DETAILED PROJECT REPORT AND
DRAFT ENVIRONMENTAL ASSESSMENT
WATAUGA SECTION 206 AQUATIC ECOSYSTEM RESTORATION PROJECT
TOWN OF BOONE, NORTH CAROLINA

U.S. ARMY ENGINEER DISTRICT, HUNTINGTON
CORPS OF ENGINEERS
HUNTINGTON, WEST VIRGINIA

May 2008

Draft FINDING OF NO SIGNIFICANT IMPACT

WATAUGA AQUATIC RESTORATION PROJECT
SECTION 206 WATER RESOURCES DEVELOPMENT ACT
TOWN OF BOONE, NORTH CAROLINA

1. Members of my staff have conducted an Environmental Assessment (EA) and a Detailed Project Report (DPR), in the overall public interest, concerning the design and implementation of the Watauga Aquatic Restoration Project. Under the authority of Section 206 of the Water Resources Development Act (WRDA) of 1996, the Huntington District has evaluated alternatives for the aquatic restoration of an approximately 3,730-foot segment of the South Fork New River in Watauga County, Boone, North Carolina.

2. The possible consequences of the project have been studied for environmental, cultural and social well-being impacts.

3. Four alternatives, including the No Action Alternative (NAA) and the Proposed Action Alternative (PAA), were carried forward for detailed evaluation. Alternative A2 (Riparian Zone and Ecosystem Improvements) was identified as the PAA because it was the most cost effective and is both environmentally and socially acceptable. The NAA would not be in the public's best interest and would allow continued aquatic habitat degradation. The other alternatives included in this assessment did meet the purpose and needs of the project, but were not as cost efficient as the PAA and would result in greater long-term impacts to recreation and short-term impacts to air quality and noise due to a longer construction phase.

4. An evaluation of the Alternatives produced the following pertinent conclusions:

   a. Environmental Considerations. The Huntington District has taken reasonable measures to assemble and present the known or foreseeable environmental impacts of the project in the Draft Environmental Assessment (DEA). All adverse effects of project implementation are considered insignificant and should occur during the construction period.

   b. Social Well-Being Considerations. No significant economic or social well-being impacts that are both adverse and/or unavoidable are foreseen as a result of the proposed action. The project will not have any impact on sites of known significant archeological or historical importance. Hazardous, Toxic, and Radioactive Waste (HTRW) in not present on the site.

   c. Coordination with Resource Agencies. Pursuant to the Fish and Wildlife Coordination Act (FWCA) of 1958, coordination with the U.S. Fish and Wildlife Service (USFWS), Natural Resource Conservation Service (NRCS), and the North Carolina State Historic Preservation Office (SHPO) has been maintained throughout the study. Appropriate

measures and best management practices will be identified and incorporated into the PAA. Also, in accordance with the Endangered Species Act (ESA), as amended, the recommended plan would not impact listed species.

d. Section 176(1C) Clean Air Act. The PAA has been analyzed for conformity and applicability pursuant to regulations implemented by Section 176(1C) of the Clean Air Act (CAA). The county in which the project site is located is in attainment for all six criteria pollutants described by the National Ambient Air Quality Standards (NAAQS). The PAA will not exceed *de minimis* levels or direct emissions of a criteria pollutant or its precursors and is exempt by 40 CFR Part 93.153. Any later indirect emissions are generally not within the District's continuing program responsibility and generally cannot be practicably controlled by the District. For this reason a conformity determination is not required for this action.

e. Other Pertinent Compliance. No prime or unique farmland under the Farmland Protection Policy Act (FPPA) will be involved. The PAA is also in compliance with the National Historic Preservation Act (NHPA), (Section 10632 CFR 300, Executive Order (EO) 11988 (Floodplain Management), and EO 11990 (Protection of Wetlands).

f. Other Public Interest Considerations. There has been no significant opposition to the PAA by Federal, state, or local Governments, or other stake holders. Comments received during the public review period will be included in the Final Environmental Assessment (FEA).

5. I find the Watauga Aquatic Restoration Project Section 206 Project has been planned in accordance with current authorization as described in the DEA. The PAA is consistent with national policy, statutes and administrative directives. This determination is based on thorough analysis and evaluation of the PAA and alternative courses of action. In conclusion, I find the proposed Watauga Aquatic Restoration Project Section 206 Project will have No Significant Adverse Impacts on the quality of the human environment.

Date: _____ _____

Dana R. Hurst
Colonel, Corps of Engineers
District Engineer

EXECUTIVE SUMMARY

This Draft Project Report/ Environmental Assessment (DPR/EA) presents the findings of the Watauga Aquatic Restoration Project, an aquatic ecosystem restoration study, and has been prepared to document the plan formulation process and potential environmental effects associated with the implementation of restoration alternatives for the proposed site. The study area is located along the South Fork New River in the Town of Boone, Watauga County, North Carolina. The proposed restoration work, a reach of the South Fork New River extending approximately 3,730 feet, is adjacent to the recreational property of Appalachian State University near Boone.

The overall goal of the Watauga Aquatic Restoration Project is to restore ecosystem functions that are currently lost or degraded along this reach of the South Fork New River. This area has been modified by deforestation and urban development. The restoration would produce wetland and riparian habitat of significantly higher quality than is currently found along this reach of the South Fork New River.

This DPR/EA summarizes baseline existing conditions in the study area. It also develops and discusses potential solutions as a guide to potential Federal and non-Federal involvement in the restoration project and serves as a resource to assist in the decision-making of local government and others. This report provides a description and discussion of the likely array of alternative plans, including their benefits, costs, and environmental effects and outputs. This report also identifies, evaluates, and recommends a solution (the Preferred Action Alternative) that best meets the planning objectives of comprehensive habitat restoration through the study area.

The Preferred Action Alternative (Alternative **A2**) focuses on the development and expansion of a riparian corridor, improvements to eroding streambanks including overbank plantings, bank protection using woody material, and the construction of bend way weirs. In addition, new wetland areas will be created, an established wetland will be rehabilitated and areas adjacent to the river that are currently overgrown with invasive plants will be replanted with native species. The total first cost for implementation of the preliminary recommended plan is $1,748,000. The period of analysis used to compute costs is 50 years with a FY 08 Federal interest rate of 4.875%. The preliminary recommended plan provides restoration benefits of 11.4 average annual habitat units, which results in an average annual cost per average annual habitat unit (AAHU) of $6,540

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1 BACKGROUND

1.1 Study Authority*

This study is conducted under the authority U.S. Army Corps of Engineers' Section 206, Aquatic Ecosystem Restoration, of the Water Resources Development Act (WRDA) of 1996, as amended, Public Law 104-3030, which states that:

> *"The Secretary is authorized to carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project (1) will improve the quality of the environment and is in the public interest, and (2) is cost-effective."*

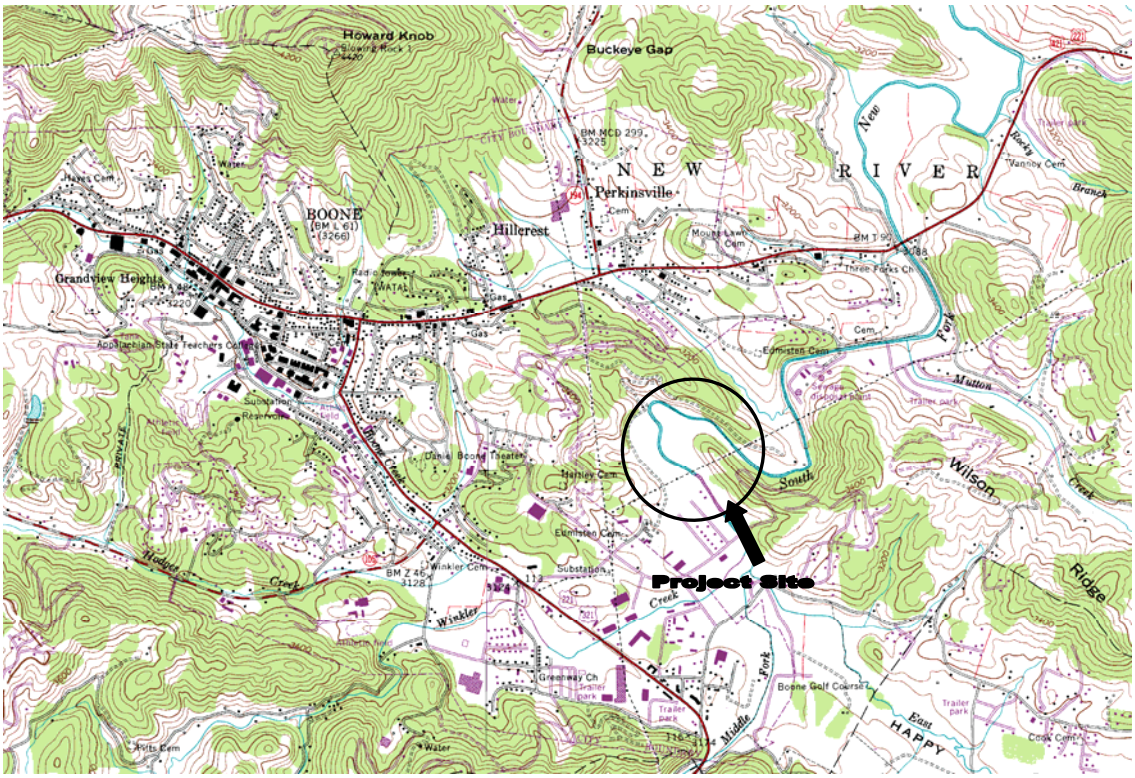


Figure 1. Map of the Watauga project site relative to the town of Boone, North Carolina.

