interest in watershed restoration activities and ways to better protect the Tribe's natural resources. The OENR feels it is an opportune time to develop a watershed plan, particularly in light of what is perceived by OENR staff to be a continual upward trend in residential and commercial development in the foreseeable future. Although housing is needed, it remains imperative that sites are thoroughly evaluated and the area of land disturbance is minimized and/or restored given the numerous streams and steep terrain common to much of the Lower Oconaluftee drainage. A watershed plan will aid Tribal officials and the community in identifying major sources of pollutants that threaten or have the potential to threaten waters within the Lower Oconaluftee watershed. The plan can also be used to identify sections of stream corridor and other sites where BMPs, enhancement or restoration work are warranted.

In the long term, the OENR intends to establish watershed plans for each of the watersheds (or primary subwatersheds) located on Tribal lands. These plans will be revised on a 5-year rotational cycle. Beyond the comprehensive revision process that occurs on a 5-year cycle, this plan will-be revisited regularly and- - as major milestones are met to ensure restoration and management activities are made from a watershed-based approach.

The primary goals that will drive the development of these plans will be to maintain waters within the drainage to meet their designated uses and ecological value by identifying and resolving water quality problems. The OENR is charged with protecting Tribal water resources and in doing so, must work with other Tribal officials to manage impacts from economic growth and services provided to community members. In addition, the OENR wishes to utilize this plan to work with community members and other stakeholders to continue improving public awareness of watershed protection measures and better evaluate the effects of various pollutant sources on Tribal waters.

In recent years, the OENR has assisted the local groups and an area watershed organization, the Watershed Association for the Tuckaseegee River (WATR), obtain small planning grants from the Cherokee Preservation Foundation (CPFdn) to promote interest in and the eventual development of community based watershed groups to take a more active role in assisting the OENR protect Tribal watersheds. Both entities were successful in obtaining grant funds to build community interest in watershed planning and community based coalition building.

While OENR staff and community members are knowledgeable of what the ecological health is of the Lower Oconaluftee watershed, such information is not currently stored in any organized document. Development of a watershed plan enables the OENR and community members to capture existing conditions of the watershed, evaluate disturbances that impact functions of the stream corridor, and identify opportunities for restoration and protection activities. The plan will also establish a framework for addressing issues identified in such a way as to minimize disjointed decision making. Management decisions and projects implemented will be based on sound data and a prioritized set of goals agreed upon by community members, OENR staff and other stakeholders. Additionally, the watershed plan will address monitoring strategies that both Tribal officials and community members can participate in, aiding the OENR in its water quality standards development, designated use classifications and assessment reporting.

A6. PROJECT/TASK DESCRIPTION

To identify problems and opportunities for watershed protection activities, the OENR will complete the following exercise recommended by the USEPA when developing watershed plans:

1. Collect and review existing watershed data. Nonpoint source pollutants will be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.
2. Create a general set of goals to guide the watershed planning process; seek community input.
3. Conduct field characterization of streams and determine of sources of degradation.
4. Refine goals as needed and develop project specific goals and opportunities by a review of data and field reconnaissance information.
5. Compare existing conditions to desired conditions or that of a reference site and analyze the causes of [1]altered or impaired conditions. General conditions at sites recommended for improvement or protection will be summarized and will include management measures that can be implemented to meet goals identified in the watershed plan. Critical areas will also be denoted on a location map.
6. Develop watershed management strategies. Management strategies will be drafted and will identify stakeholders needed to make the watershed plan a success.
7. Identify educational opportunities. The OENR will produce a strategy aimed at ensuring community members understand the watershed planning process, are given opportunities to provide input for selecting and implementing management measures, and are kept up to date on project implementation and associated monitoring taking place.
8. Develop an implementation schedule for management activities identified in the plan.
9. Define progress measurement criteria. A description of interim, measurable milestones will be developed to track tasks and measures being implemented.
10. Develop a monitoring plan. Monitoring efforts will be flexible with parameters, monitoring frequency and study design components adjusted to meet the type of management measure being implemented and resources available. It will be revised as necessary to remain appropriate for measures being implemented.
11. Identify prospects for technical and financial assistance. This section of the watershed plan development will consist of developing a "Resources" section that includes information on such issues as technical and financial sources that may be called upon for assistance, costs associated with strategies.

As the EBCI Watershed Restoration Program works through this process, a statement will be drafted that characterizes the scope of opportunities for watershed restoration and protection that is important to resource managers and community members. This statement will become the focal point for management objectives developed and on-the-ground activities implemented. The opportunity statement will also aid staff in tailoring a monitoring approach to gauge the success or failure of management actions taken.

By this common vision, more specific goals and objectives will be developed. Once goals have been established, objectives will be developed that support the general approach being taken to lead future watershed restoration efforts. A number of objectives created will be expressed in terms of measurable conditions to enable successful monitoring of the project.

As the OENR, community members, and other stakeholders reach an understanding of the scale of watershed restoration and protection activities for this phase of watershed plan development, issues and constraints will be identified. Recognizing potential constraints and/or issues early on will enable OENR staff to factor in these limitations when finalizing specific goals and objectives. Discussing constraints and limitations with community members and other stakeholders at this time will also prevent people from having unrealistic expectations and may even lead to ideas to address issues and constraints identified. These discussions on limitations and other issues will be held with an interdisciplinary team of stakeholders. This group will be comprised of technical and nontechnical experts and representatives of the community.

Incorporating technically feasible alternatives and other contingency measures into the watershed plan will greatly aid the OENR in problem solving during the implementation process and is an integral component of the plan to ensure management goals and objectives are carried out in an efficient and expeditious manner. Acceptable alternatives for watershed projects can range from making minor modifications to totally altering existing conditions of the physical setting. As part of the site conceptualization and prioritization process, an overall strategy will be developed and general solutions identified. After a identifying a solution, alternatives will be chosen based on information produced during the evaluation process. As alternatives are considered, the following factors will be used to guide the selection process:

1. Implications of past management practices in the stream corridor (what effects have been generated)?
2. Determining the realistic opportunity for eliminating, modifying, mitigating, or managing a given activity or condition impacting the watershed?
3. What the effect would be on the watershed if the activity or condition were addressed?

If the impairment can realistically be eliminated, feasible objectives will be developed for this watershed management activity. If-the impairment cannot be realistically elhninuted—the OENRwill-workwith stakeholders to determine what options exist to better manage the impairment source and/or its effects. An instance where this situation might arise is with the management of exposed Anakeesta rock (commonly sulfidic) in the vicinity of a waterbody. Other factors that will be considered in the alternatives analysis exercise include: managing causes of impairment versus treating symptoms, scale of design approach (landscape/watershed based design versus stream corridor reach), and other relevant spatial and temporal considerations. The procedure for developing, evaluating, and determining management alternatives will be based on the results of feasibility studies, cost-benefit analyses, and the National Environmental Policy Act (NEPA) process.

When project team leaders attend community meetings to gather input, information on the watershed plan elements listed in Table 2 will be discussed:

Table 2. Watershed Plan elements to be reviewed at community input meetings.

Impairment sources identified by category;
Summary of existing stream corridor conditions and scale of watershed projects to be addressed . Identification of various causes of impairment and the results and effectiveness of prior management activities on present site conditions;
List of proposed project sites identified for plan of action and summary of factors having a bearing on prioritization of projects and management measures proposed;
Specific objectives to be ranked with proposed priority order;
Preliminary design alternatives and feasibility analyses;
(General discussion) Cost-effectiveness analysis for each treatment or alternative;
Assessment of project risks and any potential adverse impacts from alternatives selected;
Permitting needs including both environmental and cultural/archaeological;
Watershed Monitoring Plan linked to stream corridor conditions and strategy for project areas;
An anticipated maintenance needs and schedule;
An alternatives schedule and budget strategy;
Provisions for making adjustments per adaptive management.

Tribal staff, community leaders, community members and other stakeholders will be responsible for assisting the Watershed Restoration and Protection Program in the implementation of the watershed management plan. To increase the chances of successful implementation however, overall coordination of the plan will fall to the Tribal Watershed Coordinator (or Project Manager).

Watershed Data and Sample Collection

In addition to the review of various management documents, resource inventories and other watershed related plans, the OENR will use physical, chemical, biological and other stream corridor data to assess watershed conditions. The range of parameters and monitoring frequency of water quality data collected will vary according to site conditions, scale and type of impairment observed. Sample collection will be performed in accordance with the Tribe's water quality monitoring program quality assurance plan documents and standard operating procedures. These documents are listed below:

- EBCI Water Quality Monitoring Program (Clean Water Act Section 106) Quality Assurance Project Plan. *Revisions under review by the USEPA*
- EBCI Water Quality Monitoring Program (Clean Water Act Section 106 • uality Management Plan. *Revisions under review by the USEPA*
- EBCI Water Quality Monitoring Program (Clean Water Act Section 106) Standard Operating Procedures.
- EBCI Index of Biotic Integrity: Protocols and Indices for Biological Assessment of Benthic Macroinvertebrate Assemblages in Wadeable Streams and Rivers.

Quality assurance measures for geomorphic monitoring parameters such as permanent cross-sections and pebble counts can be found in the quality assurance project plan for the EBCI Adams Creek Enhancement Project (2005).

Physical and Chemical Water Quality Sampling

Physical and chemical water quality parameters monitored will be selected from the nine parameters identified in the USEPA guidance document "Final Guidance on Awards of Grants to Indian Tribes under Section 106 of the Clean Water Act: For Fiscal Years 2007 and Beyond" (USEPA 2006). Parameters such as dissolved oxygen, temperature, pH, and turbidity are expected to be utilized in conjunction with other monitoring efforts. Samples collected to assess nutrient enrichment are not expected to be performed as frequently and will be taken at areas of the watershed for which nutrient enrichment is suspected. Conversely, samples will also be taken in nutrient-poor areas for baseline data which may be used to further evaluate acceptable thresholds of nutrient enrichment as it relates to the ecological balance of the Lower Oconaluftee drainage, including its tributaries.

Benthic Macroinvertebrate Sample Collection

Benthic macroinvertebrate sampling procedures will follow one of two methods: 1) the EBCI EPT collection protocols (a modified NCDWQ EPT method), or 2) the NCDWQ Qual 4 method. As described in the NCDWQ's *Standard Operating Procedures for Benthic Macroinvertebrates* (NCDENR, 2006), the EPT and Qual 4 methods for sample collection consist of one kick net sample, one sweep net sample, one leaf pack sample and a sample taken from "visuals." The EPT method involves the collection and keying of insects belonging specifically to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT method has proven to be an effective way to track water quality changes as these groups are generally the least tolerant to water pollution. Both methods are alike with the exception of keying non-EPT taxa as called for under the Qual 4 method. For areas in which little or no benthic data exists, the OENR will also collect and key non-EPT taxa. Sample collection will take place in accordance with the Tribal or NCDENR's quality assurance protocols. Data reports generated will address total taxa richness and abundance values, but will also specifically address EPT metrics and other indices as identified in the Tribal IBI Protocol (2005) § 1.01 "Sampling Process Design" as well.

Habitat Assessment

Habitat assessment protocols used by the NCDWQ will be completed at each benthic macroinvertebrate sample site as required under the EBCI 1BI Protocols. For this study, the form for Mountain/Piedmont streams will be used. A maximum possible score of 100 can be achieved with this method. Parameters to be evaluated include the amount of reach favorable for colonization or cover, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and riparian vegetative zone width. Measurements for stream temperature, dissolved oxygen, conductivity, and pH will also be recorded during habitat assessments.

Photo Log/GPS Coordinates

In addition to assigning habitat rating scores for each sample site, reference photos will be taken with a digital camera to record current site conditions and to aid the Tribe in tracking landscape changes at the sample points. The stream will be photographed longitudinally beginning at the upstream end of the site and moving downstream to the end of the site. Reference photo locations will be marked and described for future reference. Points will be close enough together to get an overall view of the reach. In order to locate project sample points for future in-house monitoring efforts, site coordinates will be taken with a sub-meter GPS unit and marked with rebar and flagging.

Stream Geomorphology and Vegetation Survival Surveys

Sampling methods for pebble counts, embeddedness, cross-sections, longitudinal profiles, turbidity, total suspended solids (via single stage sediment samplers), visual inspection, and vegetation surveys will be utilized to characterize stream channel and riparian conditions for projects carried out under the watershed plan. To determine the dominant channel substrate and what particle sizes the channel is transporting and depositing in various sections of Lower Oconaluftee, pebble counts will be performed. Embeddedness measurements may also be used to monitor changes in channel hydraulics and to assess impacts to spawning areas and aquatic habitat functions of streams sampled. In addition, cross-sections and longitudinal profile surveys will be conducted to record existing channel features and to monitor changes in channel pattern, dimension and profile over time, especially where projects have been implemented.

Project Schedule

The key tasks and schedule listed in Table 3 will be used by the OENR Watershed Coordinator to guide the watershed planning process. The scheduling of tasks was developed with the assumption that the Tribe's watershed plans will be revised on a 5-year rotational basis.

Table 3. Project Schedule

Project Schedule	
Primary Tasks	**Frequency/Schedule**
* Receive authorization from Tribal leaders to seek resources to develop a watershed plan; Submit funding request (USEPA)	Once per 3 to 5 Years (Based on Tribe's watershed rotation)
A. Draft QAPP for EBC review and submittal to USEPA -Make revisions as necessary and get QAPP approval	-Once -Minor revisions annually; major updates 3 to 5 years
B. Data review and analysis of resource conditions -Analyze water quality data (physical chemical and biological) -Characterize and assess geomorphic and general biological (terrestrial) conditions (field reconnaissance) -Data and literature research -GIS mapping	-Annually
C. Scoping/Brainstorming sessions for drafting watershed plan -Coordinate interdisciplinary stakeholder team -Non-point source identification and opportunities discussion	-6 to 8 months; Years 4-5
D. Formulate opportunity statement	-Year 4 of plan review
E. Identify goals and objectives	- 6 to 8 months; Years 4-5
F. Attendance at community club meetings for: -Kick-off of initiative; gathering of input for goals and objectives -Providing periodic updates while drafting watershed plan -Conducting educational events in support of watershed plan -Gathering input for plan updates	- 3 to 6 months; Year 4 - Quarterly; Years 4-5 - Bi-monthly; Ongoing - Ongoing
G. Refine goals and objectives; draft management strategies	-6 to' 12 months; Years 4-5
H. Continue analysis of available data; conduct field surveys in support of prioritized projects	Data analysis ongoing; Years 1-3
I. Develop schedule for implementing management measures; identify major interim milestones *Any contingency measures, schedule and milestones should be developed at this _time_also -	1-2 months; Year 5; revise as needed
J. Develop monitoring strategies for tracking progress of watershed plan implementation and watershed conditions (via use of parameters highlighted in QAPP) as well as (interim) adaptive management measures	2-3 months; Year 5 (revisit in Year 3 as needed)
K. Draft list of potential educational tools and activities to conduct with community members and implement	Ongoing
L. Commence with monitoring and on-the-ground restoration and protection activities	Monitoring ongoing; On-the ground projects should commence Years 1-3
M. Complete draft watershed management plan. Present to community members.	18-24 months; Year 5
N. Finalize changes to watershed plan	6-9 months; Year 5
O. Adoption by the Tribe (brought before Timber and Natural Resources Committee for preliminary approval and final approval by the Tribal Council and Executive Office)	2-3 months; Year 5
P. Submit applications for funding based on the watershed plan	As approved by Tribal Leadership and after plan officially approved
Q. Review watershed plan and make necessary updates	Annually
R. Revision to watershed plan	Every 5 Years

A7. QUALITY OBJECTIVES AND CRITERIA

Data quality objectives (DQOs) encompass all aspects of data collection, analysis, validation, and evaluation. Data quality may be assessed by verifying that correct entries and calculations have been made, or by using quantitative performance criteria. Quantitative performance criteria include measures of precision, accuracy, and completeness, while more qualitative evaluations include representativeness and comparability.

Table 4 identifies key questions that were considered by OENR staff and other officials prior to the decision to draft a watershed management plan. Alternative actions to developing a watershed plan were also identified.

The OENR's preferred action is to develop a watershed management plan to guide future restoration and protection efforts. If development of a watershed management plan is not feasible at this time, the next preferred option would be to continue conducting periodic windshield surveys and identifying pollutant sources via fieldwork while conducting water quality monitoring to characterize watershed health. If the Tribe were to develop a watershed plan with little or no community input, there would be less buy-in from the community and key opportunities for watershed protection efforts could be lost. Likewise, if the Tribe targeted projects and managements strategies based solely off of community member input and no plan was developed, the OENR would lack a coordinated approach in carrying out the Tribal Watershed Restoration and Protection Program. The Program would likely have difficulty balancing site-specific goals with goals that are identified for the Lower Oconaluftee watershed as a whole and resources could be wasted by not having a more efficient approach to conducting watershed projects.

