Snowbird Creek Tributaries Mitigation Project

Baseline Monitoring Document and As-built Baseline Report

Graham County, North Carolina

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EXECUTIVE SUMMARY

The Snowbird Creek Tributaries site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents base-line, as-built monitoring data for the five-year monitoring period. The goals for the restoration project were as follows:

- Promote and recreate geomorphically stable conditions at the Snowbird Creek Tributaries project site;
- The reduction of sediment and nutrient inputs through restoration of riparian areas and stream banks; and
- To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restoration of an incised, channelized, and eroding stream by creating a stable channel that has access to its floodplain; enhancement of a previously disturbed stream reach by replanting the riparian corridor with native woody vegetation;
- Improve water quality by establishing buffers for nutrient removal from runoff;
- Improve in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion; and
- Improve terrestrial habitat by removing invasive species, planting riparian areas with native vegetation and protecting these areas with a permanent conservation easement so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

Except for low density residential development, logging roads and remnants of a small, recent logging operation, the Snowbird Creek tributaries are in a watershed that is primarily deciduous forest. Although the project watershed has been impacted by past logging activities, the upland areas comprising the larger part of the watershed have largely returned to a more natural state. Various sections of property within the valley bottom have since been converted for residential and agricultural use. The present landowners currently maintain a couple of acres as open field. There are three single-family residences located in the vicinity of the project streams.

During development of the land for agricultural and residential use, the lower reach of UT3 to Hooper Branch was impacted by channel relocation, channelization, and pasture conversion. Other sections of the project area were impacted during historic logging activities. The affects of these practices over time led to channel incision in some areas of UT3 and to a decreased quality of in-stream habitat from a combination of channel aggradation and embeddedness, proliferation of invasive species within the riparian buffer, and reduced channel shading. Widespread or systemic channel incision has been limited by a combination of grade control structures like exposed bedrock, large cobble and boulder substrate that are frequently found throughout these stream systems. Existing woody vegetation along stream banks has maintained stream stability although some channel erosion was present where woody vegetation had been removed.

This Baseline Monitoring Report presents data on as-built stream geomorphological parameters, stem count data from the vegetation monitoring station, and the number of times bankfull flows have been met or exceeded as measured by an on-site crest gauge. The design implemented for Snowbird Creek Tributaries mitigation project involved restoration, enhancement, and preservation. Reach 2 of UT3 was built to become a stable B3-type channel while the enhancement reach on UT2 should become a more stable B4-type channel. Based on geomorphic and vegetation data collected, this Site is currently on track to meet the hydrologic, vegetative, and stream success criteria specified in the Snowbird Creek Tributaries Mitigation Plan.

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1.0 PROJECT GOALS, BACKGROUND, AND ATTRIBUTES

The Snowbird Creek Tributaries mitigation site is located approximately one and a half miles southwest of Robbinsville in Graham County, North Carolina (Figure 1). The project site is situated in the Little Tennessee River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 04-04-04 and United States Geologic Survey (USGS) hydrologic unit 06010204020010. The Snowbird Creek Tributaries mitigation project is located in a watershed that is predominantly forested that also contains a small number of residences near the tributaries and Hooper Branch. The vast majority of the watershed is in forested cover, with less than one percent of land being in agricultural use. Over the past 100 years, various parcels within the project area have been impacted by logging activities as well as residential and agricultural land use within the valley bottom.

The project involved restoration or enhancement of 714 linear feet (LF) of two streams: Reach 2 of UT3 and Reach 2 of UT2. In addition, 7,497 LF of UT1, UT2 and UT3 were preserved with conservation easements. All three tributaries within the project area are identified as “blue-line” streams on the USGS topographic quadrangle (Robbinsville) that covers the site. In order to confirm stream determinations of these “blue-line” streams, a field evaluation was conducted using the North Carolina Division of Water Quality (NCDWQ) stream assessment protocol. Field observations noted on the NCDWQ Stream Identification Forms confirm that each of the project tributaries is perennial within the project area.

1.1 Restoration Summary

1.1.1 Location and Setting

The Snowbird Creek Tributaries mitigation site is located approximately one and a half miles southwest of Robbinsville in Graham County, North Carolina. To reach the project site from the intersection of NC Highways 143 and 129, turn south onto N.C. Highway 129. At the first stop light past the Microtel, turn right onto East Main Street, continue for approximately 0.3 miles, and turn left onto Atoah Street. Atoah Street becomes Snowbird Road (both are NC Highway 143). Snowbird Road (NC 143) will come to parallel Santeetlah Reservoir (an inundated portion of Snowbird Creek). At the intersection of IU Gap Road and Snowbird Road, the property will be situated to the east. The last house on the left before you get to this intersection is the property owner and just before you get to this house there is a gated dirt road that leads to UT1 and UT2. To get to UT3, turn left on IU Gap Rd., go .15 miles, the UT3 property is on the left and the access drive is on the left just past a small rented farm house.