The Federal costs to carry out such a project shall not exceed $5,000,000 without specific authorization by Congress. Cost sharing under this authority is 65% Federal, 35% non-Federal, with operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) as 100% non-Federal responsibility. The non-Federal sponsor of the proposed aquatic restoration project is the Town of Boone, Watauga County, North Carolina.

1.2 Study Area Location and General Description

The site of the proposed aquatic restoration project is located in the Town of Boone, Watauga County, North Carolina, along 3,730 feet of the South Fork New River, a National Heritage River. Watauga County is approximately 100 miles northwest of Charlotte in the mountainous region of the state (Figure 1). The East and Middle Forks join in Boone to form the South Fork New River, which flows in a northeastern direction into Virginia and then West Virginia. The proposed restoration work is located adjacent to the recreational property of Appalachian State University (ASU) on the east side of Boone. The area surrounding the stream is composed of athletic fields, urban grasslands and a paved hiking trail.

The New River watershed upstream of the project is continuing to be developed. This development has resulted in the loss of vegetated corridor that surrounds the river, known as the riparian zone, and an increase in impervious surfaces (such as parking lots). The development of land and poor land management practices have resulting in larger and more frequent high water events. As the hydrologic nature of the New River becomes more "flashy," streambank instability and the lateral migration of the river channel results.

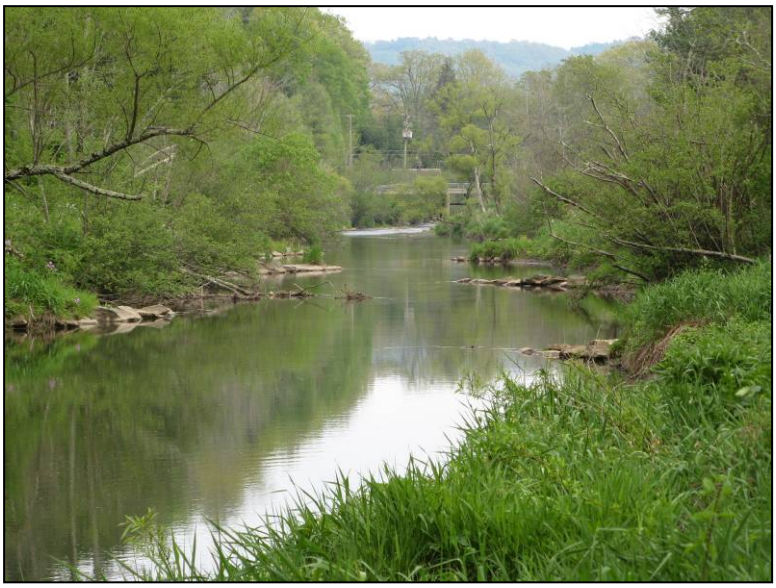


Figure 2. A restoration measure, a diagonal dike field, completed during the previous Section 206 project by the US Army Corps of Engineers. This feature is located on the upstream boundary of the proposed project.

Prior to this study, the United States Army Corps of Engineers (USACE), Huntington District recognized the changes that were occurring in the watershed and the impacts to the aquatic system. A similar, but independent restoration project under the 206 designation has already been designed and constructed in the river reach immediately upstream of the current study area. This project included a variety of different restoration activities. In-stream rock structures, including diagonal dikes and bend way weirs, were installed to alter the direction and speed of water flow through the reach (Figure 2). Wetlands were created to filter runoff from the

surrounding athletic fields and impervious surface. Also, a section of riparian forest was revegetated with trees. The proposed project is completely independent of the earlier effort and can fulfill the project goals and objectives regardless of the previous efforts. However, the lessons learned from this earlier study were used to design the elements that have been included in the current project.

1.3 Purpose and Need*

Section 206 projects specifically address aquatic ecosystem restoration activities. The section of the South Fork of the New River encompassed by the study has been negatively affected by human activities and development upstream of and within the project site. The morphology (physical characteristics and shape) of the stream and the aquatic community are exhibiting signs of degradation.

Bank erosion and failure is evident throughout the project site (Figure 3). In two instances, this erosion is occurring at the two extreme bends in the river. These bends force the water flow towards the bank. The current undercuts the banks, which causes the banks to over steepen and fall into the stream bed (termed bank failure). At other sites, bank failure is due to vegetation removal by pedestrian traffic straying from the walking path. Bank failure is a problem in these instances because the introduction of failed soils into the stream results in decreased water quality and increased stress on the aquatic community.

In addition to impacts that can be observed within the stream itself, alterations and losses of riparian habitat (the vegetated area adjacent to the stream) have also occurred. In the past, this area was thought to be separate from the river proper. However, it is now understood that the lands adjacent to the stream are essential to the health and function of the stream, acting in conjunction with the stream to create a single, complex ecosystem. An aquatic restoration project cannot ultimately succeed if the planned restoration does not include the surrounding riparian area. The connections between the elements which make up a stream corridor are discussing in depth in Section 2.2.1.

The riparian zone at the project site is extremely narrow. In many places, it is only one tree in width. The loss of the riparian zone impacts the aquatic system in many negative ways. These include:

- Decrease in food items (such as leaf material and insects) entering the system,
- Decreased shade cover to the stream, resulting in higher water temperatures,
- Decreased spawning habitat during spring high flow season,
- Increased nutrient, sediment and chemical exchange between the river and the riparian corridor,
- Decreased available habitat for both aquatic organisms and terrestrial animals that are essential to the aquatic system,
- Decreased ability to offset impacts of flooding events,
- Decreased ability to filter field runoff before it enters the aquatic system (such as pesticides and fertilizers).

Figure 3. An eroding streambank located on the left descending bank within the project site.

Without this project, the processes of destabilization and degradation are expected to continue within this reach of the South Fork New River, resulting in increased economic costs and additional environmental degradation.

The purpose of the proposed action is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. The measures through which this goal will be accomplished will include streambank restoration, instream rock structures, wetland rehabilitation and creation, plantings of native species, expansion of the riparian zone and exotic species eradication. Indicators of success would include the establishment of a variety of native plants and animals, the ability of the area to sustain more biologically desirable species, and the capacity of the restored area to continue to function and produce the desired outputs with minimal continuing human intervention.

1.4 Proposed Action and Alternatives*

Four alternatives, including the No Action Alternative (NAA), were evaluated to address aquatic ecosystem restoration. Each alternative and the method with which they were developed are described in detail in Section 4.2.

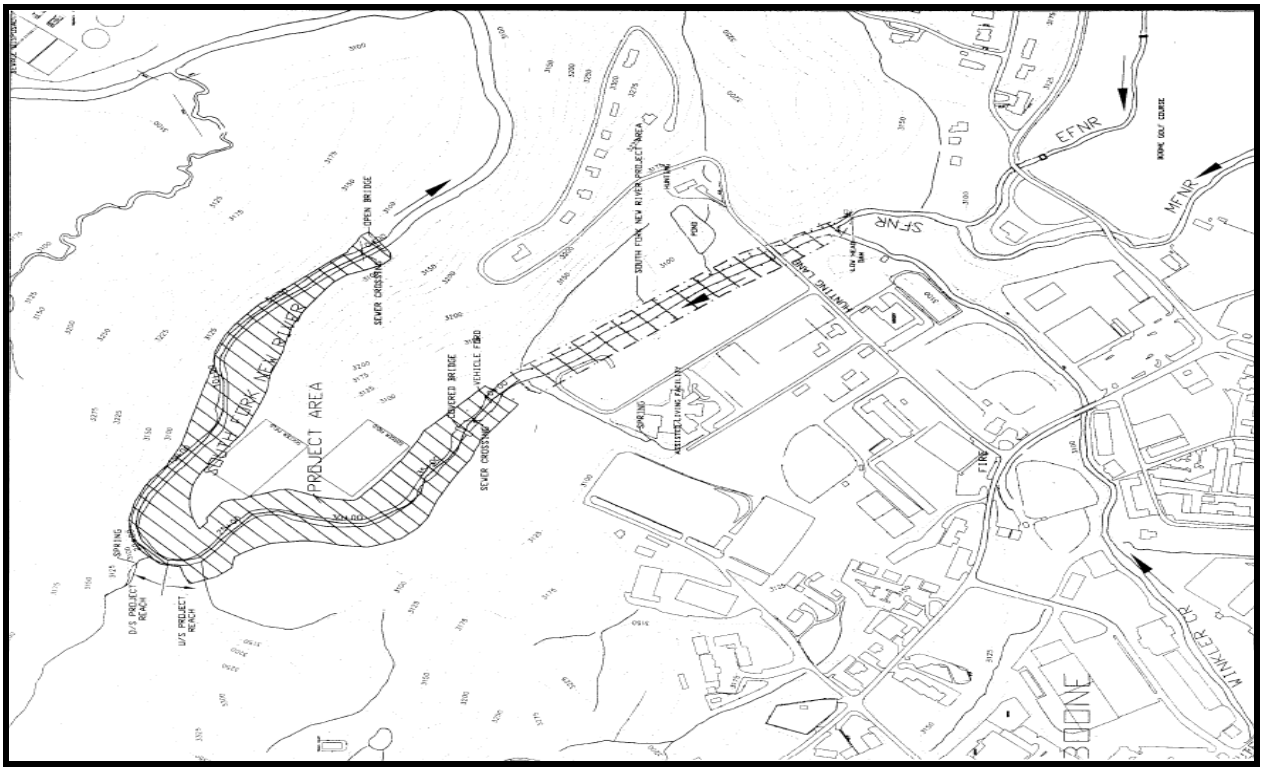


Figure 4. Site map of the Watauga Project.