As summarized in Section A5, once a common vision and supporting goals and objectives have been established, the watershed plan will be drafted. It will include, but not be limited to:

- A list of prioritized management objectives and projects
- An approach for tracking progress of watershed plan implementation
- A monitoring strategy for quantifying watershed health
- A contingency plan for changes in scheduling, projects or other management measures
- Educational tools and activities that can be implemented to engage community members

Table 4. Principle Study Questions for the Lower Oconaluftee Watershed Plan

Principal Study Questions	Alternative Actions
1. What are the known or perceived impairments and problems in the watershed?	Conduct periodic windshield surveys and identification of potential pollutant sources via fieldwork and continue water quality monitoring to characterize watershed health.
2. f f there are pollutants impairing water quality, what are they and what are the sources?	Community club or OENR to draft a management plan with little/no input from each other; drafting of a management plan without sufficient stakeholder involvement.
3. What information is already available, and what is the basis for development of a watershed plan?	Identification of projects via community club meeting attendance (project-by-project basis).
4. To what degree have the primary pollutants or stressors causing impairment been quantified?	Develop a watershed management plan to guide future restoration and protection efforts.
5. What is the history of management efforts or projects aimed at controlling primary pollutants or stressors?	No action.
6. What are potential threats to the watershed in the foreseeable future and what can be done to avoid/lessen these threats?	
7. What are enhancement, restoration and improvement opportunities throughout the watershed that would improve water quality?	
8. How will the watersheds natural resources (particularly high quality and and sensitive areas) be managed?	
9. How will ongoing concerns or new goals identified by the stakeholders be addressed if a plan were developed?	*Alternative actions proposed are not meant to correspond to principal questions listed numerically

A8. SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

The OENR requires that the Watershed Coordinator and other team members have training in developing natural resource management documents and be experienced in facilitating meetings involved in developing a watershed plan. In addition, the Watershed Coordinator must be able to work with community members, effectively communicating the OENR's procedure for developing a watershed plan and initiating subsequent management actions. Other team members who will have leading roles in the production of educational material and outreach events, have prior experience through other initiatives the OENR has taken. New personnel or personnel with less experience will receive closer supervision and will be placed with more experienced staff.

The majority of water quality sampling procedures will be performed in-house by OENR staff. OENR Tribal Environmental Laboratory staff have attended numerous water quality and biological training sessions; all possess laboratory analyst credentials certified by the State of North Carolina. Monitoring and data analyses performed by other professionals will be conducted in accordance with the Tribe's quality assurance documentation where applicable. USEPA Quality Assurance officials will be forwarded an amended quality assurance project plan and further quality assurance documentation should a monitoring method not currently identified under this plan be utilized.

A9. DOCUMENTATION AND RECORDS

The EBCI Watershed Coordinator will use the "Restoration Checklist," developed by the National Research Council (1992), to identify critical issues and activities that are a part of the watershed plan development process. It will also be used to keep track of those activities to monitor progress throughout the planning and implementation process. The checklist is presented in Appendix H.

Updates to the QAPP and watershed management plan will be considered annually by the Project Manager. -More-complex-revisions-will-be-made-to-the-watershed-plan-on a 5-year-basis. The Project Manager will ensure that project personnel have access to the most current approved version of the QAPP and watershed plan. The revision number will be updated in the control footer shown on each page. Updates will be distributed electronically by the Project Manager to the individuals on the distribution list as well as the project personnel. Highlights of the document changes and a recommendation to dispose of the older QAPP will be included in these transmittals.

Physical and chemical water quality data will be uploaded by the Tribe into the EPA WQS data warehouse. Until such time that the EBCI begins to upload biological data into the EPA WQS data warehouse, a generic excel spreadsheet will be maintained for all project data locally. A reference collection of benthic macroinvertebrates identified in tribal waters will be maintained in the Tribe's environmental laboratory. Field logs are kept as part of the Tribe's Water Quality QAPP. Geomorphic data and vegetative mortality data will also be stored in Microsoft Excel spreadsheets, Autocad and Adobe pdf. files. Excel spreadsheets allow users to print laboratory bench sheets for each sampling event. Other data collected such as habitat assessments, bank stress ratios, etc. will also be maintained in the Tribe's project database and filing system. Backup electronic files will be maintained on CDs and on separate computers from the primary database. Additionally, a hard copy file system will be kept by the Project Manager. Hard copies of individual sampling station results will be kept for at least 10 years.

DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN

Watershed monitoring methods are necessary for the watershed plan to be a functional approach for guiding future management efforts. While some monitoring will involve tracking deadlines and completion dates for tasks and projects, the key purpose behind the monitoring component is to assess watershed health and identify activities or sites that may be causing or will cause a decline in watershed health. Various monitoring methods will be employed to aid the OENR, community members and other stakeholders monitor the effects of management measures on the watershed.

Quantifiable measurements will be calculated using vegetative and geomorphic data and parameters listed under the Tribe's comprehensive water quality monitoring strategy. The Tribe monitors water quality based on the nine parameters currently listed in the USEPA Clean Water Act Section 106 Water Quality Monitoring Strategy guidance document. Parameters that will be utilized for monitoring in the Lower Oconaluftee watershed are listed in Table 5.

Table 5. Monitoring parameters to be Used in the Lower Oconaluftee Watershed.

Parameter	**Analytical Method**	**Reporting Limit**	**Accuracy % Recovery**	**Precision Relative % Difference**
Turbidity	Std Method 2130B	0.001 NTU	± 2%=0.01	0-10
pH	Std Method 4500 H B	0.01 unit	Decade slope 45-65mV @25°C	0-10
Dissolved Oxygen	Std Method 4500 O G	0.01 mg/L	± 0.3% mg/L	0-10
Temperature	Std Method 255DB	0.0 LC'		0-10
Orthophosphate*	EPA 365.2	TBD	TBD	TBD
E coli	Not yet determined	TBD	TBD	TBD
Total nitrogen (TN)	LaMotte Test Kit for TN	TBD	TBD	TBD
Benthic Macroinvertebrates**	EPT or Qua14	Family level	n/a	n/a
Vegetation Survival	Vegetative Plot	Per stem	n/a	n/a
Pebble Counts	Bunte & Abt (2001)	0.1 mm	n/a	n/a
Embeddedness	Burns Method	0.1 mm	n/a	n!a
Survey Cross-sections	Newberry/Rosgen	0.1 foot	n/a	n/a
Survey Longitudinal Profiles***	Newberry/Rosgen	0.1 foot	n/a	n/a
Survey Bank Pins	n/a	0.1 foot	n/a	n/a
Visual Inspection***	NCDWQ	n/a	n/a	n/a

* In process of certification.
** Completeness of a data set for a given monitoring site and project needs will determine whether the EBCI EPT Method or the NCDWQ Qua14 Method will be utilized. *** Qualitative Measurement

Monitoring stations selected for the watershed plan will be identified by a site number and a location description. Coordinate and elevation data for these sites will also be collected by Global Positioning System (GPS) units. Stations used to measure the general condition of the watershed will be sampled a minimum of two times every five years. Stations will also be set up to monitor site-specific management measures. The monitoring frequency for these stations is expected to vary based on site. The location, frequency and parameters monitored for both types of sample stations will be determined during the development of the watershed plan. The monitoring strategy developed will then be submitted to the appropriate Tribal and USEPA personnel once the plan and monitoring strategy have been approved by the Tribe and the USEPA Project Officer(s). Data collected will ultimately be uploaded into the Tribe's Geographic Information System (GIS), and environmental information database. Data will also be forwarded to USEPA data repositories per agreements between the Tribe and USEPA . Sample sites and sampling frequency will be selected based on factors including areas where data gaps exist, priority and other project areas, and proximity to existing sample stations.

PHYSICAL AND CHEMICAL WATER CHEMISTRY DATA SAMPLING DESIGN

The primary measurements to be assessed using performance criteria are the sampling and analyses of physical and chemical water quality features. Biological data is also another primary measurement that will be used and is discussed below. Physical and chemical water quality data will be measured in the field and in a laboratory certified by the EPA or the state of North Carolina. Results from the water quality samples taken will be compared to standards and action levels outlined in the Tribe's Water Quality Code (EBCI 2006). Reporting limits for these indicators should be at or below these critical values. Performance criteria for physical and chemical water quality samples taken will adhere to measures outlined in the EBCI Clean Water Act §106 Water Monitoring Program Quality Assurance Project Plan and is described below.

The determination of choosing which of the Tribe's existing water quality monitoring sites will be used in this plan is an example of a partly biased sampling design decision. The stations to be used for this watershed restoration and protection projeet w-ill-be-us-ed-fora minimum ofthree-to-five-years-during-each watershed plan cycle. In addition, data generated from these sites will be coupled with monitoring data generated from sites that are identified using widely accepted stream corridor assessment practices such as the Bank Erodability Hazard Index. These types of bias have been deemed acceptable for the purposes of the project. Other biases the Tribe will consider when observing data trends include time of sample collection which can vary by month, and unusual monitoring conditions (i.e. storm events, moderate to severe drought conditions, etc.). To minimize bias associated with sample collection, water quality monitoring staff will consistently apply sampling and analytical methods in adherence with standard operating procedures (SOPS), adopted by the Tribe.

<u>Data Representativeness</u>

Data representativeness is the degree to which data accurately and precisely represent a characteristic of a population or community, natural variability at a sampling point, or an environmental condition (USEPA, 1995). Representativeness of a sample depends largely on randomized sampling of the target assemblage (Green 1979; Smith et al. 1988; Freedman et al. 1991) and therefore is highly dependent on the sampling program design. Representativeness of samples will be ensured by developing a monitoring strategy that incorporates sites that are based on such factors as the level of impairment present, representativeness of prevailing stream corridor conditions for that watershed, and the site's ability to be used as a reference site. Producing representative data will be one of the primary considerations when developing the monitoring strategy for the watershed project(s) to be implemented. Variations that occur in data results over time should reflect what is occurring in the watershed. The monitoring approach for watershed plan implementation is multi-tiered in approach. Project-specific monitoring will occur on smaller tributaries where nonpoint source pollutant impacts are being assessed, while watershed monitoring already occurring on larger waterbodies will continue. This will aid in achieving representativeness for watershed based monitoring as sample sites established on higher order streams are more likely to be sampled on a routine basis over a longer period of time. Larger waterbodies also lend themselves better for factoring in such issues as "mixing zones," which are defined in the Tribe's water quality standards and certain SOPS. Representativeness of the samples collected for this project will be assessed during preliminary monitoring efforts and will be adjusted as needed. Historical data sets developed under approved quality assurance plans will be reviewed to aid in determining relative representativeness.

Data Comparability

Comparability measures the confidence with which data sets can be compared. It is often described in qualitative terms, but must be considered during the planning of sampling strategies. Comparability factors include but are not limited to index period (season during which sampling is done), topography, geological and hydrogeologic characteristics, analytical methodology used, quality control, and data reporting (USEPA, 1995). The use of standardized sampling techniques and analytical methods enhances the comparability of data generated from different sources. All data collected under this plan will follow well established and commonly accepted methods that will permit results of this work to be compared with similar products developed by local, state and federal agencies. The Tribe's water quality monitoring program utilizes standardized testing methods that are USEPA-approved. Site selections will favor locations where previous water quality monitoring has taken place; efforts will be made to duplicate the effort of past studies where possible.

Data Completeness

Over the course of time, it is expected that some site visits or samples will be missed due to unavoidable problems such as inclement weather, temporary station inaccessibility, equipment malfunctions, operator error and staffing issues such absence on monitoring days or staff turnover where the position remains vacant for a time. Therefore, the target completeness goal for this project is 80% or better for sample completion during the course of ongoing watershed monitoring efforts. The minimum number of observations to be made to meet this goal will be determined once project sites have been identified and a monitoring strategy is developed: Percent compldeness wilrbe calculated using the following formula:

%Completeness (per parameter) _ (# of valid results / # of samples taken) x 100

Precision and Accuracy

Precision measures the mutual agreement among individual measurements or enumerated values of the same property of a sample, usually under similar conditions. Achieving precision assures consistency of sampling and sample processing, as well as the repeatability of measurements (Platts et al., 1983). Field analytical precision will be evaluated by the relative percent differences (RPD) between field duplicate samples and/or replicate readings using the following formula:

$$RPD = \frac{(R1 - R2) \times 100}{(R1 + R2)/2}$$

Where: R1 = the larger of the two replicate values
R2 = the smaller of the two replicate values

Field accuracy will be routinely checked according to the instrument and analytical method accuracy requirements of each parameter.

Laboratory precision and accuracy will be performed in accordance with the Tribal laboratory QA/QC procedures.

BENTHIC MACROINVERTEBRATE DATA SAMPLING DESIGN

Based on the limited availability of Tribal staff to perform biological assessments, it was determined that the Tribal EPT method would be the primary method used. The NCDWQ EPT method served as a model by which the Tribal EPT Method was developed. The EPT method is an abbreviated version of NCDWQ's standard semi-quantitative. method. The collection and analysis time has been decreased in two ways for the EPT method as compared to NCDWQ's Standard Method. First, the number of collections is decreased from 10 samples per site (standard method) to only 4 samples per site (EPT method).

Secondly, the EPT method focuses on collecting and keying a subset of the benthic community, the EPT taxa. The EPT taxa include specimens belonging to the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These groups are generally the least tolerant to water pollution and therefore are very useful indicators of water quality degradation/impairment.

The Tribal EPT collection method involves collecting EPT organisms from 4 different sample measurements: kick net, 1 sweep net, 1 leaf pack, and "visuals". Field notes or collections of abundant non-EPT organisms will be conducted to further support water quality determination. This is especially useful when comparing stream segments upstream and downstream of known discharges, nonpoint source pollutants or other stressors. The EPT method adopted by the EBCI is described in the Tribe's Index of Biotic Integrity Protocols (EBCI 2005). The samples are sorted, picked, and preserved in the field. In the laboratory, samples will be sorted and identified to the family taxonomic level by OENR. Samples are then sent to a qualified taxonomist for species (or lowest practicable), taxonomic level identification. The contracted taxonomist will give feedback on accuracy of family level identification to OENR as part of QA/QC process.

Until such time that a reference collection is established for waters monitored, all taxa collected will be identified to the lowest practical taxonomic level as funding permits. For sampling conducted in support of the Lower Oconaluftee watershed plan, physical habitat information will also be collected using the NCDWQ Habitat Assessment W i t . Preliminary bioclassifications will-l-e determ#rred-based o n the number of-EPT taxa collected at the site pending an adequate data set of 3 or more. Bioclassifications are ratings of diversity in a stream's benthic macroinvertebrate assemblage. Higher taxa richness indicates greater diversity and is awarded a higher bioclassification. For the North Carolina Mountain Ecoregion, the EBCI's bioclassifications for streams with drainage areas greater than 3.5 square miles are as follows:

Table 6. EBCI- Bioclassification Criteria for EBCI Waters

Bioclassification	EPT taxa richness
Optimal	>45
Excellent	36-45
Good	28-35
Good-Fair	19 - 27
Fair	11 - 18
Poor	0 - 10

Taxa richness ranges used to assign bioclassifications for Tribal waters may be adjusted once more baseline data are collected. First and second order streams sampled will not be assigned a bioclassification as there is currently no method in place for the western North Carolina mountain region. Bioclassifrcations for Tribal waters will be finalized once an adequate dataset is achieved and, in some instances, when more guidance becomes available regarding the assignment of bioclassifications to low order streams. It is possible that bioclassification criteria for EPT biotic index (BI) values could be established in a small geographic region such as the EBCI area in the future. Very low BIEPT values would be especially useful in the identification of exceptional waters. In circumstances where waters have been classified as"exceptional" or of particular importance, the Tribe might decide to limit development as could be the case for the headwaters and upper reaches of Lower Oconaluftee located on Tribal land.

According to the Tribe's "Protocols and Indices for Biological Assessment of Benthic Macroinvertebrate Assemblages in Wadable Streams and Rivers," correction factors will be applied to taxa richness values for streams with a drainage area of less than 1.0 square mile by multiplying EPT taxa richness by 1.45. EPT taxa richness values for streams with drainage areas between 1.0 and 3.5 square miles will be multiplied 1.25. An EPT biotic index will also be calculated for samples collected in the Lower Oconaluftee watershed during this project. To determine the EPT biotic index, the abundance values for EPT taxa multiplied by the assigned tolerance values of each EPT organism is calculated. The sum of tolerance values multiplied by abundance values is then divided by the total abundance value.