Unnamed tributary 1, UT2 and UT3 comprise the three main watersheds within the project area, having a combined total drainage area of 0.39 square miles. Unnamed tributary 2 converges with UT1 before flowing into Snowbird Creek. Unnamed tributary 3 flows into Hooper Branch which then drains into Snowbird Creek.

1.1.2 Project Goals and Objectives

The goals for the Snowbird Creek Tributaries mitigation project are as follows:

- Promote and recreate geomorphically stable conditions at the Snowbird Creek Tributaries project site;
- Reduce sediment and nutrient inputs through restoration of riparian areas and stream banks; and
- Improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restoration of an incised, channelized, and eroding stream by creating a stable channel that has access to its floodplain; enhancement of a previously disturbed stream reach by replanting the riparian corridor with native woody vegetation;
- Improve water quality by establishing buffers for nutrient removal from runoff;
- Improve in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion; and
- Improve terrestrial habitat by removing invasive species, planting riparian areas with native vegetation and protecting these areas with a permanent conservation easement so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

In addition to the objectives stated above, the following overarching design objectives were incorporated into the design of the streams on this site:

- Make important design decisions based on hydraulic and sediment modeling in order to solve the issues of concern with process-based, site-specific information with consideration of regional hydrology and restoration design research and information.
- Use constructability as a guiding consideration in order to produce a realistic design that will be possible to build given field constraints and construction tolerances. Design ideas should be discussed with knowledgeable construction personnel to determine the constructability, likely footprint, and severity of impacts to on-site resources.
- Minimize disturbance to ecologically functional and physically stable areas; mimic the character of these areas and borrow materials from them where appropriate to create a more natural design.
- To the utmost extent possible, utilize native, on-site materials to realize design features. Utilizing on-site resources within the project area will aid in re-establishing a contiguous habitat between the project site and surrounding area that favors native flora and fauna. Minimizing construction materials brought onsite also reduces compaction and site disturbance from material transport, and produces an aesthetically pleasing result with the goal being minimal evidence of site disturbance.

1.1.3 Project Structure, Restoration Type, and Approach

1.1.3.1 Project Structure

Please refer to Table A1 in Appendix A for a summarization of the project structure of the Snowbird Creek Tributaries mitigation work. Figure 2, also in Appendix A, illustrates restoration approaches by project reach.

1.1.3.2 Restoration Type and Approach

UT2 (Reach 2)
An Enhancement II approach was used to improve a section of the riparian zone on UT2 that was left open by previous logging activities. The riparian buffer was replanted with native woody vegetation to provide bank stabilization, shading and other habitat functions. In addition, logging debris was removed from the channel where the banks had become unstable or the channel had aggraded due to impeded flow.

UT3 (Reach 2)

A Priority I Restoration approach was used to establish a stable, step/pool channel with greater pool habitat at the historical stream location in the lowest point in the valley. The constructed channel has also improved connectivity of the channel to floodplain. Bank stability was improved by eliminating nonnative vegetation and planting diverse tree, shrub and herbaceous species.

UT1, UT2 (Reaches 1 and 3), and UT3 (Reach 1)

These project reaches were preserved within a conservation easement that extends 50 linear feet on each side of the channel. They are characterized by a wide buffer of mature trees scattered within the stand with a dense herbaceous understory including ferns and mosses that line both banks.

1.1.4 Project History, Contacts and Attribute Data

The Snowbird Creek Tributaries project area drains low-density residential and forested land. The general area in which the project is located is rural in character, and is not likely to change significantly in the foreseeable future.

Except for a parcel of land near the confluence of UT1 and UT2, and UT3 and Hooper Branch that have been developed for residential use, the project area is forested. The largest percentage of land use in the project watersheds currently is in forested cover for wildlife habitat and hunting as well as timber production.

Anthropogenic land use alteration and channelization of streams in the Snowbird Creek Tributaries project watersheds have resulted in various stream corridor impacts. Small areas of incision, bank erosion, and other ongoing stream processes typical of adjusting streams were found on various reaches of UT3 and other tributaries within the project area. However, it was determined that the benefits of stream and riparian enhancement on most of these channels would not offset the disturbance required to address these needs; also the watershed continues to revert to a more natural state in the absence of intensive logging activities.

In accordance with the approved mitigation plan for the site, construction activities were conducted in August 2010. Project activity on UT2 consisted of improving bank stability and riparian conditions along a small section of UT2 that had been degraded by previous logging activities. An Enhancement II approach was used to stabilize this reach; efforts included replacing native woody vegetation in an area previously disturbed during logging activities and removal of debris from the channel that was contributing to channel disturbance. Re-vegetation of the riparian corridor will improve shading and provide high quality biomass to the stream in addition to other habitat improvements.