2 ENVIRONMENTAL SETTING*

2.1 Existing Conditions

2.1.1 Physiography

The project area encompasses a 3,730-foot reach of the South Fork New River and approximately 15 acres of the adjacent floodplains in the Town of Boone, North Carolina. The project area is at an elevation of approximately 3,100 feet above mean sea level (msl). Headwaters of the South Fork New River originate in the nearby Blue Ridge Mountains at elevations greater than 4,200 feet msl. This river is a tributary to the New River, part of the Kanawha River basin. The project area lies in a valley with a wide, flat floodplain and is surrounded by mountains. Much of the urban development occurs on the floodplains because of the inability or prohibitive cost to develop steep mountain slopes.

The project area extends from immediately downstream of the South Fork New River Restoration Section 206 Project (USACE 2001), which was constructed in the spring of 2002, to a pedestrian bridge 3,730 feet downstream (Figure 4). The effective drainage area within the project area is about 31 square miles. The confluence of the East and Middle Forks is located 2,000 feet upstream of the project area where it forms the South Fork New River. Winkler Creek drains much of the urbanized area of Boone and joins the river 1,500 feet upstream of the project area. There are no significant tributaries within the project area. The river makes a sharp bend in the project area changing the flow direction from northwest to southeast.

2.1.2 Geologic Setting

The project area is located in the Blue Ridge physiographic province. The Blue Ridge is a deeply dissected mountainous area of numerous steep mountain ridges, intermontane basins, and trench valleys that intersect at all angles and give the area its rugged mountain character. The Blue Ridge contains the highest elevations and the most rugged topography in the Appalachian Mountain system of eastern North America. The North Carolina portion of the Blue Ridge is about 200 miles long and ranges from 15 to 55 miles wide. It encompasses an area of about 6,000 square miles, or about 10% of the area of the state. The Blue Ridge Province is underlain mostly by crystalline rocks. The bedrock is blanketed by weathered material, or regolith, typically less than 20 feet thick. The Blue Ridge Belt region is composed of rocks from over one billion to about one-half billion years old. This complex mixture of igneous, sedimentary, and metamorphic rock has been repeatedly squeezed, fractured, faulted, and folded. The Blue Ridge belt is well known for its deposits of feldspar, mica, and quartz, which are basic materials used in the ceramic, paint, and electronic industries. Olivine is mined for use as a refractory material and foundry molding sand. The valleys are alluvial (not glacial) and are often controlled by the shallow bedrock (NCDENR, 2000a).

2.1.3 Biological Resources

This section describes the biological resources within the project area, including habitat types, fisheries and wildlife, and sensitive species.

The New River and its major tributaries have considerable regional ecological value in North Carolina, supporting rich riparian corridors and a diverse fish population. Major land uses within the basin include forestland, pastureland, cropland, and urban development (Environmental Defense Fund, 1999; NCDENR, 1999). Land use at the project site is open space used for a variety of recreational purposes. The right overbank is bordered by a greenway, consisting of mowed grass, a multi-use paved trail, and a large flat grassy area that is currently used for overflow soccer fields. The left overbank is bordered by athletic fields for the majority of the upper reach and by forest in the lower reach. A strip of riparian vegetation, which is variable in composition and width, borders the river on both banks; however, many locations have 25 feet or less of riparian area, barely wide enough for a single tree. The study area is within the upper reach of the South Fork New River. This section of the river is considered by the North Carolina Natural Heritage Program to be of biological significance because it contains a cluster of sixteen rare animal species, including three fishes endemic to the New River drainage. This river contains the only known population of the Gammon's Stenelmis riffle beetle (*Stenelmis gammoni*) (NCDENR, 2000a). Sensitive species are described in more detail in Section 0.

2.1.3.1 Habitat Types

Four habitat types were determined to be present in the study area: riverine/aquatic, willow-alder riparian, forestland, and urban grassland. Characteristics of each habitat type are discussed below.

Riverine

Riverine habitat consists of the area within a river channel, which is defined as "an open conduit either naturally or artificially created, which periodically or continuously contains moving water" (Langbein and Iseri, 1960). Riverine habitat tends to be devoid of lush vegetation; rather, it functions to break down detritus and provides aquatic functions. This habitat is located within the defined stream channel and generally is aquatic, except for some scattered sand and rock bars. The aquatic habitat is variable, with riffle, run and pool habitat existing throughout the project area. The stream bottom also is diverse in character including fine sediment dominating the substrate in the pools, gravel and cobble in the riffles, exposed bedrock in the lower reach of the river and randomly dispersed large rocks and boulders available as cover habitat for the aquatic community. Large woody debris, such as fallen trees and branches, as well as limited areas of macrophytes are also present within the reach.

Willow-Alder Riparian

Willow-alder riparian habitats generally grow in narrow strips adjacent to the streambank, dominated by young to intermediate-age willows *(Salix spp.)* and alder *(Alnus spp.)*. Generally,

these plants grow prolifically on wet, exposed mineral soils, with an average height of 4 to 6 feet, although some individuals attain 15 feet or more. Within the project area, this habitat is primarily on the left overbank where the mountain slope is adjacent to the river. On the lower left bank, this shrub habitat is relatively continuous, shading the water and providing a diverse canopy structure. This habitat is generally in good condition, providing cover and food for numerous wildlife species, as well as nesting cover and food for songbirds. Vertical and eroding banks prevent riparian habitats from forming in much of the rest of the study area. The naturalized border between the banks and the maintained urban grassland are colonized mainly by herbaceous vegetation. Although this herbaceous vegetation provides some terrestrial wildlife habitat, erosion control, and aesthetic value, it is taking the place of forested and shrub riparian habitat that would occur naturally in its place. The forested and shrub riparian habitat would provide superior wildlife habitat and bank stabilization functions. Herbaceous species include giant ragweed *(Ambrosia trifida)* and spotted jewelweed *(Impatiens capensis)*.

Forestland

Forestland habitat within the study area is located on the uplands, adjacent to the riparian habitat. Forestland consists of mature deciduous and coniferous trees, with a variable understory. This habitat can further be broken down into upland hardwood forest and bottomland hardwood forest. Upland forest habitat is located on the left overbank for the entire length of the downstream reach of the project area and is comprised primarily of oaks *(Quercus spp.)*, hawthorn *(Crataegus spp.)*, maples *(Acer spp.)*, yellow birch *(Betula alleghaniensis)*, American sycamore *(Plantanus occidentalis)*, and black cherry *(Prunus serotina)*. Dominant understory species may include Rhododendron *(Rhododendron catawbiense)*, witch hazel *(Hamamelis virginiana)*, and alternate-leaf dogwood *(Cornus alternifolia)*. Most of the bottomland hardwood forest within the project reach has been replaced with urban grassland habitat. Bottomland forest covers the periodically inundated floodplains along the river and contains flood tolerant species, in many cases the same species as the lower-elevation upland forests. Some bottomland hardwood forest still remains upstream of the project area along the right overbank between the river and the hill. Species include black cherry, Rhodedendron, red maple, pin oak, witch hazel, and alder.

Urban Grassland

Urban grassland habitat is located on the uplands surrounding the riparian area except for the left overbank of the downstream reach of the project, which is forested. This habitat was planted and is utilized for recreational purposes including athletic fields as well as aesthetic appeal adjacent to the trail. Annual grasses and pioneering weed species dominate most of the habitat, although several deciduous trees have been planted in the habitat adjacent to the riparian area. The urban grassland was designed for athletic use and not for wildlife habitat or erosion control.

2.1.3.2 Fisheries and Invertebrate Resources

As many as 29 species of fish occur within the project area (Table 2). All species collected from the project site are native with the exception of brown trout, which are stocked in the South

Fork New River, which is upstream of the project area. (Mickey, 2002). The South Fork is able to support a coldwater wild trout fishery due to the colder water temperatures.

In the fall of 2000, the North Carolina Wildlife Commission (NCWC) conducted an electrofishing survey in the project area. The sampling effort included a 260- to 300-foot reach of the river below the covered pedestrian bridge. This was a single sampling event; therefore no quantitative estimates can be made about fish populations in the project area. Additional sampling would be required to make quantitative statements about fish populations. Thirteen species, listed as "confirmed" in Table 1, were found during this survey. In addition to the data produced from that survey, the NCWN believed that three other species listed as "probable" were not found during the survey but were suggested as likely to occur in the project area (Mickey, 2002). The NCWN identified four species of game fish have been documented, or are likely to occur, in the project area.

In 2004, the USACE Water Management Section in coordination with USACE Planning Division, ASU, and North Carolina Division of Natural Resources (NCDNR) performed a fish survey at the project site. Fish were collected using an electric seine electrofishing unit with 30 ft wires. Samples were collected from five 150 meter reaches. One site was located in the bounds of the first Watauga Aquatic Restoration Project completed in 2002; while the other four sites were located within the limits of the current restoration project.

Table 1. Fish species confirmed by the NCWC 2000 survey or likely to occur in the project area

Common Name	**Scientific Name**	**Native/ Nonnative**	**Game/ Nongame**	**Presence**
White sucker	*Catostomus commersoni*	Native	Nongame	C
Blacknose dace	*Rhinichthys atrarulus*	Native	Nongame	C
Mottled sculpin	*Cottus bairdi*	Native	Nongame	C
Kanawha darter	*Etheostoma kanawhae*	Native	Nongame	C
Fantail darter	*Etheostoma flabellare*	Native	Nongame	C
Central stoneroller	*Campostoma anomalum*	Native	Nongame	C
Kanawha minnow	*Phenacobius teretulus*	Native	Nongame	C
Silver shiner	*Notropis photogenis*	Native	Nongame	C
Tonguetied minnow	*Exoglossum laurae*	Native	Nongame	C
Longnose dace	*Rhinichthys cataractae*	Native	Nongame	C
Bluehead chub	*Nocomis leptocephalus*	Native	Nongame	C
Creek chub	*Semotilus atromaculatus*	Native	Nongame	P
Redbreast sunfish	*Lepomis auritus*	Native	Game	P
Smallmouth bass	*Micropterus dolomieui*	Native	Game	P
Rock bass	*Ambloplites rupestris*	Native	Game	C
Brown trout	*Salmo trutta*	Nonnative	Game	C
Brook trout	*Salvelinus fontinalis*	Native	Game	U

Source: NCWC, 2000; Mickey, 2002
Notes: C = Confirmed by electroshocking survey (NCWC, 2000)
P = Probable (Mickey, 2002)
U= Unlikely but possible in project area, known to occur upstream

Twenty-nine fish species were collected during this survey. The data were analyzed using the North Carolina Index of Biological Integrity (NCIBI) for the New River. All sites scored within the "Good-Fair" to "Good" categories with a range in scores from 46 to 55. Three of the sites scored 55, 55, and 53 respectively, which would be expected given the similarity of habitat types and riparian zones among the sites. These sites had a slightly elevated percentage of tolerant individuals and the percentage of omnivores and herbivores was slightly out of the optimal range. The site that received the lowest score (46) was characterized by large stretches of sandy substrate, slower current, and shallow water. This same site had the highest number of fish collected which actually worked against it in this IBI because in this instance, nutrient enrichment or environmental degradation may actually increase the number of fish supported by

Table 2. Fish species collected during the fish survey completed in 2004 by the USACE, Huntington District.