EPT Biotic Index (BIEPT) = $\frac{\text{Sum (TV)th}_i)}{N}$

TV; = ith taxa's tolerance value
ni = ith taxa's abundance value (1, 3 or 10)
N = sum of all abundance values

Other metrics that the Tribe may use to help interpret the benthic macroinvertebrate assemblage include percent by feeding group, percent by family, or as ratios of one group to another. Cumulatively, these metrics will be used to provide insight on water quality and aquatic habitat. Bioclassifications will be referenced when evaluating use support ratings for waterbodies, and will be included in future Clean Water Act Section Tribal reporting that is submitted to the USEPA.

Performance criteria will be used to evaluate the sampling, sorting, and picking of benthic macroinvertebrates in the field as well as the sorting of EPT field samples by family in the laboratory. A professional taxonomist will be used to sort taxa to the species or lowest level practicable.

It is possible that certain EPT taxa will be missed by the sampling. This would lower the taxa richness level and potentially cause the site to be rated as impaired when in fact it is not impaired. Because sites will be re-sampled to monitor post project activity site conditions, some uncertainty about making this error is tolerable. Streams that appear to be impaired should be initially be sampled annually during the watershed plan cycle as funding permits. At a minimum, these sites will be sampled every other year during the 5-year plan cycle to evaluate impairment conditions. This will lower the risk of improperly listing streams as impaired while characterizing the watershed.

Reference sites are useful for measuring data quality and uncertainty because they have experienced minimal human disturbance and are typical for the study area. The number of reference sites selected will be determined after OENR officials determine which locations benthic macroinvertebrates will be collected from in the Lower Oconaluftee watershed. Sample sites will be used to assess the effects of human activities and to collect baseline information on the benthic macroinvertebrate communities that currently exist in these waters. Going forward, attempts will be made to sample within the same timeframe in subsequent monitoring years to more accurately reflect natural variability and minimize uncertainties (USEPA, 1995). If this is not possible, the OENR will utilize seasonality correction factors as described in pages 11-19 of the NCDWQ's *Standard Operating Procedures for Benthic*

Macroinvertebrates (NCDENR, 2006). Benthic macroinvertebrate samples will be collected during the time period of May 1st to September 30th. If samples are collected outside of this period, data will be corrected in accordance with the Tribe's Index of Biotic Integrity Protocols.

To measure precision, in addition to following sampling SOPS, replicate samples of benthic macroinvertebrates will be collected from adjacent reaches where different results are not expected because additional stressors are not evident. The number of EPT Families identified at each site will be compared to determine precision; consequently, the samples must be verified by the taxonomist before this calculation can be done. Additionally, precision will be measured by comparing the total habitat assessment scores from the adjacent reaches.

Precision of two replicate samples is calculated by relative percent difference (RPD) as follows:

$$RPD = \frac{(C1 - C2)}{[(C1 + C2)/2]} \times 100$$

where C1 is the larger of the two EPT Family(or Species) values and C2 is the smaller value. Habitat assessment scores may also be used in place of the EPT values.

Precision will be measured for 10 or more percent of the sample sites monitored each year. A minimum of two replicate samples are recommended if less than 20 stations are sampled. Measurement of precision will be performed at a reference site and at two non-reference sites, chosen at random. A sample. will be considered precise if it attains an RPD of 15 percent or less (USEPA, 1995).

Accuracy will be measured by comparing the identified number of EPT Families by Tribal laboratory staff with the number identified by the qualified taxonomist. Ninety percent accuracy will be required during these comparisons for a sample to be considered accurate.

Misidentifications will be noted by the taxonomist. The taxonomist data may still be used for the database, bioclassification and impairment decisions, but corrective steps will be taken to improve the Tribe's abilities to accurately identify benthic macroinvertebrates.

Generally, the sampling program has been designed to ensure representative sampling of the habitat or population. The sampling method prescribed in this plan addresses representativeness by using a variety of techniques (e.g., kick nets, sweep nets, visual selection, and leaf-pack collections) to obtain samples from multiple Mbitats. Also, the original-Rapid-Bioassessment Protocols (RBPs)-(Plafkin et¯a -1989)- were developed primarily for higher gradient streams with a predominance of riffles which are considered to be the most biologically-productive habitat in such streams. The streams on the EBCI Tribal lands fit this description.

The use of standardized sampling techniques and USEPA and/or NCDWQ-approved analytical methods increases the comparability of data generated from different sources. Reporting of data in units used by other organizations also improves comparability. For biological assessments, comparability of data would also need to be determined by strata such as ecoregion (or smaller geographic unit), index period, and sampling gear (USEPA, 1995). For example, samples collected within the same ecoregion using the same sampling equipment during different seasons (index periods) may not be directly comparable.

The Tribe's sampling methods are designed so that data collected are comparable with the same results produced by the NCDWQ when using the EPT method. Additionally, the taxa richness from one site within the project area should be comparable with another, provided unusual circumstances are not present.

Every effort will be made to avoid sample and/or data loss through accidents or inadvertence. Accidents during sample transport or lab activities that cause the loss of the original sample could result in irreparable loss of data. Collection of sufficient samples allows re-analysis in the event of an accident involving a sample. Assigning a set of continuous laboratory identification numbers to a batch of samples which have undergone chain-of-custody inspection makes it more difficult for the laboratory technician or taxonomist to overlook samples when preparing them for processing and identification. The laboratory serial numbers also make it easy to determine if some samples have not been analyzed as part of the data compilation stage.

A measure of percent completemness will be used to judge the quality of the macrobenthos sampling program. Percent completeness (% C) for all measurements (i.e., sample sites) can be defined as

$$\% C = (v/T) * 100$$

Where v = the number of measurements judged valid and T = the total number of measurements (Plafkin 1989). In order for macrobenthos sampling to meet the data quality objectives of the watershed plan, the percent completeness must be 90% or higher. An individual sample (EPT Family) will be judged valid if it is listed in the final database without being rejected or qualified as problematic and unfit for use. Reasons for rejecting data will be discussed later in this plan, but include irreconcilable entries, use of improper sampling techniques, and mislabeling that cannot be corrected with certainty.

GEOMORPHIC SURVEY AND RIPARIAN PLANTING DESIGN

Geomorphic quality will be assessed by evaluating such parameters as transport competency, channel stability, and the riparian buffer integrity to determine if the projects are performing as intended. Parameters to be assessed using performance criteria are grain-size distribution of bed materials in the project reach (via pebble counts), embeddedness, erosion rates, bank profiles, channel cross-sectional area, longitudinal profile, riparian vegetation survival, and visual inspection of streambanks and planted riparian areas.

As the majority of all geomorphic and vegetative data collected will be field data, analytical error and sample handling will not be significant issues for this project, particularly where field assessments used are primarily descriptive in nature. For a small percentage of projects, bulk sorting of channel sediments may be performed which will be processed away from the field. Analytical methods for this procedure are described in Section B4.

Total error will primarily depend upon measurement error and, to a greater extent, sampling error. Measurement error is the difference between the sample values and the true in situ values and will be controlled with staff training and practice. Sampling error occurs when there is natural spatial and temporal variability that sampling design does not capture because it occurs on a scale that is finer than the sampling. QA activities and procedures documented in this plan are intended to help reduce the magnitude and frequency of these sources of error.

To measure precision, replicate samples of bed material size distrubution and vegetation live stem counts will be conducted at selected reaches. The resulting grain size distribution and stem counts at each site will be compared to determine precision. Precision of two replicate samples is calculated by relative percent difference (RPD) as follows:

RPD = [(C1 — C2)*100] / [(Cl + C2)/2]
where Cl is the larger of the two values and C2 is the smaller.

Precision will be measured for 10 or more percent of the sample sites each year. A minimum of two replicates are recommended if less than 20 sites are sampled. Stream enhancement or restoration activities across the Qualla Boundary will be considered collectively, so one to two replicates are planned for any project reaches located on the mainstem of Lower Oconaluftee. A second replicate will be used for project activity on smaller drainages to Lower Oconaluftee. The vegetation sample will be considered precise if samples from the same reach attain an RPD of 15 percent or less. For grain size distribution, the replicate grain size classes (e.g., fine sand) of D_{16}, D_{50}, and D_{84} should be different to meet precision criteria. Precision will not be measured for longitudinal profile, stream bank profiles, visual inspection, or cross-sections. Obtaining a replicate of longitudinal profile and visual inspection is not practical given project resources and standard survey techniques competently address issues of precision. Under standard procedures, any "busted" survey (generally > 0.1 foot error for known elevation such as a permanent pin) will be discarded and the work repeated.

Data representativeness is the degree to which data accurately and precisely represent a characteristic of a population or community, natural variability at a sampling point, or an environmental condition (USEPA, 1995). Representativeness of a sample depends largely on randomized sampling of the target assemblage

(Green 1979; Smith et al. 1988; Freedman et al. 1991) and therefore is highly dependent on the sampling program design. Generally, the sampling program has been designed to ensure representative sampling of the in situ substrate, channel dimensions and profiles, and riparian buffer establishment. Representative sample locations will be selected by trained staff and/or consultants. However, the fact that such discrete locations must be used to characterize stream reaches is an unavoidable source of error in this type of work.

Pebble counts and survey data will be directly comparable to state and federal databases. Vegetation survival data will be comparable to data from the North Carolina Ecosystem Enhancement Program which funds more stream restoration than any other organization in the state and catalogs numerous stream restoration monitoring projects across the state.

Reporting of data in units used by other organizations also improves comparability. For geomorphic assessments, comparability of data could also be determined by classifications such as ecoregion (or smaller geographic unit) and stream type (Rosgen, 1994). Comparing data collected by OENR with data from other organizations will highlight differences and potentially point to problems in the data collection or analysis procedures.

Percent compldeness for geomorphic surveys will be measured m the same manner It was for other monitoring to be completed under the watershed management plan. Percent completeness (% C) for all measurements (i.e., sample sites) can be defined as:

% C = (v/T) * 100

Where v = the number of measurements or surveys judged valid and T = the total number of measurements or surveys (Plafkin et al. 1989).

In order for the annual sampling exercise to meet the data quality objectives, the percent completeness must exceed 80%. This will be applied to pebble counts, embeddedness, cross-sections, longitudinal profiles, bank erosion and vegetation monitoring. An individual sample (e.g., elevation point) will be judged valid if it is listed in the final database without being rejected or qualified as problematic and unfit for use. Reasons for rejecting data include irreconcilable entries, use of improper sampling techniques, and mislabeling that cannot be corrected with certainty.

If the data quality objectives described above are met, it is still possible that errors may be made in decisions regarding channel and buffer integrity. For example, unusual weather conditions can effect particle size distributions in a stream for short periods of time. This could overlap into a data collection schedule. This would effect reported particle size distribution and potentially misrepresent the coarseness or amount of fine-grained material in the substrate. An incorrect decision regarding embeddedness (the degree to which the channel bottom is buried by fine-grained sediment) may result. However, because each site will be resampled before each 5-year watershed plan revision, some uncertainty about making errors of this type is tolerable. Futhermore, such uncertainty is inevitable in an open environmental experiment such as stream enhancement.

B2. SAMPLING METHODS

PHYSICAL AND WATER CHEMISTRY DATA SAMPLING METHOD

The Tribe or a professional contractor will collect physical and water chemistry data for analysis and interpretation in the Tribal laboratory. Community volunteers may also assist in collecting samples under the supervision of OENR water quality monitoring staff, or other professional water quality monitoring personnel including USEPA water monitoring staff. Any samples not processed in the Tribe's laboratory will be submitted to a state certified laboratory; the quality assurance project plans for the watershed plan and on-the-ground projects will be revised accordingly. Monitoring and assessment efforts across Tribal lands is on-going. Therefore, both previously collected data as well as new data will be used in assessment, goal setting and project implementation under the watershed plan.

The Eastern Band of Cherokee Indians has established Standard Operating Procedures (SOPS) for all parameters collected and analyzed, excluding those the Tribe is currently establishing with the assistance of the USEPA Region 4 SESD and Region IV Project Officers. Once determined, the Tribe will collect and analyze these parameters using EPA approved methodology. Table 5 in Section B l. *Sampling Process Design*, identifies standard methods utilized by the Tribe for watershed monitoring and restoration projects. Action levels for each parameter are determined based on water quality standards contained within the Tribal Water Quality Code (Municipal Code Corporation 2002). As a certified Tribal laboratory, established and documented SOPs are required. Inspections and performance evaluations of the Tribal environmental laboratory are conducted every one to two years by the NC Department of Environment and Natural Resources. Additionally, EPA Regional and SESD staff may inspect the laboratory facility at any time.

In the field, OENR staff adhere to all quality control procedures established in the QAPP and follow applicable SOPS. A monitoring sample sheet is completed, and when required, chain-of-custody procedures are followed. All sampling and analytical instruments are calibrated based on existing SOPs prior to use. Calibration is performed by the instrument user; training for calibration is provided in-house by the laboratory supervisor and through training sessions offered by a qualified third party. All calibration records are maintained in a standard calibration log. Preventative maintenance for all sampling and analytical instrument are performed based on manufactured instruction. The laboratory carries an inventory of spare parts and batteries.

Sample stations for physical and chemical water quality monitoring are established at publicly accessible, fixed locations (i.e., specific lat/long), and are generally at bridge crossings or within 300 feet of other notable landmarks. Latitude and longitudinal information sampling locations (both existing and proposed), will be provided in the monitoring strategy and will be identified using GPS units and software or topographic mapping. Sample sites monitored for the purposes of the watershed plan will be strategically located to monitor such watershed concerns as:

- the overall water quality in the watershed;
- NPDES permitted facilities;
- the effect of non-point sources of pollution (e.g., urban areas, land disturbing activities, dirt/gravel roads and ATV trails);
- tracking changes in land use and percent imperviousness;
- drainages for which little or no data exists and development pressures are increasing;
- waters of significant ecological, cultural, recreational, political, or municipal use; and
- significant waterbodies as they enter or leave Tribal jurisdictio

Adjustments to station location, scheduling and parameters may be made concurrently and with sufficient reason by the Sampling Design Leader and Restoration Activities Leader. Such adjustments can be made out of safety concerns or changes in station accessibility, as well as station changes based on the validity of continuing or adding new stations. Other reasons for altering the monitoring strategy developed during the watershed planning process may be based on staffing and funding resources as well as avoiding monitoring redundancy by other stakeholders who assume a role in watershed monitoring efforts. Final approval for adjustments will be made by the Project Quality Assurance Manager.

Problems encountered by field and laboratory staff will be brought to the Tribal Quality Control Officers who will assess the situation and recommend a course of action for resolution.

Physical and water chemistry data will generally be collected mid-channel or in a portion of the stream determined by field staff as being representative of the waterbody being sampled. Other factors that define sample points used for watershed monitoring will be based on flow (should be sufficient enough to produce a well-mixed sample), distance from mixing zones downstream of point discharges, and distance from impoundments or other material which may prevent a representative sample from being collected. Samples taken from monitoring points located by bridges should be collected upstream of the bridge.

Sampling methods for parameters used in this project will be conducted as outlined in the SOPs for these parameters. These SOPs identify the parameter, sampling equipment, container, method of preservation, and maximum holding time. Water quality data not obtained by use of field meters identified in Table 7.1 (Appendix I), will be generated by taking grab samples from the middle of the water column. Water is collected in the bottles by submersing them manually or with the aid of other sampling devices created to assist in submersing sampling bottles. Other sampling devices used to assist in bottle submersion will be coated with Teflon or will otherwise be covered with a non-reactive material. Prior to each use, these devices wilFbe rinsed ale three times in the stream being sampled to avoid possible contamination. Parameters which may be utilized in the course of implementation of the watershed plan for which grab samples will be taken include E. coli and other nutrients, and turbidity.

Samples that arrive in the laboratory in unacceptable condition (i.e. improper handling procedures employed, temperature of sample out of range, etc.) can be rejected by the Tribal Quality Control Officers for laboratory activities which take place under this QAPP. This also applies to samples that must be sent to another USEPA and/or N.C. state-certified laboratory. A chain of custody form (Appendix A), will be shipped with these samples that details the conditions of the samples as they were shipped and received. Parameters that are sampled monthly do not have to be resampled immediately unless requested by the Watershed Restoration Activities Leader. In the case of quarterly sampling, if a sample arrives at the laboratory in unacceptable condition, the monitoring site should be resampled at the next practicable time possible within the following two months. When sampling events are missed or must be repeated, it will be documented in the Tribe's monthly monitoring records (Appendix B), along with an explanation. Missed sampling is acceptable as long as the reasons are documented in the monthly field data submissions. If a sample is inaccessible during a scheduled station visit (including for safety reasons), field staff will not sample at another location; they will follow the same procedure as noted above for resampling.