A Priority I Restoration approach was used on Reach 2 of UT3 to address prior manipulation and relocation of the reach by restoring a channel with step-pool morphology in the low part of the valley. The restoration of this reach of UT3 eliminated the bank erosion, aggradation of fines, and lack of native riparian vegetation and rootmass that characterized the former location of Reach 2 on UT3. The new channel has improved connectivity to its floodplain and channel bedform was improved by constructing a series of step-pool and riffle-pool sequences using grade control structures. These grade control structures will aid in dissipating streamflow energy, decrease pool-to-pool spacing and improve the quality of in-stream habitat present. Given the steepness of the project area, creating a step-pool channel system was critical in achieving a more stable profile and preventing self-propagating headcuts. A vegetated riparian buffer was also planted which will support streambank stability along the new reach while serving a variety of terrestrial and aquatic habitat functions.

In-stream structures were used to control streambed grade, reduce stresses on streambanks, and promote diversity of bedform and habitat. In-stream structures installed consist of constructed riffles, boulder steps, rock/log vanes, and embedded logs. Structures were spaced at a maximum distance that results in the downstream header protecting the upstream footer to create a redundancy that will ensure long term vertical stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and live staking. Transplants will provide living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

The chronology of the Snowbird Creek Tributaries mitigation project is presented in Table A2, Appendix A. Tables A3 and A4, which summarize the contact information for designers, contractors and plant material suppliers, and other relevant project background information are also located in Appendix A. Total stream length across the project is 8,135 LF.

2.0 SUCCESS CRITERIA

The five-year monitoring plan for the Snowbird Creek Tributaries mitigation project includes criteria to evaluate the success of the geomorphic, vegetative and hydrologic components of the project. The specific locations of the cross-sections, sediment sampling location, vegetation plot, crest gauge installation and permanent reference photo stations, are shown on the as-built plans submitted with this report.

2.1.1 Morphologic Parameters and Channel Stability

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include stream dimension (four permanent cross-sections), pattern (longitudinal survey), and profile (profile survey). Also related are the monitoring of bankfull flows and photographic documentation which are discussed in Sections 2.1.3 and 2.1.4, respectively. The methods used, and related success criteria, are described below for each parameter.

2.1.1.1 Dimension

Four permanent cross-sections were installed in representative riffle and pool reaches on UT3 to help evaluate the success of the mitigation project. Each cross-section was established by installing permanent pins on each bank to establish a consistent and repeatable transect from year-to-year. The cross-sectional surveys capture points at all breaks in slope and includes typical features such as top of bank, bankfull (if different from top of bank), inner berm, edge of water, and thalweg. Cross-sections are provided as Exhibit 2 of Appendix B. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

From year-to-year, change in cross-section dimensions should typically be limited to steepening of the banks from a gentler side-slope that they are typically constructed at to a steeper slope that is sustainable once complementary vegetation establishes. This vegetation of the banks and floodplain may promote further bank deposition and channel narrowing based on the resulting increase in roughness that accompanies dense vegetation establishment. These, and any other changes, will be evaluated to determine their root cause and whether they represent movement toward a more unstable condition (e.g., down-cutting or erosion) or movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.1.1.2 Pattern and Longitudinal Profile

A longitudinal profile was also completed for the entire project length of UT3-Reach 2 to provide a baseline for evaluating changes in channel bed conditions over time. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken along the longitudinal profiles include thalweg, water surface, left and right channel, bankfull, and top of low bank. The pools should remain deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type. Profile data collected should reflect stable channel bedform and a diverse range of riffle and pool complexes.

All measurements will be taken at the head of each feature (e.g., riffle, and pool) and at the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark to maintain a consistent vertical datum. Surveyed longitudinal profile data is provided in Appendix B as Exhibit 1.

The longitudinal profiles show that the bed features are stable; closely-spaced grade control structures should help maintain the overall profile desired.

2.1.1.3 Substrate and Sediment Transport

Bed material analysis will consist of a pebble count taken in the same constructed riffle (noted on the plans) during annual geomorphic surveys of the project site. This sample, combined with evidence provided by changes in cross-sectional and profile data will reveal changes in sediment transport and bed gradation that occur over time as the stream adjusts to upstream sediment loads and cross-sections evolve into a more permanent stable dimension. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes. The As-built survey does not reveal any significant areas of aggradation or degradation within the project area at this time.

2.1.2 Vegetation

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community.