Common Name	Scientific Name	Game/Nongame
Appalachia Darter	Percina gymnocephala	Nongame
Bigmouth Chub	Nocomis platyrhynchus	Nongame
Blacknose Dace	Rhinichthys atratulus	Nongame
Bluegill	Lepomis macrochirus	Nongame
Bluehead Chub	Nocomis leptocephalus	Nongame
Bluntnose Minnow	Pimephales notatus	Nongame
Brown Trout	Salmo trutta	Game
Central Stoneroller	Campostoma anomalum	Nongame
Creek Chub	Semotilus atromaculatus	Nongame
Fantail Darter	Etheostoma flabellare	Nongame
Fathead Minnow	Pimephales promelas	Nongame
Golden Shiner	Notemigonus crysoleucas	Nongame
Green Sunfish	Lepomis cyanellus	Nongame
Greenside Darter	Etheostoma blennioides	Nongame
Kanawha Darter	Etheostoma kanawhae	Nongame
Kanawha Minnow	Phenacobius teretulus	Nongame
Largemouth Bass	Micropterus salmoides	Game
Mottled Sculpin	Cottus bairdi	Nongame
New River Shiner	Notropis scabriceps	Nongame
Nocomis Sp.	Nocomis Sp.	Nongame
Northern Hogsucker	Hypentelium nigricans	Nongame
Rainbow Trout	Oncorhynchus mykiss	Game
Redbreast Sunfish	Lepomis auritus	Nongame
Rock Bass	Ambloplites rupestris	Game
Rosyface Shiner	Notropis rubellus	Nongame
Rosyside Dace	Clinostomus funduloides	Nongame
Silver Shiner	Notropis photogenis	Nongame
Tonguetied Minnow	Exoglossum laurae	Nongame
White Sucker	Catostomus commersoni	Nongame

Source: USACE 2004

Figure 5. Sampling sites in the New River (Subbasin 01) monitored by the NCDENR for macroinvertebrates in order to determine water quality changes.

the stream. This site had a relatively high percentage of tolerant individuals, mostly white suckers (*Catostomus commersoni*), probably due to the dominance of sandy substrate and lack of riffle, run, pool sequences.

The NCDENR collected benthic macroinvertebrates in order to classify sites in the New River Basin. Although the sites surveyed were not located within the limits of the current project, four sites were located upstream and in the vicinity of the restoration project (Figure 5). The 2008 draft North Carolina 303(d) List of impaired surface waters lists the New River within the bounds of project area as impaired and is unable to fully support "aquatic life propagation and maintenance of biological integrity" (NCDWQ, 2008). An area is judged "impaired for aquatic life when a fish community or benthos sample received a bioclassification of Severe, Poor or Fair and there were no other Aquatic Life standards violations". 2008 will be the first year that this area will be judged as impaired. Similarly, the East Fork South Fork New River, located upstream of the site, is also being added to the 303(d) list for the first time.

Benthic samples collected during previous sampling season in the vicinity of the project were higher in quality. In 2003, the East Fork South Fork New River site (site B-2) was judged to be of "good" quality because species intolerant to poor water quality including the mayflies *Epeorus rubidus* and *Drunella conestee* and the caddisfly *Ceratopsyche sparna* were collected. The South Fork New River site (site B-3) was assigned the designation of "Good-Fair" in 2003.

The intolerant stonefly *Tallaperla sp*. was collected in 2003, while species that could bear poor water quality (*Chironomus sp.* and *Procladius sp.)* were absent from survey. The macroinvertebate community at Middle Fork South Fork New River (site B-1) showed signs of decline. Intolerant species that were previously found at the site were not collected in 2003, including the Mayflies *Rhithrogena sp., Drunella wayah, Serratella serrata.*

Two common crayfish species in the South Fork, the Spiny stream crayfish (*Orconectes cristavarius*) and the New River crayfish (*Cambarus chasmodactylus*) have been collected in the project reach. The latter species is only found in the New River. Fortino and Creed have studied both these species at the project area as part of research on relationships between crayfish and predatory fish (Creed, 2006). Spiny stream crayfish, a species that was just described by Chris Taylor in 2000, is found in the New and the Green River. Both adults and young *Orconectes* were collected in the South Fork, while only adult *Cambarus* were found in that reach. Both species are classified by Fetzner (2005) as being currently stable, a designation which identified a species or subspecies whose distribution is widespread and stable and is not in need of immediate conservation management actions.

2.1.3.3 Wildlife Resources

Wildlife species that have been observed within and immediately adjacent to the project area during field assessments include several bird, amphibian, reptile, and mammal species. In addition to species observed, which are listed in Table 3, several species of warbler and sparrow were seen but could not be identified. Other common species that likely occur, based on habitat types and known species' ranges, are listed below.

The forestland and riparian habitats, described in Section 0, provide foraging, roosting, and nesting habitat for a variety of songbirds, both migratory and resident. Waterfowl also may make use of the riverine and riparian habitats, foraging on aquatic plants and insects. Wading birds, such as the great blue heron, use the site to forage on small fish during periods of low water, as observed during recent field surveys (Tetra Tech, 2002).

A variety of small to medium-sized mammals are known to use the site including eastern chipmunk, cottontail rabbit, and beaver. Numerous species of common small mammals likely use the site including deer mouse, meadow vole, eastern gray squirrel, and eastern fox squirrel. Several other species of medium-sized common mammals such as raccoon, striped skunk, and porcupine are also likely to occupy the project area. Large mammal occurrences may be limited to white-tailed deer because of the lack of riparian cover.

Table 3. Wildlife documented within the study area.

Common Name	Scientific Name
Birds	
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American robin	*Turdus migratorius*
Belted kingfisher	*Ceryle alcyon*
Gray catbird	*Dumetella carolinensis*
Great blue heron	*Ardea herodias*
Great egret	*Casmerodius albus*
Green-backed heron	*Butorides striatus*
Mallard	*Anas platyrhynchos*
Northern cardinal	*Cardinalis cardinalis*
Ruby-throated hummingbird	*Archilochus colubris*
Sharp-shinned hawk	*Accipiter striatus*
Spotted sandpiper	*Actitis macularia*
Wood duck	*Aix sponsa*
Mammals	
Beaver	*Castor candadensis*
Eastern chipmunk	*Tamias striatus*
Eastern cottontail rabbit	*Sylvilagus floridanus*
Muskrat	*Ondatra zibethicus*
Red squirrel	*Tamiasciurus hudsonicus*
White-tailed deer	*Odocoileus virginianus*
Reptiles	
Northern water snake	*Nerodia sipedon*
Amphibians	
Bullfrog	*Rana catesbeiana*
Green frog	*Rana clamitans*
Red-spotted newt	*Notophthalmus viridescens viridescens*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Hyla crucifer*

Source: USACE, 2001; Tetra Tech, 2002

2.1.3.4 Sensitive Species

Eight federally listed threatened and endangered species are known to occur in Watauga County. These include bog turtle *(Clemmys muhlenbergii)*, Carolina northern flying squirrel *(Glaucomys sabrinus coloratus)*,Virginia big-eared bat (*Corynorhinus townsendii virginianus*) spruce-fir moss spider *(Microhexura montivaga)*, Blue Ridge goldenrod (*Solidago spithamaea*), Heller's blazing star *(Liatris helleri)*, spreading avens *(Geum radiatum)*, and Roan mountain bluet *(Hedyotis purpurea* var. *montana)* (USFWS, 2008). However, habitat for these species is not present in the project area.

Table 4. Sensitive species confirmed or possible in the project area.