BENTHIC MACROINVERTEBRATE DATA SAMPLING METHOD

Unless otherwise noted, ECBI will utilize the Tribal EPT method or a modified version of the NCDWQ's Qua14 method for sample collection, as well as NCDWQ's method for calculating EPT biotic index and other related metrics. The procedures for sample collection that will be used are detailed in the NCDWQ's Standard Operating Procedures (SOPs), for benthic macroinvertebrate monitoring (pages 5-9). The full SOP document is available at http://www.esb.enr.state.nc.usBAUwww/benthossop.pdf. As is the case with physical and chemical water quality monitoring, the location and frequency of sampling efforts for macrobenthos will be defined during the development of a monitoring strategy.

For data collection in the field, the time estimate recommended for unbiased and consistent implementation of the EPT method by two collectors is 5.5 to 6.5 hours (total man hours, meaning staff should be on site for approximately three hours). The amount of time needed may vary from site to site depending on the available stream habitat and other circumstances. Macroinvertebrate samples will be picked and preserved in the field, so maximum holding time to sample analysis is not applicable. Unless otherwise approved by the Sample Design Leader, macrobenthos monitoring will occur between May 15 and September 30. Correction factors will be applied to biotic metrics for samples taken outside of this period as outlined in the NC Division of Water Quality's SOPS for macrobenthos monitoring (pages 12-15). As part of the sampling effort, the Tribe will implement NCDWQ's habitat assessment method found in Appendix C. Chain-of-custody forms and bench sheets used for macroinvertebrate sample collection are included in Appendices A and D. As with other parameters, sampling frequency will be determined in project specific monitoring plans.

As part of the Tribe's sampling protocols, all equipment must be routinely calibrated or otherwise maintained to prevent data error. When using a net for collection of benthos, the nets will be thoroughly cleaned between samples so that organisms captured at one station do not get carried over and included in the next station. The stream water is suitable for this purpose. If it appears that an organism may have been carried over from a previous site, the field notes should be checked to determine if the organism could in fact have been left over. If it is obvious that the organism has been carried over from a previous site, a comment should be added to the site data sheet that the organism should not be included in the metric calculations. Field meters will be calibrated prior to each sampling event and periodically as defined by the instrument operators manual.

GEOMORPHIC SURVEY AND RIPARIAN PLANTING METHOD

The-purpose of-implementing-stream-projects-in-the-Lower Oconaluftee-watershed-is-to-ere-ate-(or-protest)-streamchannels that are both vertically and laterally stable, have coarse substrate free of embedded materials, and have a functioning and healthy riparian buffer. Unstable channels may downcut though the Stream bed and become incised, widen as banks erode, change stream course and/or fill with excess sediment. Each of these processes impacts aquatic resources and can threaten riparian property and habitat. A successful enhancement or restoration project should allow transport of water and sediment through the project reach without significant changes to channel dimension and profile over the long term. Functioning riparian buffers stabilize streambanks and filter overland runoff and shallow groundwater.

To assess the effectiveness of stream restoration projects, the Watershed Restoration and Protection Program will utilize various monitoring methods including channel cross-sections, bank pins that measure streambank erosion, stream profile, streambed grain size, staged sediment samplers and survival of riparian plantings along project reaches. Data collected with these methods will be complemented with visual inspections of stream banks and planted riparian areas.

Project reaches will be sampled once per year during the first and third years following the project and at the end of the fifth year. This will be done to monitor progress on the stability of the stream channel and the establishment of riparian vegetation. On-the-ground project implementation will be scheduled in accordance with applicable moratoriums and guidelines in place to protect various flora, fauna and aquatic species.

Geomorphic parameters measured should characterize the stream's transport competency, channel dimension stability, and the integrity of riparian buffers to determine if the projects are performing as intended. The major measurements to be assessed using performance criteria are grain-size distribution of bed materials in the project reach (via pebble counts), embeddedness, bank erosion, channel cross-sectional area, longitudinal profile, riparian vegetation survival, and visual inspection of streambanks and planted riparian areas.

As has been the case with other watershed restoration and enhancement projects conducted on Tribal lands since 2005, channel stability will be monitored at established locations selected by the Project Manager, in consultation with the sampling design QC manager. Cross-sections will be collected at one riffle and one pool on each project reach less than 1,000 feet in length. Additional riffle and pool cross sections will be measured for each additional 1,000 linear feet within the project reach. Each cross-section will extend from established pins on either side of the channel set at elevations at or above the top of streambank. The survey will collect points at significant changes in slope, as well as at the left and right top of bank, bankfull elevation, left and right edge of channel, water surface, and thalweg. Bank pins will be installed near each of the channel cross-sections.

Many of the stream restoration or enhancement projects that are likely to be identified in the watershed plan will be on small streams and be limited in scope; therefore, channel profile will only be surveyed for reaches where instream structures have been designed and installed to control grade. For simple stream enhancement and stream bank stabilization projects, channel profile will be assessed indirectly as part of the cross-section surveys. This will be accomplished by surveying all the cross-section pins to determine their relative elevations. This work will be completed during the initial and as-built cross-section surveys and will provide simple elevation benchmarks of low top of bank, bankfull, water surface, and thalweg at three locations on each project reach. This data can be used to document larger profile changes such as the development of a substantial headcut or abundant sediment deposition.

For streams dominated by gravel and cobble-beds such as the streams found in the Lower Oconaluftee watershed, bed grain-size distribution will be measured using pebble counts at the established cross-sections. If any sand-bed streams are located in the Lower Oconaluftee drainage, grain-size distributions will be determined using bulk samples collecteelc from each cross-section. The 1)16, D50i D84, and maximum pa-rricle-size will-be determined.

Because short-term weather conditions greatly influence stream turbidity, sediment transport and channel , stability will be measured by examining parameters that reflect longer-term conditions, such as those parameters described above. In addition, total suspended solids concentrations will be measured using staged sediment sampling stations.

The OENR will use visual inspection of the project reaches to detect problems that may not have been captured by other channel stability measurements. Visual inspections will be conducted by walking the project reach within the channel while checking for instability in the form of headcuts, channel aggradation, and streambank erosion. Any instance of instability will be documented with a photograph, GPS location, and written description. The Project Manager and Sampling Design QC Manager will use professional judgment to determine if the instability is likely to cause longer term problems or appears to be inconsequential. This information will be cataloged by including it within a separate worksheet in the electronic cross-section file.

Many of the methods outlined below are adapted from standard operating procedures used by local stream restoration practitioners. Other water quality parameters referenced are covered under the Tribe's QAPP and SOPS for water quality monitoring.

<u>Pebble Counts</u>

Pebble counts begin by determining if the reach has a gravel bed. This is determined by estimating whether sand or gravel is the predominant material. The division between very coarse sand and gravel is 2.0 mm. Most streams within the Qualla Boundary have gravel or cobble beds, though sand-bed streams are also present on Tribal lands.

For sand-bed channels, a bulk sample will be collected from a representative riffle. Bulk samples are collected by using a trowel to remove the top four inches of sediment from a three-inch by three-inch area. Caution must be taken to prevent fine materials from washing away as the sample is collected. A bottomless five-gallon bucket will be used for sealing off the sample location from stream flow. This exercise is then repeated up to ten times along a channel cross-section at regularly spaced intervals between the left and right edges of the channel.

If the project reach has a gravel-bed stream, the EBCI will select a stable riffle in which to conduct a pebble count. The riffle should be located towards the downstream end of the reach and at least 25 feet in length. If it is not that long, a longer or second riffle will be selected. The pebble counts will include 100 samples in reaches that are less than 1,000 feet long. For restored or enhanced reaches longer than 1,000 feet, a 200-sample pebble count or two separate 100-sample pebble counts will be performed. If there is a change in stream type within a project reach at least one sample will be taken for each stream type.

The EBCI will conduct heel-to-toe pebble counts of the bed material using a zig-zag method, covering the entire length of the riffle between the left and right edge of channel. Without looking, the sampler places his/her finger on the substrate below. The first particle touched is measured and recorded (i.e., a small pebble should be counted if it is lying on top of a cobble and touched first). The sampler will measure the intermediate axis of each particle with a standard ruler or a gravelometer. The size of sand particles should be estimated (e.g., fine sand, silt/clay, coarse sand). The reader is referred to Bunte and Abt (2001) section 6.1.5 for a more detailed discussion of pebble count sampling procedures. This reference will be read by OENR staff the conduct pebble counts. Sand particle reference cards and gravelometer will-he standard sampling equipment. Pebble count data will be recorded and plotted on semi-log paper (Appendix E), and compared with data from previous years.

<u>Embeddedness</u>

Burns (1984) used embeddedness to characterize the proportion of individual particles buried in fine sediment. This method and others are described in the U.S. Army Corps of Engineers' Technical Bulletin, "Techniques for measuring substrate embeddedness," (Sylte and Fischenich 2002). Under the Burns Method, particles measured for embeddedness range from 4.5 to 30 cm while fine sediments are considered to be particles less than 6.3 mm in diameter. To use the Burns Method, a set of 60 cm-diameter steel hoops are used to define the sample perimeter. These hoops are tossed randomly within the specific habitat area being sampled.

Other devices needed to measure embeddedness using the Burns Method include a 30 cm-transparent ruler to measure particle dimensions, and a float and stopwatch to measure velocity. Float time across the hoop diameter for habitat areas selected should range between .9 and 2.5 seconds. Per the Burns Method, water depth must be between 30 cm and 45 cm. Habitat areas that will typically be sampled in Tribal waters consist of riffles and shallower reaches of stream in step-pool systems. Hoop measurements should also not be taken in eddies caused by pools or boulders.

Field staff will begin by collecting each free particle between 4.5 and 30 cm in diameter. The embeddedness measurement of these particles by definition is zero so these particles will not be counted and should be discarded.. After removing the free particles, embedded particles are systematically removed. Rocks with 50% or greater of their surface area lying within the diameter of the hoop are counted; each rock measured represents a single measurement. Measurements are made of the depth of embeddedness and the particle height.

All particles exposed to the water column within the hoop are measured until only substrate greater than 30 cm or less than 4.5 cm remains. Hoops will continue to be cast into the sample area until a minimum of 100 particles have been measured. All rocks in the last hoop are counted even if the count exceeds 100. Embeddedness is calculated by dividing the embedded depth by the total depth of rock lying perpendicular to the embeddedness plain (Burns 1984). The average of these particles is then taken.

Various forms of error can occur while determining embeddedness. Opportunities for error can arise as rocks are measured along the incorrect plane or from shifting the particle or changing the collector's position in orientation to the particle when measuring embeddedness depth. These types of error have not been deemed to cause significant bias when comparing sample values.

Embeddedness can also be measured another, more qualitative and time efficient manner. Field staff can use an aqua viewer and camera to photograph the sample area. Photographs are particularly useful if the sample area is not assessed on-site. It also serves as a record of reference when comparing evaluation scores among various field staff. To use this method, the OENR would develop a ranking system for assessing embeddedness visually. The average of scores taken by field staff would be used to evaluate embeddedness. This method would require field staff to evaluate his or her individual interpretation of the assessment guide with that of other field staff. This "calibration" of scoring embeddedness should improve site assessments for embeddedness. Field staff may utilize both the Burns Method and the visual assessment approach described until such time that field staff are able to closely correlate data obtained by visual assessment with an embeddedness assessment based on the Burns Method.

Cross-sections

Two permanent cross-sections will be installed per restored reach or 1,000 linear feet of restored stream, with one located at a stable riffle and the other at a pool.—Reaches longer than 1;000-feet will-require a riffle and pool cross-section for each additional 1,000 feet. Each cross-section will be marked on both banks with permanent steel pins encased in concrete to establish the exact transect used. Permanent crosssection pins will be surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg. Riffle cross-sections are classified using the Rosgen stream classification system (Rosgen, 1991). Cross-section data will be recorded in the field with horizontal distance determined by tape measure and vertical distance determined using a laser level and survey rod. If a total station surveying instrument is available, this data will be collected using it. All cross-section surveys will be tied to a common benchmark, established based on an assumed local datum.

Bank Pins & Bank Profiles

Four-foot sections of rebar will be driven horizontally into the streambank and the end (last inch, which protrudes from the streambank) will be painted. A GPS point will be saved to expedite location of the bank pin. Each year, the amount of rebar protruding from the bank will be measured and then pushed back into the bank until it is flush with the bank. The amount of erosion in feet and inches will be measured using a tape measure and recorded in a cross-section spreadsheet. A photograph of the bank pin will also be taken.

Longitudinal Profiles

Longitudinal profiles will be surveyed in Years 1, 3 and 5 for stream reaches where the design and construction have changed the reach-wide profile of the streambed. For small stream enhancement and bank stabilization efforts, channel profile will only be measured indirectly as part of the cross-section surveys. This work will be completed during the initial cross-section surveys and will provide simple elevation measurements of lowest top of bank, bankfull, water surface, and thalweg on a transect across the stream on each project reach. When measuring across a pool feature the deepest point on the thalweg should also be measured. To obtain a representative channel profile, measurements should be taken at every change in stream slope, ie. at the point where the stream habitat changes from run to pool to glide to riffle. These data can be used to document larger profile changes such as the development of a substantial headcut or abundant sediment deposition. A common benchmark will be used each year to facilitate comparison of year-to-year data.

Vegetation Monitoring

To evaluate the success of buffer establishment, vegetation mortality rates will be measured at sample plots established within planted "areas. Where vegetative'monitoring is selected as a monitoring tool, The Carolina Vegetation Survey (CVS) Protocol will be used (Peet et.al. 2008). Currently the OENR plans to perform mortality rate surveys on a minimum of 10% of project areas planted, with additional surveys as funding allows. Mortality rate surveys will be completed during post construction monitoring. Individual quadrant data collected will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings. Plots I will be established on selected restoration and enhancement reaches; vegetation monitoring plots will be 100 square meters for tree species to 1 square meter for herbaceous vegetation. The plots will be randomly located and oriented within the planted riparian buffers. Vegetation monitoring will occur in spring, after leaf-out has occurred. At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between July and November.

Plots will be constructed using metal fence posts at each of the four corners to clearly and permanently lestablish the area that is to be sampled. Ropes are hung connecting all four corners to help determine if trees are inside or outside of the plot. Trees on the plot boundary and trees just outside of the boundary that appear to have greater than 50 percent of their canopy inside the boundary will be counted inside the plot. A piece of white PVC pipe ten feet tall is placed over the metal post on one corner to facilitate visual location of site throughout the five-year monitoring period.

All of the planted stems inside the plot will be marked with flagging to mark them as the planted stems (not volunteer species) and to help with locating them in the future. Each planted stem is then tagged with a permanent numbered aluminum tag. The number of stems of each species within the plots will be counted and tabulated on a worksheet in the field. This information will be cataloged by including it within a separate worksheet in the electronic cross-section file.
Specific and measurable success criteria for plant density on the project site will be based on the recommendations found in the US Army Corps of Engineers (Corps) Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997) and past project experience.
The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. In cases where the Watershed Coordinator monitors BMP projects that involve planting less than one acre of vegetation, the Watershed Coordinator will adjust the vegetation survival rate according to the size of the buffer area planted. Survival rate criteria will be calculated using the ratio provided in the Corps of Engineer's success criteria for plant density described above.

Visual Inspection
OENR will use visual inspection of the project reaches to detect problems that may not have been captured by the above channel stability measurements. The visual inspections will be conducted by walking the project reach within the channel while checking for instabilities in the form of headcuts, channel aggradation, and streambank erosion. Any instance of instability will be documented with a

photograph, GPS location, and written description. Reference photos will also be taken at each permanent cross-section from both streambanks. A survey tape measure will be centered in the photographs of the bank and the water line will be located in the lower edge of the frame, with as much of the bank as possible included in each photo. Photos of each grade control structure will be taken.

The project manager and sampling design QC manager will use professional judgment to determine if the instability is likely to cause longer term problems or will be inconsequential. This information will be cataloged by including it within a separate worksheet in the electronic cross-section file.

Turbidity

Turbidity data will be collected during during or immediately following storm events using a nephelometer, a meter that measures the intensity of light scattered at 90 degrees as the light travels through a water sample (or column of water in a stream). Data will be measured and recorded in nephelometric turbidity units (NTU). OENR has a conditionally approved water quality QAPP that includes turbidity monitoring. The basic quality control steps that apply to water quality monitoring are applicable with turbidity (e.g., measuring from a bridge or downstream from the instrument is important for preventing sample contamination, as is not disrupting the channel upstream from the instrument).

Problems encountered by field and laboratory staff, including persistent site accessibility or equipment issues, will be brought to the Tribal Quality Control Officers who will assess the situation and recommend a course of action for resolution.

The series of tables starting with 7.1 in Appendix I. provides a list of monitoring equipment needs based on parameters to be utilized in association with the watershed plan.