In order to determine if the criteria are achieved, a vegetation monitoring quadrant was installed within the conservation easement of UT3 Reach 2. The restoration plan for the Snowbird Creek Tributaries Site specifies that the number of vegetation monitoring quadrants required will be based on the species/area curve method, as described in NCEEP monitoring guidance documents. The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. One vegetation plot, 10 by 10 meters in size, was established at the restored site and includes a 1 square meter sub-quadrant for herbaceous vegetation. The initial planted density within the vegetation monitoring plot is given in Table 6, Appendix C. The average density of planted bare root stems, based on the data from the eight monitoring plots, is 1,012 stems per acre which indicates that the Site is on track for meeting the minimum success interim criteria of 320 surviving planted trees per acre by the end of Year 3 and the final success criteria of 260 per acre by the end of Year 5. The location of the vegetation plot is shown on the as-built plan sheets. At the EEP's suggestion, Baker will also establish a smaller vegetation plot in the Enhancement II Reach on UT2 to evaluate riparian conditions over the course of the monitoring period. Findings from this plot will be reported in subsequent monitoring reports.

At the end of the first growing season, species composition, density, and survival will be evaluated for the vegetation plot on UT3. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between June and November. Individual quadrant data provided will include stem diameter, height, density, and herbaceous coverage. 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. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP. Seeding applied to streambanks beneath the erosion matting has sprouted with mixed success. Although initial seeding applied did not experience vigorous growth, erosion control applications including matting and straw mulch have been effective at preventing erosion and sedimentation and have helped ensure adequate streambank stabilization. To encourage a more vigorous herbaceous layer, permanent seed mix was re-applied on Reach 2 of UT3 and the site is being monitored. If groundcover continues to be weak, further action will be taken to ensure adequate soil fertility; a more prolific seed mixture will be employed at the site if necessary.

Live stakes and bare root trees planted were also planted to establish a healthy riparian buffer and to provide streambank stability. Bare-root trees were planted throughout the conservation easement within the enhancement and restoration reaches. A minimum 30-foot buffer was established along all restored or enhanced stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in the winter of 2011. Species planted are listed below.

Riparian Buffer Plantings (Bare-Root and Live Stake Species)

<u>Trees</u>	
Sycamore	*(Platanus occidentalis)*
Willow Oak	*(Quercus phellos)*
River birch	*(Betula nigra)*
Persimmon	*(Diospyros virginiana)*
White Oak	*(Quercus alba)*
Shagbark Hickory	*(Carya ovate)*
<u>Alternate Species</u>	
Tulip Poplar	*(Liriodendron tulipifera)*
Green Ash	*(Fraxinus pennsylvanica)*
Swamp Chestnut Oak	*(Quercus michauxii)*
Tag Alder	*(Alnus serrulata)*
Flowering Dogwood	*(Cornus florida)*
<u>Shrubs/small trees</u>	
Pawpaw	*(Asimina triloba)*
Witch-hazel	*(Hamamelis virginiana)*
Spicebush	*(Lindera benzoin)*
<u>Alternate Species</u>	
Sweet Shrub	*(Calycanthus floridus)*
Redbud	*(Cercis canadensis)*
American Hazelnut	*(Corylus americana)*
Arrowwood Viburnum	*(Viburnum dentatum)*
<u>Woody Vegetation for Live Stakes</u>	
Silky willow	*(Salix sericea)*
Ninebark	*(Physocarpus opulifolia)*
Elderberry	*(Sambucus canadensis)*

Silky Dogwood *(Cephalanthus occidentalis)*

2.1.3 Hydrology

2.1.3.1 Streams

The occurrence of bankfull events within the monitoring period will be documented by the use of a crest gauge and photographs. A crest gauge was installed on the floodplain of UT3-Reach 2 at the bankfull elevation. The crest gauge will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years, otherwise the stream monitoring will continue until two bankfull events have been documented in separate years.

2.1.4 Photographic Documentation of Site

Photographs will be used to document restoration success visually. Reference stations were photographed during the as-built survey and will be repeated for at least five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established and prior reference photographs used in the field to ensure that the same locations (and view directions) on the site are photographed during each monitoring period. Selected site photographs from the restoration, enhancement and preservation reaches are provided in Appendix B as Exhibit 4. Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate progressive maturation of riparian vegetation and consistent structure function.

2.1.4.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.4.2 Structure Photos

Photographs of constructed grade control structures (i.e. vanes and weirs) along the restored streams are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

2.2 Areas of Concern

At this time the only area of concern is the lack of groundcover in Reach 2 of UT3. Soil quality and a shallow groundwater table may be contributing factors to the lack of ground cover observed at the time of the initial monitoring assessment of vegetative cover. The perennial seed mixture applied to the site does contain a mix of grasses and herbaceous cover that are more tolerant of wet conditions; it is expected that this vegetation will become established in time. As noted in Section 2.1.2, Reach 2 will be monitored and if necessary, soil fertility and a seed mixture with a greater composition of seeds tolerant of wet conditions will be evaluated to ensure a healthier stand of ground cover.

3.0 MAINTENANCE AND CONTINGENCY PLANS

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed
- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will, if needed, be detailed and documented in future monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP will be notified prior to any remedial action.

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