Common Name	Scientific Name	State Status
	Mammals	
Northern long-eared bat	*Myotis septentrionalis*	SC
Southern water shrew	*Sorex palustris punctulatus*	SC
New England cottontail	*Sylvilagus transitionalis*	SR
	Birds	
Sharp-shinned hawk	*Accipiter striatus*	SR
Migrant loggerhead shrike	*Lanius ludovicianus migrans*	SC
Vesper sparrow	*Pooecetes gramineus*	SR
Appalachian yellow-bellied sapsucker	*Sphyrapicus varius appalachiensis*	SR
Golden winged warbler	*Vermivora chrysoptera*	SR
Warbling vireo	*Vireo gilvus*	SR
	Amphibians	
Hellbender	*Cryptobranchus alleganiensis*	SC
Long-tailed salamander	*Eurycea longicauda longgicauda*	SC
Weller's salamander	*Plethodon welleri*	SC
	Fish	
Sharpnose darter	*Percina oxyrhynchus*	SC
Kanawha minnow*	*Phenacobius teretulus*	SC
Kanawha darter*	*Etheostoma kanawhae*	SR
Tongue-tied minnow*	*Exoglossum laurae*	SR
	Mollusks	
Spike	*Ellipito dilatata*	SC
Green floater	*Lasmigona subviridis*	E
Seep mudalia	*Leptoxis dilatata*	T
Velvet covert	*Inflectarius subpalliatus*	SC
	Insects	
Mayfly	*Ephemerella floripara*	SR
Stonefly	*Attaneuria ruralis*	SR
Caddisfly	*Ceraclea mentiea*	SR
Dragonfly – Maine snaketail	*Ophiogomphus mainensis*	SR
Butterfly – Appalachian Azure	*Celastrina neglectamajor*	SR
Butterfly – Edwards' Hairstreak	*Satyrium edwardsii*	SR
Butterfly – Diana Fritillary	*Speyeria diana*	SR

Source: NCNHP, 2001; NCWC, 2000; NRDENR, 2000.
Codes: E = Endangered; T = Threatened; SC = Special Concern; SR = Significantly Rare
* Confirmed in the project area

Three state-designated rare fish species, Kanawha darter, and Tongue-tied minnow, and the state-designated species of special concern, the Kanawha Minnow, have been documented on site as described in Section 0. Table 4 presents species listed by the North Carolina Wildlife Resources Commission (NCWRC) as rare in North Carolina that have been documented in Watauga County and have habitat requirements that could possibly be met in the project area (NCNHP, 2001).

2.1.4 Water Resources

2.1.4.1 Hydrographic Survey

Hydrographic surveys were performed on September 11 through 15, 2002, to document site conditions (Tetra Tech, 2002). The survey of over 500 points included establishing a control network, verification of previous surveys, utilities, water surface elevations, vegetation delineation, 38 channel cross-sections, and bridge detail. In addition, ten bed and seven bank material samples were collected, three water surface profiles were each coupled with a discharge measurement, and a number of photographs were taken and recorded. The controls used for the surveys were the National Geodetic Survey (NGS) monuments 'Fire' and 'Hunting.' A survey was performed with a total station and differential leveling. All coordinates were adjusted to or surveyed in North American Vertical Datum of 1988 (NAVD88) and North Carolina State Plane Coordinates, units in feet.

An existing survey of the right bank and floodplain of the project area was completed recently for ASU to develop soccer fields on the right overbank. Existing aerial photographs from 1999 were obtained from the Town of Boone as well as 1995 aerial photographs with photogrammetric mapping in 5-foot contour intervals from CARDAN (1995).

2.1.4.2 Surface Water Hydrology

The South Fork New River originates in the Blue Ridge Mountains where winter snow packs and perennial springs feed the river. Weather conditions in the area vary greatly throughout the year. Rainfall in Boone averages over 55 inches per year with winter snow and snow packs developing in the surrounding mountains. The annual average July temperature is 68.9° F with a record high of 96° F. In contrast, January temperatures average 35.1° F with a record low of -18° F (FEMA, 1998).

Floods in the project area can occur any time of year and are usually the result of intense rainfall. Floods are usually of short duration with peak flows on many streams occurring before the rain ceases. Since 1878, 15 extreme storm events have occurred in Watauga County. Nine of these events have occurred in the last 28 years, and numerous localized thunderstorms have resulted in drainage problems. Widespread flooding occurred in the county during a hurricane event between August 10 and 17, 1940. The 1940 flood was estimated to have a recurrence interval greater than 100-years (Dewberry and Davis, 2000). This was also considered the highest gauged event with rainfall in Boone of over 13.5 inches in a six-day period. Between August 29 and 31, 8 more inches of rain was recorded (Town of Boone, 1997). Table 5 shows a list of the extreme rainfall events near Boone.

The nearest maintained stream gauging station on the South Fork New River is located near Jefferson, North Carolina (USGS #03161000). This gage has a drainage area of 205 square miles, which includes the 31 square miles above the project area, and a continuous record of mean daily flows and instantaneous peak discharges beginning with water year 1929.

Table 5. Extreme rainfall events near Boone, North Carolina.

Date	Rainfall Event
9/12/1878	(Rainfall not recorded)
1892	(Rainfall not recorded)
4/20/1901	(Rainfall not recorded)
7/15/1916	(Rainfall not recorded)
8/14/1940	Highest: 2 inches in 1 hour, Aug. 10-17, 13 inches; Aug. 29-31, 8 inches
1952	4.7 inches
5/1973	5.3 inches
11/5/1977	10 inches, 36 hours
1982	8 inches, 6 hours
9/25/1989	Hurricane Hugo; 2 inches in a 3-hour period. 3 inches total
4/22/1992	4.2 inches, 48 hours
8/1994	6 inches
1/1995	10 inches at Boone, 14 inches in Watauga County
10/1995	Hurricane Opal; 4.5 inches on Oct. 5
8/1996	7 inches

Source: Town of Boone History, 1997

There have been a number of flood studies performed on the South Fork New River including the project area. A 1979 Flood Insurance Study (FIS) used Putnam's Regional Equations (FEMA, 1979) to estimate flood events. However, these were considered to underestimate discharges in this area (HSMM, 1994). A second FIS was published for the Town of Boone in 1994 (FEMA, 1994) implementing rainfall-runoff analysis, which estimated significantly greater return flood discharges than the 1979 estimates. A countywide FIS was developed in 1998 (FEMA, 1998), wherein slightly lower discharge values were estimated compared to 1994. A fourth study was completed in the spring of 2000 for the Town of Boone (Dewberry and Davis, 2000). In the 2000 study, revised peak flow estimates, based on *Rainfall Frequency Atlas* (NWS, 1961), Muskingum-Cunge routing methods, and additional field surveys, were calculated and resulted in lower flows than the 1998 values. The return period discharges at Hunting Lane from the Dewberry and Davis 2000 study are considered the most current estimates and are used in this report to represent flows in the project area. The calculated return period discharges, based on the studies described above, are presented in Table 6**.**

Table 6. Flood peaks (cubic feet per second - cfs) for the South Fork New River, Boone, North Carolina.

Return Period (Years)	2000 Town Study at Hunting Lane	2000 Town Study at Mutton Creek	1998 FIS at Mutton Creek	1994 FIS at Mutton Creek	1979 FIS at Mutton Creek
1.5	1200**	1200**	1980*	2180*	895*
2	1730	1750	2810*	3000*	1250*
5	4200	4210	5700*	6000*	2300*
10	7690	7690	8838	9082	3390
25	10430	10310	12500***	13000***	4700***
50	12870	12650	15630	16002	5540
100	16240	16000	19182	19617	6700

*Extrapolated from FEMA 1979, 1994, 1998
**Extrapolated from Dewberry and Davis, 2000
***Interpolated from FEMA 1979, 1994, 1998

Field surveys in September 2002 included three discharge measurements. September 13, 2002, was the last of nine consecutive dry days; measured flow into the project area was less than 10 cfs. On September 14, tropical storm Hana brought rains, and the nearest climate station, Boone 1 SE (#310982) maintained by the National Oceanographic and Atmospheric Administration (NOAA), recorded 0.15 inches of rain. This resulted in a discharge of 20 cfs. On September 15, the river rose to approximately 80 cfs with an additional 0.60 inches of rain. Analyses were performed to examine the relationship of precipitation recorded near the project area to the Jefferson gage. Unfortunately, good correlation between the stream and the precipitation gages does not exist with current available data. This is possibly indicative of the use of regional regression analyses in mountainous sub-basins because storms are often isolated in one of the many upper mountain sub-basins and not recorded.

Because average daily flows could not be estimated from comparisons of either the Jefferson stream gage or the Boone 1 precipitation gage, a representative low flow was estimated. Base flows for habitat design for the South Fork New River Restoration (USACE, 2001) upstream of this project area are 50 cfs. The discharge measurements during the 2002 hydrographic survey showed a range of low flows, including a low-flow measurement in a drought period of approximately 10 cfs. For this analysis, the average of the extreme low flow and the prior assumed baseflow is 30 cfs and is assumed herein to be the representative low flow for habitat design in the project area. The ratio of the low flow to the 1.5-year return flood is less than 3 percent.

2.1.4.2 Groundwater Hydrology

Groundwater occurs primarily in fractures in the crystalline rocks of the basin. The pore spaces of the regolith and the alluvial deposits of the valleys also reserve groundwater; however, these are relatively shallow, often less than 20 feet thick. Natural fractures are most common near the land surface, along valley sides and bottoms, and near the crest of upward folds in the rocks.

The shallow aquifers are found to be extremely permeable and allow for rapid infiltration of recharge. The South Fork of the New River was found to have the highest total groundwater recharge rate for the New River basin with an average annual groundwater recharge of 26 inches compared to the median 19.1 inches. Similarly, the South Fork of the New River was found to have the highest effective groundwater recharge for the basin with an average annual effective groundwater recharge of 22.3 inches compared to the median 15.1 inches. The difference between total and effective recharge is the riparian evapotranspiration (ET); riparian ET is the quantity of water evaporated or transpired from the aquifer by plants in the riparian zone adjacent to the stream (Kozar, *et al*, 2001).

Pesticides were detected in more than 50 percent of the wells in the Blue Ridge, an indication that the groundwater is vulnerable to contamination (NCDNER, 2000c). Additionally, total coliform bacteria were detected in approximately 38 percent of wells tested in the Blue Ridge Physiographic Province, more supporting evidence that the highly permeable soils typical in the area can allow for rapid infiltration of contaminants into the groundwater (Kozar, *et al*, 2001).

In 1995, total withdrawal of water in the Kanawha Basin was approximately 60 million gallons per day (Messinger, *et al*, 2000). Groundwater provides the domestic water supply of almost all rural residents in the basin. Wells in the Blue Ridge province are typically the deepest in the Kanawha Basin, averaging 250 feet in depth (Eychaner, 1994).