B3. SAMPLE HANDLING AND CUSTODY

Custody of samples collected will be traced through sample collection sheets. Although the Tribe performs most analyses on-site, some contractor services are required. The program has established chain-ofcustody procedures when required. If a sample requires testing outside of the Tribal laboratory, the sample will be labeled and logged in a monitoring datasheet. Such samples are stored, preserved and analyzed as outlined by the Tribal laboratory SOPS for parameters identified in Section B l., Table 5 of this QAPP. All samples will be labeled in the field with a sample identification number, stream name, date, brief site location description, and names of the collectors. Labeling will be completed using permanent pen or marker.

In the case of benthic macroinvertebrate sampling, field data sheets will be completed that include a sample identification number and taxa family collected (for EPT species); these will serve as backup documentation of the samples collected. Each site's sample labels and field data sheet will be reviewed by Field and Lab Technicians for accuracy and completeness. The bench data sheet and representative collection will be reviewed by the Project Manager before it is sent to the taxonomist. Benthic macroinvertebrate samples delivered to a professional taxonomist will be delivered with a chain-of-custody form whereby the taxonomist will check their data entry against the field sheets. The sample identification numbers will be included on the chain-of-custody form. All persons assuming responsibility for samples must sign and date the appropriate chain-of-custody forms. Samples without a label or a signed chain-of custody form will not be sent to the taxonomist for identification. These samples will be labeled and double-bagged (not including shipping container), for shipment to the taxonomist. Double-bagging the samples should prevent vial leakage and loss of contents. The shipping box will include packing material to protect the glass sample vials.

The only geomorphic indicator that may be used for which sample handling and custody applies is bulk sediment sampling. Sample handling and custody protocols for bulk sediment samples will follow the same documentation requirements referenced above for other sampling methods. Bulk sediment samples for sand-bed streams will be double bagged to prevent leakage and loss of contents.

Field data sheets will serve as backup documentation of the samples collected. The sediment samples will be delivered to the laboratory and the field technician will check their data entry against the field sheets.

B4. ANALYTICAL METHODS

PHYSICAL AND WATER CHEMISTRY SAMPLING

Analytical methods used by the OENR for physical and water chemistry data are referenced in the standard methods heading in Section B l., Table 5 and are identified in the Tribe's SOPS for the Tribal laboratory. In addition to the Tribal SOPS, manuals for field meters used are also referenced. A discussion of other parameters for which there are no standard methods identified by OENR is given below.

BENTHIC MACROINVERTEBRATE SAMPLING

Analytical methods for processing benthic macroinvertebrate data are described in § 1.03 "Analytical Methods" of the EBCI Index of Biotic Integrity for Wadeable Streams and Rivers. Benthic macroinvertebrate samples are to be preserved in a 95 percent ethanol solution in the field; afterwards, sample vials are carried to the lab for EPT family-level identification. EPT organisms not identified to family level by the unaided eye should be examined under a dissecting microscope with magnification of at-least 40x. Once the organism has been identified to the Family level, pertinent data will be recorded on laboratory bench data sheet (Appendix D).

For verification of a particular family, comparisons with a pre-established reference specimen collection should be performed to yield rapid and accurate results. The EPT organisms will then be placed in vials labeled by EPT family and preserved in a fresh 95 percent ethanol solution. Labels will include such information as the sample identification number, site location, date sampled, county, and name of collectors. As part of the monitoring efforts for this watershed plan, all non-EPT organisms will also be placed into separate, labeled vials for each site and submitted to a professional taxonomist for keying to the species level or lowest practical level. A copy of the bench data sheet is sent with samples. In future sample events for which there is adequate data, non-EPT taxa collected will be labeled in accordance with the Tribal IBI protocols outlined above and will be kept in the laboratory for future analyses as needed. Once the taxonomist has completed the sample identifications, he/she will return the collection in original vials and/or additional vials with corrected family labels. The taxonomist will also return the copy of the bench data sheet with corrections or complete a second bench data sheet. This provides the Tribe feedback on the accuracy of the family level identification performed by internal staff. Calculating EPT taxa richness and the BIEPT will follow the format found in pages 12 to 14 of the NCDWQ Benthic Macroinvertebrate SOP Guidance (NCDWQ, 2006). The tolerance values for each specimen that is incorporated into the EPT biotic index are also listed in the NCDWQ SOP and in Appendix B of the USEPA Rapid Bioassessment Protocol Manual. If a particular specimen has no assigned tolerance value, then it will not be included in the BIEPT calculation.

GEOMORPHIC SAMPLING

The only physical sample that may be analyzed under the monitoring strategy developed for the watershed plan will be bulk sediment samples. Upon delivery to the laboratory, samples are placed in an open tray (e.g., dark room photography tray) to dry. Drying may take from one to five days depending on the amount of clay and organic matter or in the Tribal laboratory oven if available. It is helpful to spread the sample across the tray to promote drying.

Dry samples are sieved by stacking the sieves from the finest on the bottom to coarsest at the top and placing a portion of the sample that fits in the top sieve. By agitating the stack of sieves, the sample will separate by particle size class. This should be repeated until the entire sample has been sieved. Next, the contents of each sieve are weighed and recorded by size class. The intermediate axis measurements and individual weights of the two largest particles collected are recorded.

The sieving and weighing results collected in this project will be entered into a sediment analysis spreadsheet (see Appendix F) which plots the data and determines the material size class distribution for all of the collected materials. The data represent the range of channel materials subject to movement or transport as bedload at bankfull discharge. The spreadsheet also calculates the size—class indices for D_{16}, D_{35}, D_{50}, D_{84}, D_{95}, and D_{100}. The number designation indicates the proportion of the sample (either by weight or number) that is the determined size or smaller. For example a D_{50} of 100 mm indicates that 50% of the sample is 100mm or smaller. The largest size particles measured will be plotted at the Dioo point. The intermediate axis measurement of the second largest particle will be the top end of the catch range for the first sieve that retains material.

Pebble count data from gravel-bed streams will also be entered in the sediment analysis spreadsheet to calculate the same values. Rather than entering a weight for each class size, a count will be kept of the number of particles in each size class and the result for riffles and pools over a given reach will be calculated in the spreadsheet. To measure project success, the D_{16}, D_{50}, and D_{84} will be compared with the D_{16}, D_{50}, and D_{84} from tine-srevious-yoar's sample. The particlesize-class-(e.-g.—medium-sand; fine-gravel) for each of these should become coarser with time. An equilibrium state may be reached after the first year where the indices may not change or change very little, but the substrate should not become finer with time. If the sampling does indicate the substrate is becoming finer, an investigation should be undertaken to determine the source of the fine particles (silt and sand). Long-range embeddedness measurements will aid in monitoring changes in substrate composition as well.

Cross-section and longitudinal-profile data will also be plotted in Microsoft Excel spreadsheets. An example of cross-sectional data is provided in Appendix G. These spreadsheets will be used to calculate and illustrate cross-sectional area at bankfull. It will also determine the average slope for each study reach by approximating the average water surface slope. Standard stream morphological parameters of channel dimension will be calculated after Rosgen (2004). These include mean bankfull depth, bankfull width, maximum bankfull depth, width-to-depth ratio, and bank-height ratio. The cross-sectional area and reach average slope estimates should be compared with those from prior years. There may be some adjustment in the bankfull cross-sectional area as the stream adjusts to find its equilibrium state (not that decided by the engineer's design). However, significant changes (especially on a reach-wide scale) may indicate an unsuccessful restoration project. Whether this is the case or not can only be determined on a site specific basis and with consideration of the goals of the specific restoration project. Indicators representing significant changes may include the following scenarios:

- Degradation, including an increase in the width-to-depth ratio by more than 20 percent,
- Unforeseen changes in stream classification,
- Transition of a surveyed feature to another feature type (e.g., pool becomes a riffle),
- An increase in bank-height ratio by more than 10 percent,
- Riffle cross-sections that downcut more than two times the size of the maximum particle size,
- Depending on stream size, features that aggrade significantly over two consecutive survey periods.

Vegetation monitoring will be performed after leaf-out has occurred. Individual plantings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and current year's live plantings. At the end of the first growing season, species composition, density, and survival will be evaluated between July and November. Specific and measurable success criteria for plant density on the project site will be based on recommendations found in the U.S. Army Corps of Engineer's Technical Note VN-rs-4.1 (1997). The interim measure of vegetative success for project sites will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. While measuring species density is the current accepted methodology for evaluating vegetation success on restoration projects, species density alone may be inadequate for assessing plant community health. For this reason, the vegetation monitoring plan will incorporate the evaluation of additional plant community indices to assess overall' vegetative success. Volunteer species will not be included in density counts used to measure the success of live stakes and other plantings installed.

B5. QUALITY CONTROL (QC) REQUIREMENTS

The EBCI's limited staff availability precludes the ability to alternate the field crews as a QC step for monitoring events. However, the Tribe has developed other QC measures for sampling which are described in this section.

PHYSICAL AND WATER CHEMISTRY DATA

For water quality measurements taken in the field, quality control (QC), practices include equipment calibrations and standard checks as recommended in the respective equipments owners manual. Other proctic ures in place include employing duplicate samples, field-blanks, and-equipment-blanks-on-a regular basis and when sample contamination is suspected. These procedures are also used when laboratory staff experiment with changes in methods, preservatives, and equipment.

BENTHIC MACROINVERTEBRATE DATA

Sampling quality control checks relate to both the care of equipment being used and of the sampling procedures themselves. All field equipment will be properly cared for and will be inspected for damage prior to sampling events. This includes looking for holes, in netting used, and ensuring that field meters are calibrated before and after use or as called for in the operating manual. Calibrations will be recorded in a logbook. Between sample collections, field equipment used to retrieve and temporarily store specimens collected will be rinsed thoroughly. Staff will also perform "duplicate" sampling. For this project, this will consist of Tribal environmental staff collecting an additional sample from one site

(Tribal protocols specify 10 percent of the total sites sampled if there are greater than 30 sites) within two to three weeks of the original sample being done. In addition, the sample must be collected before the first significant rain event following the original sampling event. The purpose of this check is to assess the consistency and reproducibility of the sampling effort.

GEOMORPHIC SURVEY AND STREAM CORRIDOR DATA

For pebble and vegetation counts, replicate samples will be collected at two established monitoring stations (or 10 percent of the total if greater than 20 sites) to assess the reproducibility of the sampling effort. This assessment will be conducted as described in A7 in the first, third and fifth post construction monitoring years. If the precision test fails (e.g., RPD exceeds 15 percent for vegetation counts), an investigation of why this occurred will be conducted and corrective actions will be sought and implemented.

The use of a sand reference card and gravelometer will promote consistent measurement of particle sizes when performing pebble counts. Records shall be maintained of any corrective actions or training undertaken to correct mistakes in procedure, identification, or documentation.

Vegetation counts will typically be conducted in carefully measured and delineated l Om2 plots, and the planted vegetation will be labeled. These measures promote quality control. Visual-based habitat assessments are subject to variability among investigators. This limitation can be minimized by ensuring that each investigator is appropriately trained in the evaluation technique and periodic cross-checks are done to promote consistency between investigators. Consistency among parallel and independent habitat assessments can be evaluated by rank order comparisons of the evaluated sites. In this situation, the emphasis would be placed on comparisons between the total habitat assessment scores assigned by investigators for sites (USEPA, 1995).

In terms of surveying, quality control checks will be performed by back sighting when moving the instrument and closing the survey grid. However, when using a laser level, the margin of error will be expected to increase since elevation readings are taken by sight off of a rod. Staff will check to ensure the instrument is level and the tape measure is taut to improve the accuracy of the cross-section and longitudinal profile readings. The height of the laser level and the laser receiver on the survey rods will be recorded to 0.01 foot. Each cross-section will be closed by returning to the starting pin and measuring its elevation. If the resulting measurement is more than 0.02 foot off from the original measurement, the cross-section will be repeated.

LABORATORY ANALYSIS QC CHECKS

PHYSICAL AND WATER CHEMISTRY DATA

Because the Tribe's laboratory is state certified, the Tribe has elected to adopt QC checks followed by the state where appropriate. For QC checks required for operation of laboratory equipment, tribal staff reference_Chapter_LLof the NCDWQ Laboratory Section's Quality Assurance Manual(http://www.esb.em%state.nc.us/documents/Attachment%202%20ALMP%20QAPP.pdO, dated November 2004. Where NCDWQ quality control checks are not feasible or necessarily appropriate for the operation of the Tribe's laboratory, other QC checks are instituted by the Tribe and are included in the SOPs and Quality Assurance Management Plan for the Tribe's laboratory.

BENTHIC MACROINVERTEBRATE DATA

Benthic samples collected in the field will be further sorted by family in the laboratory. Other qualified professional taxonomists may be consulted for samples where the Tribe wishes to identify macrobenthos to the species or lowest possible level. Specimens collected will be identified using up to date regional identification manuals or other appropriate taxonomic literature. If Tribal staff question the identification of a specimen, professional biologists with the USEPA Science and Ecosystems Division or another professional biologist/taxonomist will be consulted.

Annual sorting checks of samples maintained in the Tribal Environmental Laboratory will be conducted to maintain at least 90 percent accuracy. A qualified taxonomist will perform this assessment when they receive samples for identification to the species level (or most detailed level practical).
A record of all samples sorted along with a list of QC checks will be maintained to document the QC process. Records shall be maintained of any corrective actions or training undertaken to correct mistakes in procedure, identification, or documentation.

Tribal environmental staff and Laboratory Technicians will have taxonomic references to perform the level of identification required. Representative specimens of all families/taxa identified will be checked and verified by a qualified taxonomist. These specimens will be properly labeled as reference specimens, permanently preserved, and stored in the laboratory. Beyond consultation with a professional biologist/taxonomist, random samples will be periodically re-identified by someone other than the original Tribal sampler to build experience among Tribal environmental staff and to encourage taxonomic consistency. The results of the re-identification will be recorded in a Tribal Environmental Laboratory Quality Assurance (QA) log book; if a QA accuracy of less than 90% is found, the samples in question will be re-identified by the designated lead biologist/taxonomist for the project and the original identifier.

GEOMORPHIC SURVEY DATA

Bulk sediment samples from sand-bed streams will be sieved and weighed in the laboratory. The sieves will be inspected each time they are used to insure that there are no tears or bent wires. If such damage is found, the sieve will be repaired or replaced. Additionally, sieve inspection will include removal of any leftover particles from previous samples.

A record of all samples sieved along with a list of who inspected the sieves and when the inspections occurred will be maintained to document the QC process. Documentation will also be filed for calibration of survey instrumentation to ensure instrumentation is operating satisfactorily.

DATA MANAGEMENT QC CHECKS

Hard copies of all computer-entered data will be reviewed by data entry personnel using side-by-side comparisons with the field or laboratory hand-written data sheets. This QC check is necessary with manually-entered data. Also, periodic checks by the data processing Sample Design QC Officer will be conducted to verify that data have been entered accurately.

DATA ANALYSIS QC CHECKS

Periodic checks by the Data Analysis and Processing QC Officer will be performed on the data analysis process. Data validation and verification QC checks include examination of outliers, total numbers, odd numbers, unusual species, and, most importantly, calculation of the biotic index. Errors can occur if inappropriate calculations are used to summarize the data.

Transcription error can also occur if proper review and oversight is not performed. QC checking of data reports by peer review, the use of a technical editor, and following a standard format will help to ensure complete and relevant data analyses and reporting.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

The Tribe's Laboratory Activities Leader and respective Quality Control Officers under this QAPP will be responsible for regularly cleaning, inspecting, and maintaining water quality and biological monitoring equipment. Other equipment used for geomorphic surveys will be maintained by the Watershed Restoration Activities Leader or other parties as designated by that Leader. Laboratory and field equipment will be visually inspected daily for cleanliness and any malfunctioning parts which will be repaired and cleaned as needed before use. Meters not in use on a daily basis will be calibrated and inspected weekly to ensure they are kept in good working order for both scheduled and unscheduled monitoring alike. A calibration log will be kept for all equipment. This will reduce the incidence of poor data collection and processing from unkept equipment. The Tribal Water Quality Monitoring Program will maintain a record of equipment used; manuals for field meters, and other equipment are kept in the laboratory for reference.

Preventative maintenance and associated scheduling activities that will be implemented under this QAPP include:

- Scheduled revisions of the watershed plan and watershed monitoring plan;
- Maintaining accurate files and spreadsheets used to track the status of projects and other planning and implementation activities;
- Maintaining an overall schedule of important preventative maintenance tasks that must be carried out to minimize downtime in the field and laboratory;
- Developing a list of critical spare parts that must be on hand to minimize downtime in the field and laboratory;
- Identification of personnel whose duties include operation of specific pieces of sampling gear or detection instruments have primary responsibility for inspection of such equipment; and
- Identification of personnel are assigned responsibility for locating and gathering of all necessary field equipment at least 24 hours in advance of departure to sampling stations.