2.1.4.3 Geotechnical

Ten bed and seven bank material samples were collected by hand during the September 2002 hydrographic survey. The bed samples were analyzed for grain size distribution. The bank samples were analyzed with a combination of tests including Atterberg limits, direct shear, hydrometer for size distribution of silts and clays, and sieve analysis for grain size distribution of sands and larger sediments. Five of the samples (1, 2, 3, 16, and 17) were collected upstream of the project area in the previously restored reach to evaluate the effects of restoration measures on local sedimentation. Bank samples were non-plastic with relatively low cohesion classified as sandy silts or silty sand with internal friction angles averaging less than 32 degrees. Many of the eroding banks within the study area were observed to be vertical or near vertical and some were undercut, including banks on the insides of bends.

2.1.4.4 Hydraulics

The project area was divided into two reaches, one downstream and one upstream of a mountain slope starting at the left bank, for the hydraulic analysis. Thalweg stations 0+00 through 21+60 made up the upstream reach, while the downstream reach included thalweg stations 21+60 through 40+00. Hydraulic parameters were evaluated for the two reaches of the project area using a one-dimensional, standard step HEC-RAS model (USACE, 1997). The converging of the valley walls at the downstream end and the shallow gradients of the project area create a situation that is highly controlled by downstream conditions during flood events. Because of the bends in the river, which makes the channel significantly longer than the floodplain flow path, two existing condition geometries were developed: high-flow and low-flow. The high-flow geometry represents hydraulic conditions when flood flows submerge the channel and the constriction of the valley downstream controls the water surfaces across the entire project area. The low-flow geometry represents the flow patterns and hydraulic parameters in the channel during flow conditions that are contained in the channel and controlled by channel features.

Results of the high-flow geometry indicate that 100-year return flow submerges the entire project area including the adjacent overbank areas. Table 7 presents the reach average hydraulic parameters for the 30 cfs low flow, 1.5-year return flow, and the 100-year return flow. The upstream reach exhibits lower average velocities for all flow regimes, which are also reflected in larger flow areas and top widths. Further analysis indicates that the 5-year return flow of 4,200 cfs has the highest average shear stress and velocities at the downstream end of the project reach. The 5-year event represents the flow in the transition between high channel submergence before the valley constriction begins to impose a backwater effect on the upstream channel and slow average flow velocities of higher discharges. An analysis of the 100-year flow indicates that raising the channel bottom up to three feet in the hydraulic model caused less than a 0.1-foot rise

Table 7. HEC-RAS hydraulic analysis results, in-channel parameters

Q = 30 cfs		Percent Discharge, In-channel	Avg. Hyd. Depth (ft)	Range of Hyd. Depths		Avg. Depth (ft)	Range of Average Depths		Avg. Velocity (fps)	Range of Velocities		Avg. Area (sq. ft)	Avg. Top Width (ft)
Reach	**Station**			**Max**	**Min**		**Max**	**Min**		**Max**	**Min**		
Upstream	0+00 through 21+60	100	1.06	2.26	0.37	1.08	2.34	0.38	1.04	2.45	0.26	41	37
Downstream	21+60 through 40+00	100	0.86	1.62	0.36	0.86	1.63	0.36	1.10	3.09	0.60	31	38

Q = 1.5 year event		Percent Discharge, In-channel	Avg. Hyd. Depth (ft)	Range of Hyd. Depths		Avg Depth (ft)	Range of Average Depths		Avg. Velocity (fps)	Range of Velocities		Avg. Area (sq. ft)	Avg. Top Width (ft)
Reach	**Station**			**Max**	**Min**		**Max**	**Min**		**Max**	**Min**		
Upstream	0+00 through 21+60	100	5.41	6.33	4.32	4.79	6.14	2.10	3.79	4.96	2.85	315	69
Downstream	21+60 through 40+00	100	5.17	5.74	4.18	4.65	5.46	2.39	4.39	5.45	3.14	272	61

Q = 100 year event		Percent Discharge, In-channel	Avg. Hyd. Depth (ft)	Range of Hyd. Depths		Avg Depth (ft)	Range of Average Depths		Avg. Velocity (fps)	Range of Velocities		Avg. Area (sq. ft)	Avg. Top Width (ft)
Reach	**Station**			**Max**	**Min**		**Max**	**Min**		**Max**	**Min**		
Upstream	0+00 through 21+60	23	19.04	21.02	18.12	22.85	24.37	22.12	2.76	3.35	1.79	14165	1004
Downstream	21+60 through 40+00	53	22.02	23.08	20.84	24.90	25.88	24.22	5.88	8.10	2.47	6511	432

in the modeled 100-year water surface. The almost negligible rise in the 100-year water surface indicates the valley downstream of the project constricts the higher flows and causes the water to back up and pool throughout the project area.

2.1.4.5 Sediment Transport

Initial sediment transport predictions for the 1.5-, 5-, and 100-year recurrence interval discharges were performed using an incipient motion analysis based on Shield's criteria (Kessler, 1971). This basic analysis was used to predict relative bed mobility from channel shear stress and bed material size distributions. Critical particle sizes were determined by using the average shear stress, calculated by HEC-RAS analysis, as the critical shear stress in the Shield's Equation for each set of discharges. Once critical shear stresses and particle sizes were determined, the critical particle size was compared to surface bed material samples to estimate the amount of bed material mobilized. Surface bed material distributions were formulated from field data utilizing gradation analysis of sediment samples collected throughout the project area.

The percentages of the bed mobilized in the project area were calculated for two discharge scenarios: the 1.5-year discharge of 1,200 cfs and the 5-year discharge of 4,200 cfs. Because of the significant constriction at the downstream end, flows greater than the 5-year begin to back up and pool in the project area. The 100-year interval has energy slopes less than 0.0002 feet per foot and shear stresses averaging only 0.2 pounds per square foot. Table 8 presents the critical shear stress and bed mobility results from the incipient motion analysis of the bar and bed materials.

Analysis of the 1.5-year event shows that the reach is fairly uniform in the material sizes that move, and the bed of the entire project area probably mobilizes as flows rise.

Table 8. Predicted bed mobility

River Station	Sample	Shear Stress (lb/ft^2)		Weighted Average Energy Slope (ft/ft)		D_{50} of Sediment Sample (mm)	Mobilized Particle Size (mm) 1.5-year	Mobilized Particle Size (mm) 5-Year	Percent Mobilized 1.5-year	Percent Mobilized 5-Year
		1.5-Year	5-Year	1.5-Year	5-Year					
10+30	Surf-bed	.51	.34	.0017	.0006	3.13	32.13	21.42	87	84
15+60	Surf-bed	.39	.46	.0012	.0009	11.19	24.57	28.98	77	82
21+00	Sub-bar	.49	.61	.0015	.0010	10.00	30.87	38.43	86	87
29+40	Surf-bed	.37	.15	.0012	.0003	9.00	23.31	9.45	73	51
36+40	Surf-bar	.45	.61	.0014	.0012	13.74	28.35	28.98	72	73