Initial inspection and testing to insure that all of the sample collection and measurement kits meet the technical specification, as specified by the applicable SOPS, should be performed upon receipt of the equipment/instrumentation in the Tribe's laboratory. Maintenance of spectrophotometers, meters and other equipment should be performed in accordance with SOPS and/or manufacturer instructions. Benthic sampling equipment (nets and wash bucket) will be checked before each sample trip to ensure that no tears are present. If tears are found, the field technician will repair or replace them before the equipment is used again.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Both field and laboratory sampling and analytical equipment should be calibrated prior to use as described in the Tribal Environmental Laboratory SOPs and/or in accordance with the manufacturers' technical specifications. Primary Laboratory equipment will be calibrated at the beginning of each day or as recommended in the technical specifications manual for each device. Field meters used on a weekly basis shall be inspected and calibrated daily with a calibration occurring at the beginning and end of the day the meter is used. All other field meters will be calibrated at least once a week. Findings will be recorded in the calibration log and will include such information as staff name, date/time of initial/final calibrations, meter number, and date of last probe/battery replacement.

Other recalibrations shall be performed in the event that meter readings do not fall within calibration range, if damage to the meter is evident, or readings are otherwise suspect. Examples of circumstances in which a meter recalibration should be performed outside of the regular scheduling include:

- Membranes have been touched, fouled, or have dried out;
- Readings for a particular site are deemed unusually low or high (based on historical data) or readings are observed to be erratic over the sampling period; and if
- Data readouts are outside of the range for which the meter was calibrated.

There are limited applications for standard calibration procedures in macrobenthos monitoring as it primarily consists of manually collecting and identifying organisms. Benthic macroinvertebrate sampling is primarily a manual exercise for which standard calibration is not needed. However, good performance at taxonomic identification is partly accomplished by ensuring use of the most current taxonomic literature, by developing and using an appropriate reference collection, and by use of an expert taxonomist. The Project Manager will ensure that these resources are available and maintained. If the EBCI uses a total station or laser level for field surveying, bi-annual calibration by a qualified equipment supplier or repair shop is required. The OENR will follow calibration recommendations located in the owner's manual of survey equipment. The laboratory balance should be calibrated with a reference weight each time it is used.

B8. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Monitoring equipment and supplies are ordered from approved manufacturers and are inspected upon arrival by project personnel. Broken bottles, incomplete kits and reagents or instruments that do not meet standards are shipped back to the manufacturer for replacement. Pre-cleaned bottles and other containers ordered will possess a manufacturer's certification and will be inspected as stated above to ensure that parameters tested fall below the published reporting limits. Certificates received with containers will be filed in the laboratory for the life of the containers. Containers will remain capped and be stored in a manner that minimizes possible contamination by dust or other particulate matter.

Supplies and consumables (e.g., sample vials, preservative chemicals, sampling nets), will be re-inspected by a Field Technician on a quarterly basis. Supplies that are less than half full will be restocked. Containers that are broken, visibly dirty, or outdated and other supplies in a similar state will be discarded in a manner consistent with their labeling. Spare parts for equipment that are commonly torn or broken will be kept in stock where feasible and when funding is available.

Table 8. Consumable Inspections and Acceptance Criteria

Item	*Acceptance criteria*
Sample bottles	• Bottle blanks less than laboratory reporting limits • No visible dirt, debris, or other contaminants
pH standards (4.0, 7.0, 10.0 SU)	• Within +/- 0.4 SU of accepted value • No visible discoloration, debris, or other contaminants
Conductivity standards (147, 718, 24,800 gmhos/cm)	• Within +/- 10% of accepted value • No visible discoloration, debris, or other contaminants
Acid ampules (sulfuric, nitric)	• Ampules intact • No visible discoloration, debris, or other contaminants
Distilled or deionized water	• No visible discoloration, debris, or other contaminants

B9. NON-DIRECT MEASUREMENTS

Additional data pertaining to water quality within the Lower Oconaluftee watershed will be gathered and utilized in preparing reports for various stakeholders. Historical water quality data will be analyzed to assess direct comparability and may be qualified or excluded from trend analyses in reporting.

To calculate the EPT biotic index, tolerance values from NCDWQ's SOPs or the USEPA Rapid Bioassessment Protocols (RBP) will be used. In the absence of a tolerance value in the RBP manual, the state's SOPS will be referenced. The Project Manager will request that NCDWQ make them aware of any changes to tolerance values. Additionally, the Laboratory Technician will annually review the NCDWQ SOPs to look for changes and remain current on the methodologies not only for benthic monitoring, but water quality monitoring in general. Per the QC criteria, raw data entered electronically from the field data sheets and laboratory bench sheets will be confirmed.

Geomorphological parameters of project reaches will be compared to published values and regional curves for similar streams in the same ecoregion to ensure that values fall within range of the expected values for streams of that drainage area and stream type. The cross-sectional area and drainage area will be plotted on the North Carolina Mountain Regional Curve to allow a comparison of the project reach to stable mountain streams (Harman, et al, 2000).

Both quantitative and qualitative indicators will be used to measure the progress of the monitoring plan. Quantitative measurements related to projects implemented will follow existing Tribal QA/QC documents. Other methodologies used will be documented in reporting to the USEPA Project Officer.

Qualitative measurements used to evaluate watershed plan implementation such as community survey results and increased community awareness will be identified in the watershed plan. These measurements and by default, indicators used, will be revised as project goals, project activities and project schedules are revised.

B10. DATA MANAGEMENT

Monitoring personnel shall collect and report data using an appropriate sample sheet, or the data logging capabilities of stationary field monitoring devices utilized, to measure the Tribe's water quality monitoring parameters. All observational data, water quality data and field measurements shall be recorded at the time of sampling and analysis; and sample sheets signed and maintained at the laboratory for a period of ten years.

Field data sheets (for all aforementioned parameters measured in the field), will be checked for accuracy and completeness before leaving the field by the Field Technician. The field data sheets will be entered into an electronic database by the Laboratory Technician within one week of sampling or within one week of receipt of data (e.g. benthic data from taxonomist). If any sheets contain errors, omissions, or are unclear, the Field Technician will be contacted for clarification. Any anomolies or observations recorded on the field data sheet will be transferred into the electronic database as appropriate. Bench data sheets will be completed in the laboratory as the Laboratory Leader analyzes, sorts and reviews sample data. The EBCI Laboratory and Data Analysis Quality Control Officers will be responsible for providing further review of data to validate the results. Bench data sheets will be entered into the electronic database by the Laboratory Technician on a separate worksheet from the field data, though in the same electronic file (database). Tribal laboratory staff will be responsible for entering physical and water chemistry data into environmental databases used by the Tribe and peer reviewed by additional staff personnel for transcription or other potential errors. This electronic database is used for information retrieval from both in-house and federal agency requests. For benthic data, the labeled samples and a hard copy of the electronic bench data sheet will be sent to the taxonomist for further sorting and identification.

The taxonomist will correct the Tribe's excel-based laboratory bench sheet or complete a second bench sheet as part of this process. Backup copies of the electronic database will be made during each step. The taxonomists' results will be sent to Tribal environmental laboratory staff for calculation of the EPT biotic index and taxa richness. The calculations and taxonomist's results will be tabulated in the electronic database and a bioclassification will be assigned. Geomorphic field results will be analyzed using electronic spreadsheets. One analyzes the sediment data to provide a histogram and the size—class indices for D_{16}, D_{35}, D_{50}, D_{84}, $D_{95,}$ and Dioo. All that is needed to run this analysis is an unsorted entry of the raw pebble count data. The other spreadsheets archive cross-section and longitudinal profile data (Appendix H). Data are entered by station (horizontal direction) and rod height (as determined using a level), with markers for left and right top of bank and bankfull stations. The spreadsheet then calculates many of the geomorphic statistics, including bankfull cross-sectional area, width, and depth, as well as maximum depth, and ratios for bankfull width-to-depth, entrenchment, and bank height.

OENR staff utilize both Microsoft Access and Microsoft Excel spreadsheet based data to generate all required reporting documents, including annual reports to EPA and Tribal Council, as requested. Water monitoring reports are also included in the annual reports of the Office of Environment and Natural Resources. Analytical data is maintained in the Tribal laboratory and regularly backed-up onto compact discs. The discs and hard copies are maintained in the laboratory. Hard copies of all computer-entered data will be reviewed by the Field Technician using side-by-side comparisons with the hand-written field data sheets. Also, periodic checks by the EBCI QC Manager will be conducted to verify that data have been entered accurately.

Water quality data and other information collected during GIS and field reconnaissance studies will be used by the Watershed Coordinator and other Tribal staff to guide resource management decisions. Data management will also play a large role in the watershed plan revision process. Watershed plans and monitoring strategies will be revised on a 5-year rotational basis with other watershed management units within Tribal lands. Copies of the revised plans will be forwarded to parties identified on the distribution list in Section A3. of this document.

Upon completion of a technical review by the Tribal staff in the Tribal Water Monitoring Section and the Project Quality Assurance Officer, the Project Manager will submit a final project report to the USEPA Project Officer. The report will include a summary of data generated for the current project period as well as other information regarding projects and participation in meetings and educational events.

ASSESSMENT AND OVERSIGHT

Cl. ASSESSMENT AND RESPONSE ACTIONS

Watershed planning and subsequent implementation of projects involves applying principles and management strategies across a complex network of variable ecosystems. It is impossible to fully account for every possible consequence that may occur, especially in the field of watershed plan implementation. As unanticipated issues arise over the course of the development of a watershed plan, subsequent actions will adhere to one of the four general types of response identified in Chapter 6: Implementing, Monitoring, Evaluating, and Adapting in the "Working at a Watershed Level" training manual (1992). These options are as follows:

1. "No action. If the plan is generally progressing as expected or if progress is slower than expected but will probably meet goals within a reasonable amount of time, no significant action is appropriate. Schedules will be updated accordingly and communicated to stakeholders and the USEPA.
2. Maintenance. To keep plan development on course toward its goals, additional project actions may be required or new projects may need to be incorporated. The watershed plan itself will also need to be regularly maintained to reflect current understanding of goals and outcomes intended in the future.
3. Adding, abandoning, or decommissioning plan elements. Significant changes in parts of the implemented restoration plan might be needed. These entail revisiting the overall plan, as well as considering changes in the design of individual elements.
4. Modification of goals. Monitoring might indicate that the project is not progressing toward the original goals, but is progressing toward a system that has other highly desirable functions. In this case;-the participants might decide that the most cost=effective action would-be-to-modi the-goals rather than to make extensive physical changes to meet the original goals."

The Tribal Environmental Laboratory undergoes quality assurance and quality control assessments annually, including an inspection conducted every one to two years by the state of North Carolina. Periodic assessments by EPA Region 4 and SESD are also conducted, both on-site and through annual reporting mechanisms. In-house assessments of sampling and analytical methodology and personnel assessments are conducted at least annually by the Laboratory Supervisor. In addition, an internal quality assurance assessment and technical review is conducted annually by the program team to assess program progress and effectiveness. Proof of current certification/qualifications will be required by the Tribe of outside laboratories who receive samples for processing.

Questionable data readings, equipment malfunctions and other issues encountered during sample collection and data generation are handled as soon as possible. Measurements generated by a calibrated instrument or piece of equipment not functioning within the technical specifications of the manufacturer or appropriate SOP will not be used. Problems that may impact data quality should be properly documented and the resulting data should be flagged accordingly. Public surveys that do not meet pre-established criteria for statistical validity will be considered, but will not be used to guide the progression of watershed plan implementation. Tribal staff will coordinate with Tribal leadership and USEPA Project Officers where necessary, to identify acceptable levels of public participation prior to the use of surveys.

Any failure to meet data quality objectives will be evaluated. If the cause is found to be equipment failure, calibration and maintenance procedures well be reassessed and improved. If the problem is found to be personnel error, personnel will work with the Laboratory Activities QC Officers to resolve the problem. If accuracy and precision goals are frequently not being met, QC sessions will be scheduled more frequently by the appropriate Laboratory Activities QC Officers. Findings will be forwarded to the EBCI Project Manager and Quality Assurance Manager. Additional QC checks may also be incorporated if the Project Manager and QC Officers deem it necessary.

If failure to meet the program specifications is found to be unrelated to equipment methods, or personnel error, the QAPP may need to be revised. Revisions and subsequent modifications and amendments to this QAPP will be submitted to the designated EPA Region 4 and SESD personnel for review and approval.

A performance audit of benthic collection and identification will be performed by the EBCI Laboratory Activities QC Officers to assess the field staff's adherence to quality assurance-quality control protocols. For the field work, a qualified field biologist (e.g., USEPA biologist, NCDWQ biologist, or consulting biologist) will conduct bi-annual audits of the EPT collection method by Tribal staff. The independent biologist will also observe the Tribal collector's selection and sorting by order. These assessments will be qualitative and instructive in nature. Significant corrective actions recommended will be documented in the Tribe's CWA § 106 Quality Assurance Management Plan (QAMP) and QAPP for future reference.

Samples that have been grouped by family in the laboratory and sent to the taxonomist will also be checked for accurate identification. The number placed in the wrong Family or Families missed will be quantified. The taxonomist will document the common errors in their report to the Tribe's Laboratory Activities QC Officers and recommend corrective action. The Laboratory Activities QC Officers and Laboratory Activities Leader will discuss the corrective action with the taxonomist and are responsible for implementation. The Laboratory Activities QC Officers will also calculate accuracy based on the EPT Families identified by field staff and those identified by the taxonomist.

As the EBCI begins to implement its watershed enhancement/restoration and assessment program, independent assessments of the work will be helpful to achieve a successful program. Performance audits of pebble counts, cross-sections and other pa~anTeters are-especially important. The audits-will-be performed by individuals employed by the Tribe who are experienced in data collection methods being evaluated and who are not routinely involved in the measurement process or by a qualified outside party.

For the field work, a qualified field technician (e.g., experienced USEPA or consulting engineer/scientist) will conduct an audit of the data collection methods used by Tribal staff. These assessments will be qualitative and instructive in nature. Recommended corrective actions will be documented in the Tribe's CWA § 319 QAMP and QAPP for future reference.

The assessments planned are described in Analytical Methods (B4). They entail the use of sediment transport capacity indices, cross-sections, longitudinal profiles, and vegetation survival counts to characterize restoration/enhancement project success or failure. The assessment decisions for project success should be reviewed annually to confirm if the measurements used are appropriately representing project success or failure. The Watershed Restoration Activities Leader will be responsible for conducting this review and reporting findings to the EBCI Quality Assurance Manager. Adjustments to the collection methods, measurements, or analysis results may be made. Any changes will be reported in revised editions of this QAPP. Additionally, results of the assessments will be reported after years three and five of monitoring in OENR's annual CWA § 319 program reporting to the USEPA. Revisions to this QAPP and CWA § 319 program reporting will be the responsibility of the Project Manager.

C2. REPORTS TO MANAGEMENT

The QC Officers will report significant issues or milestones met to the Project Manager verbally or in written form (at the discretion of the Project Manager) on a monthly basis. The Project Manager will report the project status verbally or in written form to the Project QA Manager (discretion of the Project QA Manager), on a monthly basis.

The Project QA Manager and/or Project Manager will be responsible for attending community meetings and meetings with Tribal leadership to keep the community and other stakeholders abreast of project activities. Physical, water chemistry, and biological data generated will be entered on a monthly basis into the Tribe's water quality database. Data generated from geomorphic surveys will be provided to the Watershed Restoration Activities Leader in Microsoft Excel, Autocad, and/or pdf format by survey parties used (Tribal and third party) during the design and post construction phase of watershed project implementation. As-built or final drawings will be submitted to the Project Manager once construction is complete for use in drafting project reports to the USEPA. Raw data from the Lower Oconaluftee water quality monitoring will be made available to the Project Manager on a quarterly basis. As part of the Tribe's CWA § 319 program reporting to the USEPA, the following topics will be issued to the USEPA Project Officer in final project reports when applicable:

- QA/QC problems, recommended solutions, and results of corrective actions taken;
- Changes in the QAPP/QAMP;
- Summary of the QA/QC program, training, and accomplishments;
- Results of the systems audit of Tribal staff field methods;
- Data quality assessment in terms of precision, accuracy, representativeness, completeness, and comparability;
- Qualitative uncertainty estimates based on the performance evaluation and data quality assessment;
- Reporting of whether the QA objectives were met, and the resulting impact on decision making;
- An account of lessons learned while completing the nine-element process recommended by the
- USEPA for developing a watershed plan; and
- Major outcomes of the watershed plan development process.