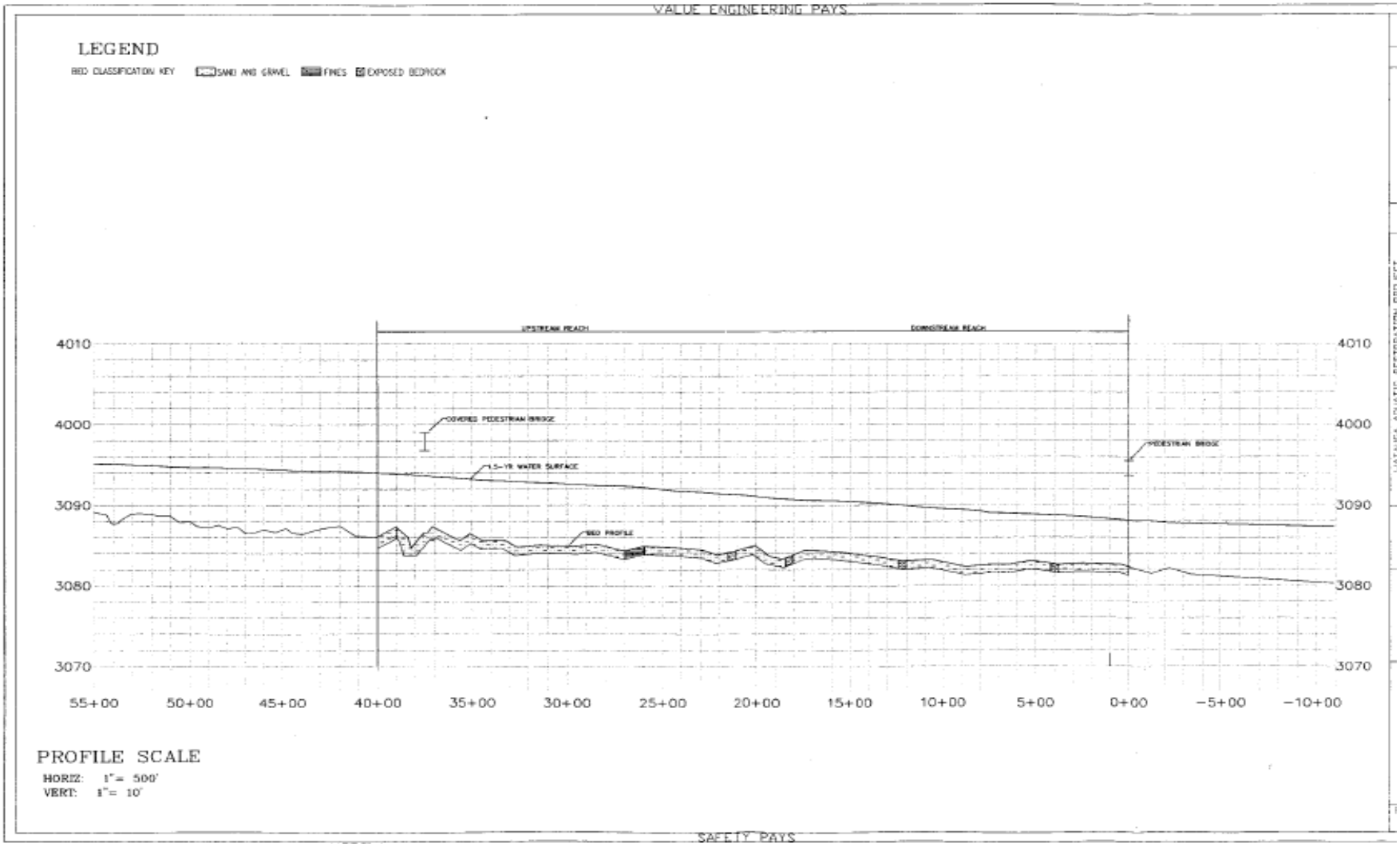
2.1.4.6 Geomorphic Analysis

The project area lies in a floodplain approximately 1,000 feet wide. However, downstream of the project area, the floodplain narrows to less than 100 feet wide where two valley walls come together. Generally, the river throughout the upper basin is confined by the mountains with the planform of the river following this confinement. The alluvial deposited floodplains periodically widen and then narrow along the bedrock and outcropping. Channel gradients are mild with the average drop in elevation approximately 7 feet per mile. Bed material consists of primarily sands and gravels, with a few cobbles, and limited areas of exposed bedrock. Woody debris and the interaction of the riparian zone appear to influence the geomorphology of this system.

For geomorphic characterization, the project area was divided into two reaches, one downstream and one upstream of a mountain slope starting at the left bank. These reaches were defined primarily based on the influence of bedrock on the channel, **w**hich has resulted in different habitat conditions. Figure 6 shows the river profile. The bankfull water surface gradient of the upstream reach averages 0.0014 feet per foot with some riffles and a long pool, and downstream the gradient is 0.0015 feet per foot.

A site reconnaissance study was performed by Tetra Tech on August 18 and 19, 2002, and on September 11 through 15, 2002, for field observations of geomorphic conditions. Detailed information was collected including bed and bank material samples, vegetation delineation, channel cross sections, water surface profiles, bridge chords, and culvert inverts. The flow during the initial reconnaissance was approximately 15 cfs. At this flow level, which was similar to base flow, the upstream reach was observed to have three riffle-pool sequences in addition to a short run and an 800-foot-long pool between stations 24+20 and 32+90. Deposition of fines was observed in this long pool. The downstream reach is more structured by the bedrock outcrops due to its proximity to the mountain slope at the left bank. The river habitat was more diverse with a number of riffles and short deep pools. The downstream reach also has two significantly long runs

Figure 6. River profile



Geomorphic characteristics were evaluated including sinuosity, bankfull top width, width-to-depth ratio, bankfull hydraulic radius, entrenchment ratio, and energy slope. Rectified aerial photographs were reviewed to determine the two characteristics; the hydraulic model was used to evaluate channel dimensions.

In the upstream reach, the channel is laterally unconfined with floodplains on both banks. However, the length of the reach through the open floodplain is relatively short, and the downstream control of the valley slopes may still influence the profile and planform. The sinuosity in this reach is close to 1.14. The one full meander in the upstream reach has a wavelength of about 1,100 feet with a radius of curvature near 400 feet where the floodplain is large enough to allow for an unconfined meander. The downstream reach is mostly confined by the mountain slope and has a sinuosity of 1.08 with small bars forming. This reach also has one full meander with a wave length of 1,100 feet with the radius of curvature approximately 400 feet for both bends.

Bankfull regional curves for the North Carolina mountain streams (Harman *et al*., 2001) show that streams in the region have bankfull return flows ranging from 1.1- to 1.9-year interval with a mean of 1.5-years, which is based on “bankfull indicators” and uniform flow theory. The 1.5-year flow recurrence interval of 1,200 cfs was used for bankfull discharge analyses based on floodplain connection in the habitat restoration upstream of the project area (USACE, 2001). Harman *et al*. (2001), also presents “power function regression equations” to calculate bankfull discharge based on drainage area; this results in approximately 1,400 cfs discharge for the project area. The 15% difference in these bankfull discharge estimates is considered herein to be insignificant, and the expected bankfull discharge calculated from site-specific analysis (1,200 cfs) is used for this analysis. Note that the calculations indicate flows within the project area exceed the top of the banks at approximately 1,700 cfs. This higher-than-expected discharge (1,700 vs. 1,200 cfs) is indicative of an incised channel. The incision process appears to have stopped at the shallow bedrock. However, the forces that started the incision process are now applied to the banks of the channel causing vertical banks and widening. The slightly incised channel and resulting enlarged channel result in a physical bankfull discharge that exceeds desired bankfull for physical connection to the overbanks.

Width-to-depth ratios are a good indicator of habitat degradation at the project area. The processes that triggered incision at the project area are still active. Field observations indicate that the shallow bedrock layers have abated incision and the increased forces are working on the banks and are increasing width-to-depth ratios. The width-to-depth ratios were analyzed for the physical bankfull discharge of 1,730 cfs (2-year) and found to average 10.6 for the upstream reach and 9.1 for the downstream reach in the existing channel. Recent bank erosion and channel widening in the project reach creates a very wide, flat channel during low flows. During the representative low flow of 30 cfs, the wetted channel has very high low-flow width-to-depth ratios (42.6 upstream and 54.5 downstream) and very shallow average depths (1.08 feet upstream and 0.86 feet downstream). Top widths at the physical bankfull recurrence flow elevations average 67 feet in the upstream and 57 feet in the downstream sub-reaches. Average energy gradients were 0.0013 feet per foot upstream and 0.0015 feet per foot downstream.

The project area has a wide, flat, low-gradient floodplain. However, the downstream end of the fluvial system is highly controlled by the entrenchment between the mountain slopes

where the entrenchment ratio is less than 2.2. The sinuosity of either the upstream or downstream reach is minimal, but an evaluation of the entire project area with both sites combined show a sinuosity as high as 1.5. Therefore, a site-specific stream classification under the Rosgen (1996) classification system would consider this a 'C' channel based on the floodplain, average entrenchment ratio, slope, and overall sinuosity. The low width-to-depth ratios (less than 12) for the physical bankfull flow (2-year) show that it is slightly incised as a 'C' channel. The upstream sub-reach is all alluvial material and therefore considered a 'C4' channel; whereas the downstream reach has some bedrock exposed and may alter the classification to a 'C1' channel. However, examination of the downstream reach begins to show other anomalies to a 'C' channel including the moderately entrenched locations (less than 2.2 between stations 0+00 and 4+00), the low sinuosity, and the high control of the valley walls on the system. Harman *et al*. (1999), also states that 'C' channels in North Carolina exhibit well-developed pointbars, which the project area lacks. This shows that the fluvial system causes a transition between a 'B' and a 'C' channel by the Rosgen classification system (1996). Harman *et al.* (2001), classified a majority of North Carolina mountain streams as 'B' type. Detailed results of the geomorphic characterization are shown in Table 9.

Table 9. South Fork New River stream classification

Sub-reach	**Thalweg Station**	**Sinuosity**	**Bankfull Topwidth (ft)**	**Bankfull Hydraulic Radius (ft)**	**Bankfull Width/Depth Ratio**	**Entrench-ment Ratio**	**Bankfull Energy Slope (ft/ft)**	**Channel Alluvium D_{50} (mm)**
Up stream	40+00 to 21+60	1.14	67	6.4	10.6:1	>2.2	0.0013	Sand, Gravel 10
Down stream	21+60 to 0+00	1.08	57	6.2	9.1:1	>2.2	0.0015	Sand, Gravel 10

The influence of the riparian zone observed today to the geomorphic form of the channel is likely seen in two linked variables. First, the root structure of the shrubs and trees in the bank maintain a slower rate of lateral erosion than a vertical bank vegetated with only grasses at the top. Second, trees and shrubs along a sloughing bank tend to promote deposition and bank accretion. The lack of structure in the grassy banks has resulted in an over-widened channel with a very uniform cross-section and little diversity in the banks and bed of the channel. In areas where riparian vegetation has sloughed to the bank toe, the face of the bank becomes vegetated and is naturally stabilized. Woody debris and the small bars that form at the toe of the banks help shape the channel bed causing localized scour of deep pools and development of a non-uniform channel.