DATA VALIDATION AND USABILITY

D1. DATA REVIEW, VERIFICATION, AND VALIDATION

The EBCI Data Analysis and Processing Leaders, Data Analysis and Processing QC Officer, and QA Manager will employ quantitative and qualitative criteria outlined in this QAPP to review, verify, and validate that project data meet the DQO(s) defined in A7. An independent expert (USEPA QC Officer, consulting watershed planner, or consulting taxonomist/biologist) may be used to provide assistance to the Data Analysis and Processing Leaders and QC Officer and the QA Manager regarding planning and alternative actions and how they affect decision making as necessary.

D2. VALIDATION AND VERIFICATION METHODS

The Project Manager, Primary Quality Control Officer and Project QA Manager will verify and validate project data using the methods described in this QAPP. Raw data should be kept in hard copy and entered in an electronic database with ample backup storage. Calculations, such as that for water quality sampling and surveying, commonly contain errors. Therefore, these will be quality checked to ensure accuracy. Project job titles have been provided to assign responsibility for individual tasks. QC mechanisms have been described to reduce the chances of errors being made. The Project Manager will attempt to resolve any errors discovered by consulting the individuals involved in that particular exercise.

For the quantitative criteria, data will be accepted if it meets the specified performance criteria. If it does not meet the specified performance criteria, an assessment of why this occurred will be conducted. If possible, the error will be corrected. For example, if field staff misidentifies a particular family level for benthic macroinvertebrate sampling, it may be corrected when that error is noted by the taxonomist. In some cases, it may be necessary to update the Tribe's SOPS, QAMP and QAPP applicable to the project. If it is determined by the Primary QC Officer or Project Manager that an uncorrectable error in the sampling or analysis process has occurred, re-sampling will be conducted after approval from the Project QA Manager. If no specific error is identified, the data will be kept though qualified in the monitoring database and project report that they did not meet performance criteria. In this case, where replicates were sampled for precision, site averages will be calculated for water quality indicators, grain-size distribution and vegetation survival.
Problems identified with individual data points will be addressed by the QC Officers for the Watershed Restoration and Data Analysis Activities Leaders. Completeness (see A7) will be assessed for each monitoring station and cumulatively. If a sample site is deemed to be invalid by the Project QA Manager, it will not be included in the database though a notation will be included in the project report that it was sampled and why it was considered invalid.

D3. RECONCILIATION WITH USER REQUIREMENTS (DATA QUALITY OBJECTIVES)

DQOs will be reviewed annually by the Project Manager, Primary QC Officer and Project QA Manager. Those individuals will also assess collected data against these objectives. If the collected data fail to meet the project specifications for impairment decisions, updates to the monitoring plan and QAPP will be considered to prevent repetition of the error(s).

Any limitations on the use of the data will be discussed and clearly communicated to the community and decision makers in project reports and meetings open to the public.

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APPENDIX A. CHAIN-OF-CUSTODY FORM

CHAIN-OF-CUSTODY FORM

DATE ______________________

FIELD LEADER SIGNATURE

____

SITES: ______________________

TOTAL # OF
SAMPLES DELIVERED ______________

____

DELIVERY TO QUALIFIED
TAXONOMIST

DATE TIME ______________

PROJECT MANAGER SIGNATURE

____

DELIVERY TO PROJECT MANAGER DATE

TIME

____

SIGNATURE OF QUALIFIED TAXONOMIST

____

DATE RESULTS

DELIVERED ______________________

RESULTS DELIVERED BY

____

PROJECT MANAGER SIGNATURE

____

SAMPLE ID NUMBERS:

APPENDIX B: LABORATORY BENCH SHEET

Figure 1.

CHEROKEE WASTEWATER TREATMENT PLANT LABORATORY SAMPLE-COLLECTION SKEET

CLIENT INFORMATION: NAME: ______________________________

ADDRESS:

WEATHER: ______________________________ **DATE:**

AIR TEMP.____________________ C

SAMPLE INFORMATION:

FIELD .TESTING

SAMPLE ID	SAMPLE	D. 0.	pH	PO4	PRESERVATION	SAMPLE	TIME

SAMPLER'S SIGNA~RE: ______________________________

FIELD ANALYST:

RELINQUISHED BY: -______________________________

DATE: ____________________

ARRIVAL

SAMPLE ID	TIME	TEMP		COMMENTS
				I

RECEIVED BY:

DATE: - TIME

ANALYST: ______________________________

DATE: TIME:

APPENDIX C: NCDWQ HABITAT ASSESSMENT FORM

Appendix E DWQ Stream Habitat Evaluation Form

5/99 Revision 4

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Directions for use of this Assessment: The observer is to survey a minimum of 100 meters of stream, preferably in an upstream direction starting above the bridge pool and the road right-of-way. The stream segment which is assessed should represent average stream conditions. In order to perform a proper habitat evaluation the observer needs to get into the stream. All meter readings need to be performed prior to walking the stream. When working the habitat index, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. There are eight different metrics in this index and a final habitat score is determined by adding the results from the different metrics.

Stream__________________________Location/Road______________________County_______________________

Date__________________CC#______________Basin_____________________Subbasin______________________

Observer(s)______________________Office Location__________________Agency __________________________

Type of Study: Fish Benthos Basinwide Special Study (Describe) _______________________________

Latitude ____________Longitude _____________Ecoregion (circle one) MT P Distance Surveyed_______meters

Physical Characterization: Land use refers to immediate area that you can see from sampling location - include what you see driving thru the watershed in the remarks section. Also use the remarks section for such descriptions as "deeply incised" or "exposed bedrock" or other unusual conditions.

Land use: Forest_____% Active Pasture_____% Active Crops_____% Fallow Fields_____% Commercial_____% Industrial_____% Residential_____% Other _____%-Describe:____

Width: (meters) Stream_________ Channel___________ Average Stream Depth: (m)__________ Velocity______m/sec

Flow conditions (circle one): High Normal Low

Manmade Stabilization: Y[ ] N[ ] Describe:____

Water Quality: Temperature____^{0}C Dissolved Oxygen _______mg/l Conductivity ______µmhos/cm pH _______

Turbidity: (circle) Clear Slightly Turbid Turbid Tannic

Weather Conditions:____**Photo #**____________________________

Remarks:____

____

I. Channel Modification (Use topo map as an additional aid for this parameter)

	Score
A. channel natural, frequent bends (good diversity of bends or falls)...	5
B. channel natural, infrequent bends..	4
C. some channelization present...	3
D. more extensive channelization, >40% of stream disrupted..	2
E. no bends, completely channelized or rip rapped or gabioned, etc...	0

Remarks____Subtotal_____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. Circle the habitats which occur- **(Rocks) (Macrophytes) (sticks and leaf packs) (snags and logs) (undercut banks or root mats)** Definition: leafpacks consist of older leaves that are packed together and have begun to decay. Piles of leaves in pool areas are not considered leaf packs. EXAMPLE: If >70% of the reach is rocks, 1 type is present, circle the score of 17.

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70%	40-70%	20-40%	<20%
	Score	Score	Score	Score
4 or 5 types present................	20	16	12	8
3 types present........................	19	15	11	7
2 types present........................	18	14	10	6
1 type present..........................	17	13	9	5
No types present..........................	0			

Remarks____Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) look at entire reach for substrate scoring, but only look at riffle for embeddedness.

	Score
A. substrate with good mix of gravel cobble and boulders	
1. embeddedness <20% (very little sand, usually only behind large boulders)........................	15
2. embeddedness 20-40%..	12
3. embeddedness 40-80%..	8
4. embeddedness >80%...	3
B. substrate gravel and cobble	
1. embeddedness <20%...	14
2. embeddedness 20-40%..	11
3. embeddedness 40-80%	6
4. embeddedness >80%...	2
C. substrate mostly gravel	
1. embeddedness <50%...	8
2. embeddedness >50%...	2
D. substrate homgeneous	
1. substrate nearly all bedrock..	3
2. substrate nearly all sand	3
3. substrate nearly all detritus..	2
4. substrate nearly all silt/ clay..	1

Remarks____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m area surveyed)	
a. variety of pool sizes..	10
b. pools same size..	8
2. Pools Infrequent (<30% of the 100m area surveyed)	
a. variety of pool sizes..	6
b.pools same size...	4
B. Pools absent	
1. Runs present..	3
2. Runs absent..	0

Remarks____Page Total______

V. Riffle Habitats

	Riffles **Frequent**	Riffles **Infrequent**
	Score	Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream.....	16	12

B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent....	0	

Subtotal_____

VI. Bank Stability and Vegetation

	Left Bank Score	Rt. Bank Score
A. Banks stable		
1. no evidence of erosion or bank failure, little potential for erosion	7	7
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems...............................	6	6
2. few trees or small trees and shrubs; vegetation appears generally healthy.....................	5	5
3. sparse vegetation; plant types and conditions suggest poorer soil binding.......................	3	3
4. mostly grasses, few if any trees and shrubs, high ersosion and failure potential at high flow	2	2
5. no bank vegetation, mass erosion and bank failure evident...	0	0

Total______

Remarks____

VII. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** shading with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent..	8
C. Stream with **partial** shading - sunlight and shading are essentially equa...................................	7
D. Stream with **minimal** shading - full sun in all but a few areas..	2
E**. No shading**..	0

Remarks____Subtotal____

VIII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters...	5	5
2. zone width 12-18 meters...	4	4
3. zone width 6-12 meters...	3	3
4. zone width < 6 meters...	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters..	4	4
b. zone width 12-18 meters..	3	3
c. zone width 6-12 meters..	2	2
d. zone width < 6 meters...	1	1
2. breaks common		
a. zone width > 18 meters..	3	3
b. zone width 12-18 meters..	2	2
c. zone width 6-12 meters..	1	1
d. zone width < 6 meters...	0	0

Remarks____ Total______

TOTAL SCORE ____________________

5/99 Revision 4

APPENDIX D: PEBBLE COUNT FORM

PEBBLE COUNT DATA SHEET: REACH-WIDE COUNT

	PROJECT NO.
SITE OR PROJECT:	
REACH/LOCATION:	
DATE COLLECTED:	
FIELD COLLECTION BY:	
DATA ENTRY BY:	

			PARTICLE CLASS WEIGHT (g)			Reach Summary		Riffle Summary		Pool Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Pool	Total	Class %	% Cum	Class %	% Cum	Class %	% Cum
	Silt / Clay	< .063					#DIV/0!		#DIV/0!		#DIV/0!
	Very Fine	.063 - .125					#DIV/0!		#DIV/0!		#DIV/0!
	Fine	.125 - .25					#DIV/0!		#DIV/0!		#DIV/0!
	Medium	.25 - .50					#DIV/0!		#DIV/0!		#DIV/0!
	Coarse	.50 - 1.0					#DIV/0!		#DIV/0!		#DIV/0!
	Very Coarse	1.0 - 2.0					#DIV/0!		#DIV/0!		#DIV/0!
GRAVEL	Very Fine	2.0 - 2.8					#DIV/0!		#DIV/0!		#DIV/0!
	Very Fine	2.8 - 4.0					#DIV/0!		#DIV/0!		#DIV/0!
	Fine	4.0 - 5.6					#DIV/0!		#DIV/0!		#DIV/0!
	Fine	5.6 - 8.0					#DIV/0!		#DIV/0!		#DIV/0!
	Medium	8.0 - 11.0					#DIV/0!		#DIV/0!		#DIV/0!
	Medium	11.0 - 16.0					#DIV/0!		#DIV/0!		#DIV/0!
	Coarse	16.0 - 22.6					#DIV/0!		#DIV/0!		#DIV/0!
	Coarse	22.6 - 32					#DIV/0!		#DIV/0!		#DIV/0!
	Very Coarse	32 - 45					#DIV/0!		#DIV/0!		#DIV/0!
	Very Coarse	45 - 64					#DIV/0!		#DIV/0!		#DIV/0!
COBBLE	Small	64 - 90					#DIV/0!		#DIV/0!		#DIV/0!
	Small	90 - 128					#DIV/0!		#DIV/0!		#DIV/0!
	Large	128 - 180					#DIV/0!		#DIV/0!		#DIV/0!
	Large	180 - 256					#DIV/0!		#DIV/0!		#DIV/0!
BOULDER	Small	256 - 362					#DIV/0!		#DIV/0!		#DIV/0!
	Small	362 - 512					#DIV/0!		#DIV/0!		#DIV/0!
	Medium	512 - 1024					#DIV/0!		#DIV/0!		#DIV/0!
	Large-Very Large	1024 - 2048					#DIV/0!		#DIV/0!		#DIV/0!
BEDROCK	Bedrock	> 2048					#DIV/0!		#DIV/0!		#DIV/0!
		Total	0	0	0	0%	#DIV/0!	0%	#DIV/0!	0%	#DIV/0!

Largest particles: ________________ **mm**
(riffle) **(pool)**

PEBBLE COUNT DATA SHEET: RIFFLE 100-COUNT

SITE OR PROJECT:	
REACH/LOCATION:	
DATE COLLECTED:	
FIELD COLLECTION BY:	
DATA ENTRY BY:	

			PARTICLE CLASS COUNT	Summary	
MATERIAL	PARTICLE	SIZE (mm)	Riffle	Class %	% Cum
	Silt / Clay	< .063			#DIV/0!
SAND	Very Fine	.063 - .125			#DIV/0!
	Fine	.125 - .25			#DIV/0!
	Medium	.25 - .50			#DIV/0!
	Coarse	.50 - 1.0			#DIV/0!
	Very Coarse	1.0 - 2.0			#DIV/0!
GRAVEL	Very Fine	2.0 - 2.8			#DIV/0!
	Very Fine	2.8 - 4.0			#DIV/0!
	Fine	4.0 - 5.6			#DIV/0!
	Fine	5.6 - 8.0			#DIV/0!
	Medium	8.0 - 11.0			#DIV/0!
	Medium	11.0 - 16.0			#DIV/0!
	Coarse	16.0 - 22.6			#DIV/0!
	Coarse	22.6 - 32			#DIV/0!
	Very Coarse	32 - 45			#DIV/0!
	Very Coarse	45 - 64			#DIV/0!
COBBLE	Small	64 - 90			#DIV/0!
	Small	90 - 128			#DIV/0!
	Large	128 - 180			#DIV/0!
	Large	180 - 256			#DIV/0!
BOULDER	Small	256 - 362			#DIV/0!
	Small	362 - 512			#DIV/0!
	Medium	512 - 1024			#DIV/0!
	Large-Very Large	1024 - 2048			#DIV/0!
BEDROCK	Bedrock	> 2048			#DIV/0!
		Total	0	0%	

Largest particles: ________

(riffle)

APPENDIX E: BENTHIC MACROINVERTEBRATE SAMPLE BENCH SHEET

MACROINVERTEBRATE IDENTIFICATION SHEET

Sample #:

Site ID: ____________________
Stream: ____________________
Sub Basin:

Collection Date: ____________________
Collectors: ____________________
Analysts: ____________________

Order	Family	Genus	Species	Total Value	Total #	Abundance	Cked BY:	FT

Total # Organisms: ____________________
Total Taxa (S_T):
Total EPT (Sept):

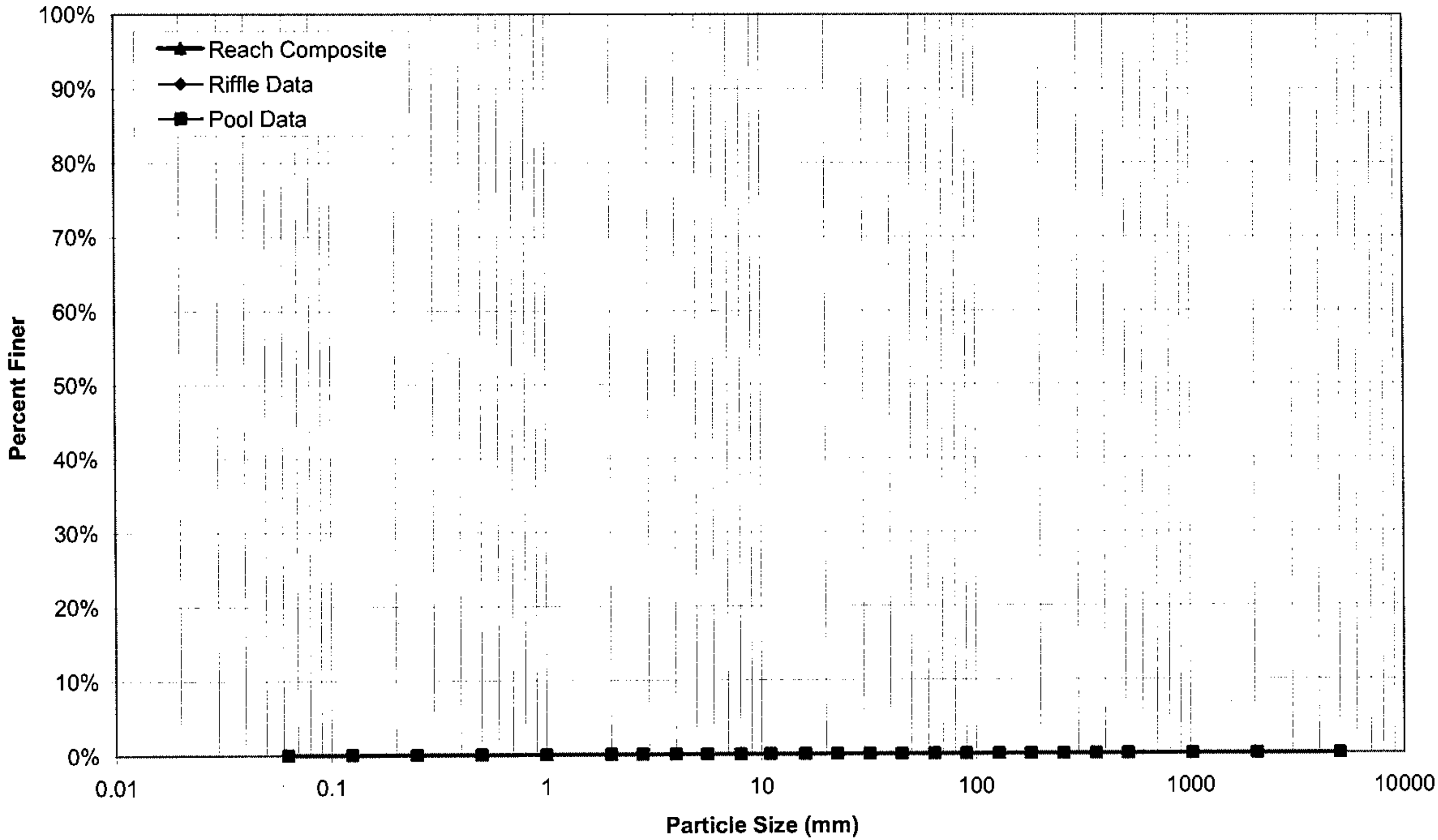
Species Diversity: ____________________
EPT Biotic Index: ____________________
Water Quality Rating: ____________________

[# counted = Abundance rating(numeric value)] 1 - 2 = Rare (1) 3 - 9 = Common (3) 10 - > = Abundant (10)

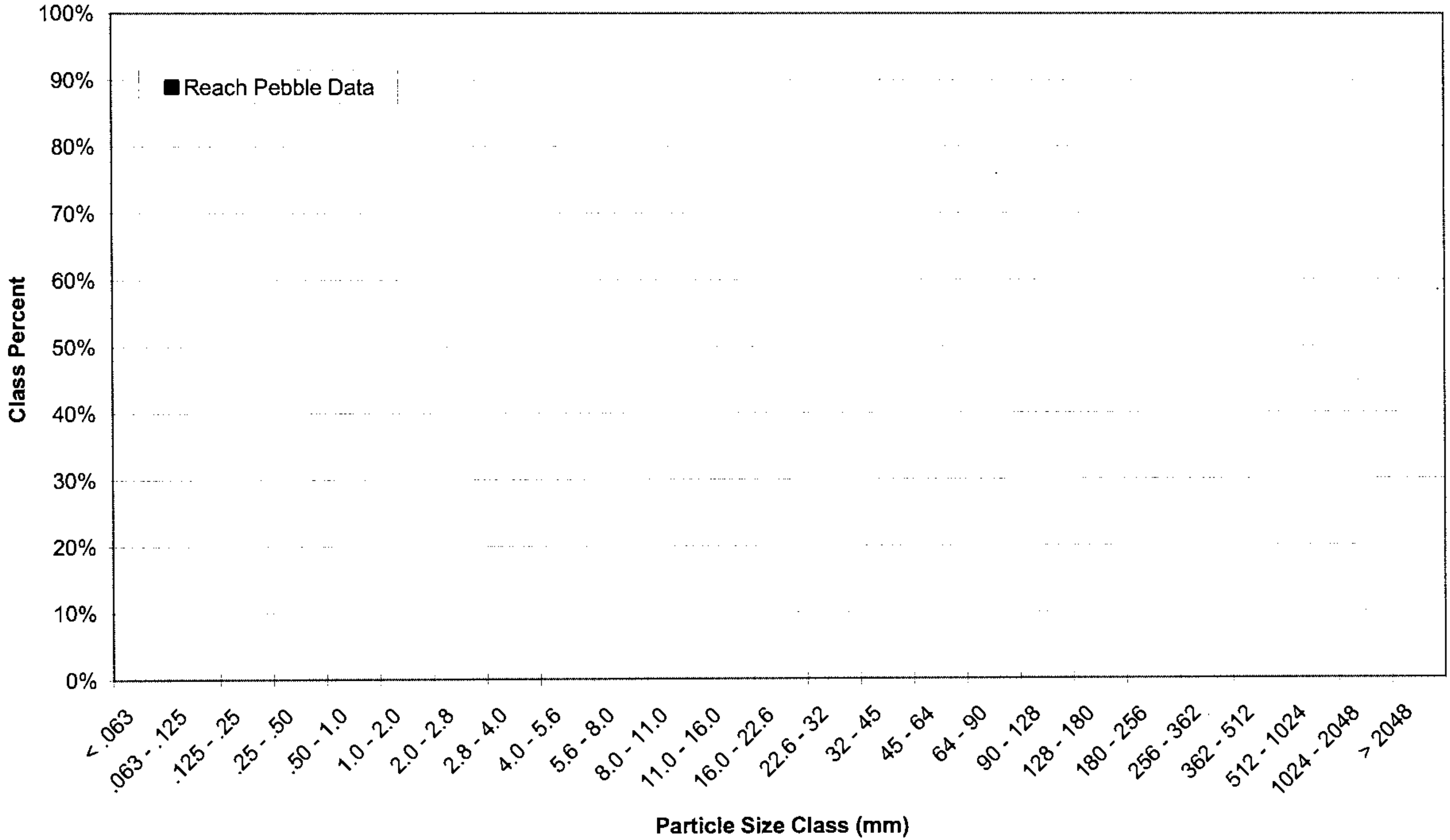
Feeding Type (FT) 0 -Herbivor // 1 -Shredder // 2 -Filter Feeder // 3 -Collector // 4 -Scraper // 5 -Predator // 6 -Omnivore // 7 -Deposit Feeder

APPENDIX F: SEDIMENT ANALYSIS SPREADSHEET

Stream
Reach
Pebble Count Particle Size Distributions



Stream
Reach
Reach Pebble Count Size Class Distribution

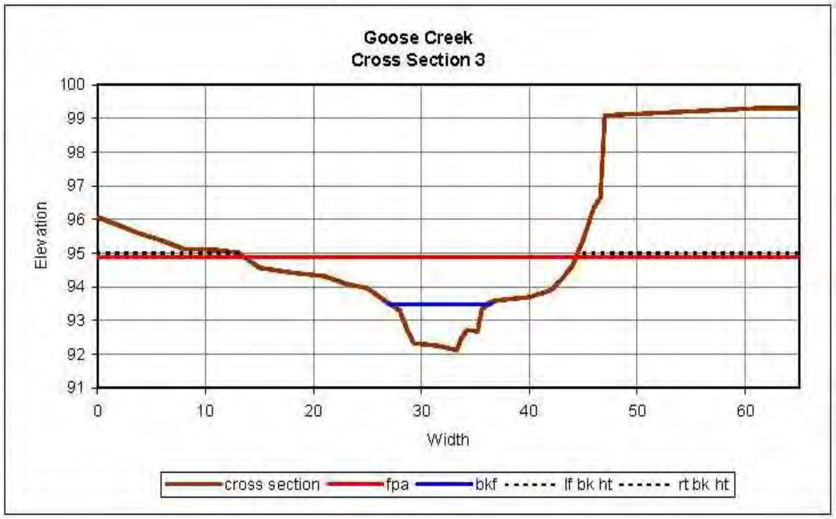


APPENDIX G: EXAMPLE OF GEOMORPHIC SPREADSHEETS

Goose Creek Cross Section 3 - 2008 Survey Data

Station	Elevation	Feature
0.00	96.06	
4.00	95.57	
6.00	95.37	
8.00	95.13	
11.00	95.10	
13.00	95.01	
15.00	94.57	
18.00	94.42	
21.00	94.32	
23.00	94.09	
25.00	93.96	
27.00	93.50	
28.00	93.31	
28.70	92.72	LEW
29.30	92.32	
30.50	92.29	
31.50	92.26	
33.30	92.13	
33.60	92.42	TW
34.20	92.72	REW
35.20	92.68	
35.60	93.34	
36.50	93.57	
38.00	93.64	
40.00	93.70	
42.00	93.90	
43.00	94.23	
44.00	94.62	
45.00	95.41	
46.00	96.36	
46.60	96.65	
47.00	99.08	
61.00	99.29	
65.00	99.29	

Cross Section Plot



Summary Data	
Parameters	**2008**
Bankfull Cross Section Area (ft²)	8.0
Bankfull Width (ft)	9.2
Bankfull Mean depth (ft)	0.9
Bankfull Max Depth (ft)	1.4
Width/Depth Ratio	10.6
Entrenchment Ratio	3.3
Classification	--

Cross Section Photos

Looking upstream.

Looking downstream.

APPENDIX H: WATERSHED RESTORATION CHECKLIST

Lower Oconaluftee Watershed Plan Restoration Activities Checklist

During Planning...

- ☐ Have all potential participants been informed of the restoration initiative?
- ☐ Has an advisory committee been established?
- ☐ Have funding sources been identified?
- ☐ Has a decision structure been developed and points of contact identified?
- ☐ Have steps been taken to ensure that participants are included in the restoration processes?
- ☐ Has the problem that requires treatment been investigated and defined?
- ☐ Has consensus been reached on the mission of the restoration initiative?
- ☐ Have restoration goals and objectives been identified by all participants in the restoration effort?
- ☐ Has the restoration been planned with adequate scope and expertise?
- ☐ Has the restoration plan had an annual or midcourse correction point in line with adaptive management procedures?
- ☐ Have the indicators of stream corridor structure and function been appropriately linked to the restoration objectives?
- ☐ Have adequate monitoring, management, and maintenance programs been specified as an integral part of the restoration plan?
- ☐ Have costs and operational details been integrated so results are available to serve as input in improving techniques used in the restoration work?
- ☐ Has an appropriate reference system (or systems) been selected from which to extract target values of performance indicators for comparison in conducting the evaluation of the restoration initiative?
- ☐ Is there sufficient baseline data on the stream corridor to facilitate before-and-after treatment comparisons?
- ☐ Have critical restoration procedures been tested on a small experimental scale to minimize the risks of failure?
- ☐ Is the length of the monitoring program sufficiently long to determine whether the restoration work is effective?
- ☐ Have risk and uncertainty been adequately considered in planning?
- ☐ Have alternative designs been formulated?
- ☐ Have cost-effectiveness and incremental cost of alternatives been evaluated?

During Project Implementation and Management...

- ☐ Based on monitoring, are the anticipated intermediate objectives being achieved? If not, are steps being taken to correct the problem(s)?
- ☐ Do objectives or performance indicators need to be modified? If so, does monitoring program need to be modified also?
- ☐ Is the monitoring program adequate?

During Postrestoration...

- ☐ To what extent were restoration plan objectives achieved?
- ☐ How similar in structure and function is the restored corridor ecosystem to the reference ecosystem?
- ☐ To what extent is the restored corridor self-sustaining (or will be), and what are the maintenance requirements?
- ☐ If all stream corridor structure and functions were not restored, have the critical structure and functions been restored?
- ☐ How long did the restoration initiative take?
- ☐ What lessons have been learned from this effort?
- ☐ Have those lessons been shared with interested parties to maximize the potential for technology transfer?
- ☐ What was the final cost, in net present value terms, of the restoration work?
- ☐ What were the ecological, economic, and social benefits realized by the restoration initiative?
- ☐ How cost-effective was the restoration initiative?
- ☐ Would another approach to restoration have produced desirable results at lower cost?

(*Adapted from National Research* Council, **1992)**

APPENDIX I: EQUIPMENT LIST

Table 7.1 Equipment List for Physical and Chemical Water Quality Sampling

1.	Oxygen-sensitive membrane electrode, with appropriate meter
2.	YSI 58 field meter
3.	LaMotte test kit for total nitrogen
4.	Orion 3-Star (or equivalent) pH meter
5.	Glass electrode (pH)
6.	Stirring apparatus (pH-optional)
7.	Squeeze bottle with deionized water
8.	Buffer reagents (pH values 4, 7, and 10)
9.	Digestion reagents and chemical constituents and solutions (i.e., HCI, sulfuric acid, sodium hydroxide, etc.) as required by standard methods used
10.	Plastic bottles as required
11.	Glass beakers, volumetric flasks and pipettes (1 and 10 mL; sterile, disposable) as required
12.	Glass culture tubes (linerless polypropylene caps, 20mm OD and 150mm long)
13.	Balance (analytical, capable of accurately weighing to the nearest 0.0001g)
14.	Spectrophotometer (capable of measurements at 650 or 880 nm with path length of 5.0 cm or longer)
15.	Spectrophotometer cells (includes flow cells with path lengths of 1.0 cm or longer)
16.	Autoclave capable of heating samples to temperatures required by standard methods used
17.	Nephelometer for assessing turbidity (with light source for illuminating sample; one or more photoelectric detectors with readout device to indicate intensity of light scattering)
18.	Sample cells of clear colorless glass (turbidity monitoring)
19..	Silicone Oil (turbidity-monitoring)
20.	Soft, lint-free cloth
21.	Reagents (stock primary formazin standards; gelex secondary standards)
22.	Hach 500 Series (portable unit)
23.	Sample bottles (250 mL or 1-1 polyethylene bottles with caps)
24.	Maps of site location and access routes
25.	Digital camera
26.	Waders, knee boots, and rain gear
27.	First aid kit, heavy duty flashlight, batteries
28.	Bug repellant and sunscreen
29.	Global Positioning System (GPS) Unit
30.	Latex Gloves
31.	Vehicle and identification
32.	Notebook, pens, pencils and field sheets (including chain-of-custody forms)
33.	Insulated coolers and access to ice
34.	Tape for sealing coolers
35.	Refrigerator
36.	Spare parts for field meters and other laboratory equipment

Table 7.2 **Equipment List for Benthic Macroinvertebrate Sampling**

1.	Square meter kicknet, standard no. 30 mesh (595 µm openings) (including pole attachments)
2.	Additional kicknet, as backup
3.	Sample containers, two-three 1-liter, plastic, opaque, straight-sided, w/ screw tops (per station)
4.	Maps of site location and access routes
5.	Two internal labels per station
6.	12 pencils, no. 2
7.	Grease pencils, two-three (per trip)
8.	Scissors, one-pair
9.	Forceps, three or four pair
10.	Wash bottle, 1-liter capacity
11.	Sieve bucket, standard no. 30 mesh (595 um openings)
12.	Two 1-gallon buckets (plastic)
13.	One clipboard
14.	95 percent ethanol; 0.5 gallon per station (container should be appropriate for pouring into sample containers with minimum spillage)
15.	Funnel
16.	Hip and/or chest waders with felt-soled boots, one per crew member
17.	Log book (bound)/Field notebook (write-in-the-rain preferred)
18.	Data sheet (may be write-in-the-rain) or PDR
19.	Box or cooler for sample transport
20.	Dice for random number determination
21.	First aid kit
22.	Rubber gloves, heavy gloves
23.	Waterproof tape
24.	Compass
25.	Watch with timer or stop watch
26.	Camera
27.	Patch kit for waders
28.	Plastic sampling trays (e.g., photography developing trays)

Table 7.3 Equipment List for Geomorphic and Vegetation Surveys	
1.	Laser level or Total station
2.	Survey rod (with laser receiver attached if using laser level)
3.	Gallon Ziploc bags
4.	Maps of site location and access routes
5.	Permanent markers
6.	Pebble count datasheet
7.	Embeddedness datasheet
8.	Survey datasheet
9.	Sand reference card
10.	60-cm-steel hoop
11.	Bottomless 5-gallon bucket
12.	Steel pry bar
13.	Stop watch and float
14.	Gravelometer
15.	Batteries (back-up); back-up batteries for survey gun
16.	Battery chargers
17.	Field notebook and writing utensils
18.	Felt-soled waders
19.	Machetes or other equipment for cutting through brush
20.	Flagging, spray paint, stakes, and survey pins
21.	Stake bag
22.	Hammer/mallet
23.	Pocket rod
24.	150' or 300' tape
25.	Survey rod bi-pod
26.	Radios for communication
27.	Field vests
28.	First aid kit, bug repellant, sunscreen, snake chaps