Geomorphic stability is a complex process affected by interrelated conditions of hydrology, bed substrate, sediment transport, bank composition, and riparian vegetation. The geotechnical, hydraulic, sediment transport and geomorphic analyses of the South Fork demonstrates that the river channel is unstable and undergoing geomorphic changes. Although it is possible to identify the conditions causing the instability and prescribe a treatment, this requires a detailed analysis to eliminate any confounding factors. For example, the hydraulic analysis demonstrates that the channel is incised and characterized by high sediment mobility, a likely effect of urbanization in the watershed. Unfortunately, the hydraulic analysis is based on historic data, which may no longer be accurate in a changing watershed. Characterizing the hydrology of the present and future watershed would require

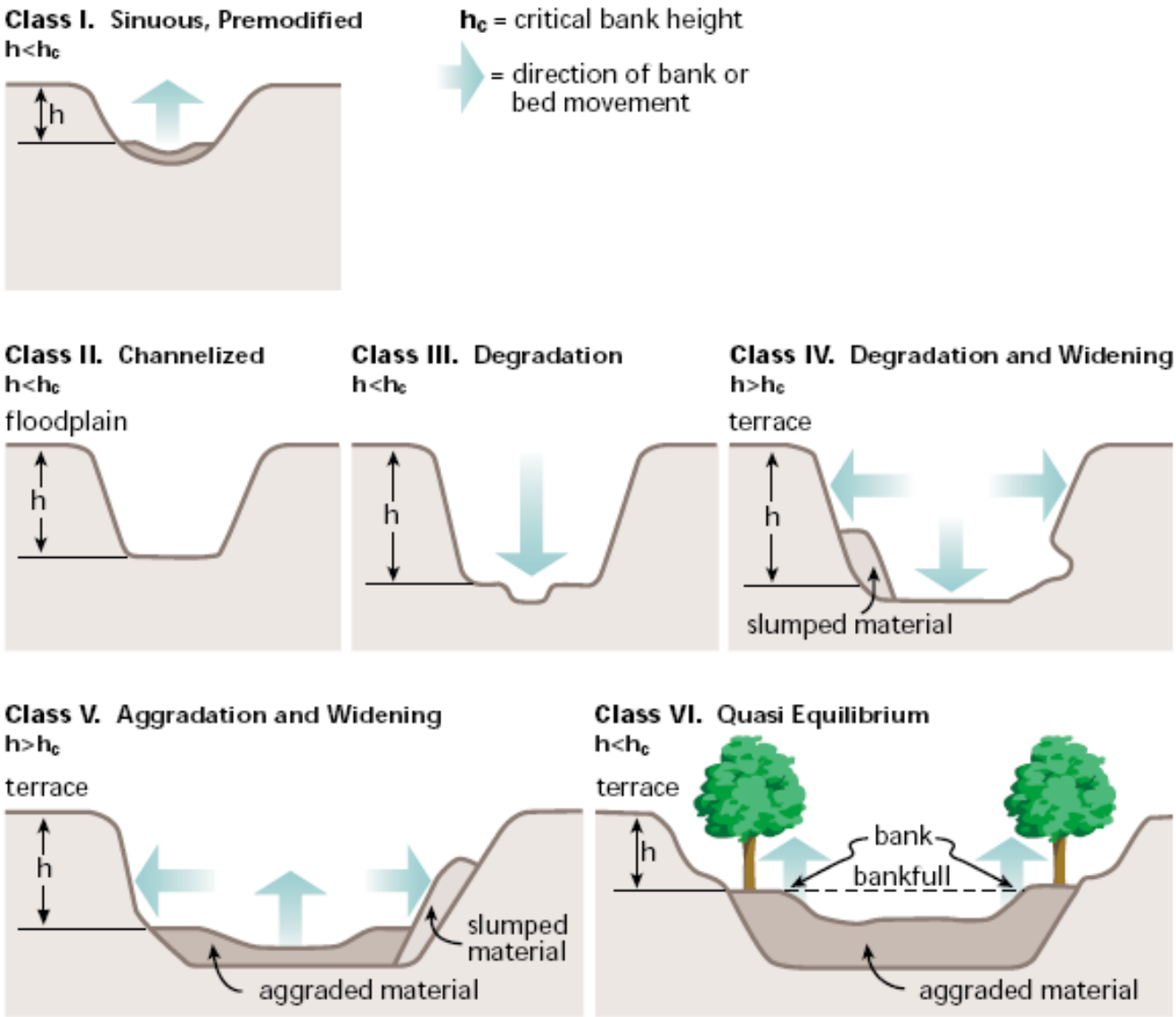


Figure 7. Channel Evolution Model demonstrating degradation and recovery due to watershed disturbances (Used with permission from Simon, 1989).

years of monitoring and even speculation into water resource policies of the future. Although channel characterization is an inexact science at best, unstable channels do follow general patterns of development.

Disturbed or unstable river channels evolve and stabilize through a process described by the Channel Evolution Model (Schumm et al. 1984; Simon 1989). When hydraulic or bank stability processes create an incised channel, the channel goes through phases of degradation, widening, and aggradation, eventually reaching a new, quasi-stable equilibrium (Figure 7). The project area exhibits different stages of channel evolution at different reaches. Some reaches with barren, oversteepened slopes are still actively degrading and widening, whereas other areas are beginning to stabilize, as evidenced by developing point bars and stable riparian vegetation. For an incised channel to stabilize itself, it requires sufficient area in which the natural widening process can occur. The widening process is currently

encroaching on the athletic fields and pedestrian paths, which presents a future challenge for balancing channel needs with recreational needs.

2.1.4.7 Water Quality

Section 303(d) of the federal Clean Water Act (CWA) requires states to identify and rank bodies of water for which required technology-based effluent limitations are not stringent enough to attain and maintain water quality standards. The law also requires that the state establish total maximum daily loads (TMDLs) for the pollutants causing impairment, and submit the list of impaired waterbodies and TMDLs to the U.S. Environmental Protection Agency (EPA).

The South Fork New River (from the confluence of Winkler Creek downstream to US Highway 221/421) is identified as a Class C river. Class C waters can support secondary recreation (i.e. wading, boating, and other uses involving body contact with water that is infrequent, unorganized, and incidental), fishing, wildlife, and fish and aquatic life propagation and survival. Agriculture and other uses are also suitable for Class C waters. This class does not support primary recreation (such as frequent swimming) and water supply for drinking, culinary or food processing (NCDWQ, 2006).

In 2008, the project reach is included in the draft North Carolina 303(d) list of impaired streams and is therefore judged by the North Carolina Division of Water Quality (NCDWQ) to be impaired and cannot fully support aquatic life. This determination was made on the declining quality of benthic samples collected from the reach and not due to a particular chemical parameter in the water (NCDWQ, 2008).

The NCDWQ performs monthly ambient water quality sampling at seven sites within the New River basin. The monitoring site closest to the project is located downstream from the wastewater treatment facility for Boone (NCDENR, 2004). In the most recent "Basinwide Assessment Report" of 2004, overall water quality measured at the site was reported to be high, however the treatment facility located upstream of the sampling site seemed to influence some water quality parameters (Table 10). All dissolved oxygen readings taken at the site were high enough to maintain aquatic life and didn't fall below the NCDWQ threshold of 4.0mg/L; therefore, dissolved oxygen was sufficient for its designated uses. Most pH measurements taken from the site were close to neutral (7.0 s.u.). "The narrow range in pH variability is most likely due to its proximity to the discharge from the wastewater facility for Boone which the pH is near neutral". Specific conductivity varied widely, from 20 to 266. This variability is also believed to be an affect of the wastewater treatment facility. Most turbidity measurements fell below the standard of 50 NTU. The incidences during which the turbidity levels were greater than the standard were correlated to events of significant rainfall. Amounts of arsenic, cadmium, chromium, lead, mercury and nickel in the river were below analytical reporting levels. 17.2% of the samples were greater than the action level (7.0 μg/L) for copper and 3.4% of the samples exceeded the action level (50.0 μg/L) for zinc.

Table 10. Water quality data collected by the North Carolina Department of Environment and Natural Resources from the South Fork New River at Perkinsville, North Carolina from September 17, 1998 to August 20, 2003.

Parameter	N	Evaluation Level	Minimum	50% Percentiles	Maximum
Dissolved Oxygen (mg/L)	45	<5	7.6	10	14.2
Specific Conductance	44	-	20	134	266
pH (s.u.)	45	<6, >9	5.9	7	7.6
Total Suspended Solids (mg/L)	29	>10	1	3	16
Turbidity (NTU)	53	>50	1	2	22
Nutrients (mg/L)					
NH_3 as N	34	-	0.01	0.03	0.5
TKN as N	33	-	0.1	0.2	1
NO_2+NO_3 as N	34	>10	0.56	2.05	5.4
Total Phosphorus	33	-	0.05	0.21	0.75
Total Phosphorus	33	-	0.05	0.21	0.75
Metals (g/L)					
Aluminum	29	-	52	120	590
Copper (Cu)	29	>7	2	3	43
Iron (Fe)	29	>1000	180	310	900
Zinc (Zn)	29	>50	10	19	55

The nutrient levels in the area were also measured. Historically, the site has had elevated levels of ammonia-nitrogen and Total Kjedahl nitrogen (TKN). In 1999, the amounts of NH3 and TKN entering the system were reduced, while the amount of nitrite+nitrate nitrogen (NO_2_NO_3) increased. The NCDENR hypothesized that this change may have been due to the alteration of the sewage processing procedure which occurred at the wastewater treatment facility. Land disturbing activities, such as construction, are very common in the watershed and may also result in the increase in concentrations of NO_2+NO_3. The highest levels of phosphorus within the watershed were collected at this site, which was also attributed to the site's proximity to the treatment facility (NCDENR, 2004).

2.1.5 Climate and Air Quality

The USEPA is required to set air quality standards for pollutants considered harmful to public health and welfare. The Primary National Ambient Air Quality Standards (NAAQS) set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, and prevention of damage to animals, crops, vegetation, and buildings. These standards have been established for the following six principal pollutants, called criteria pollutants (as listed under Section 108 of the CAA):

- Carbon monoxide (CO);
- Lead (Pb);
- Nitrogen dioxide (NO_2);
- Ozone (O_3);
- Particulate matter, classified by size as follows:
- An aerodynamic size less than or equal to 10 micrometers (PM10);
- An aerodynamic size less than or equal to 2.5 micrometers (PM2.5);
- Sulfur dioxide (SO_2).

Watauga County is in the Eastern Mountain Intrastate Air Quality Control Region and under the jurisdiction of the North Carolina Division of Air Quality (NCDAQ) Winston-Salem office. The only criteria pollutant the NCDAQ monitors for in Watauga County is fine particles (particles with aerodynamic diameters of less than 2.5 micrometers). The NAAQS for fine particles is 15 micrograms per cubic meter as the annual standard and 35 micrograms per cubic meter as the daily standard. The design value for 2004 to 2006 measured in Watauga County was 12.1 micrograms per cubic meter annually and 31 micrograms per cubic meter daily. Watauga County is in attainment with the fine particle NAAQS. The NCDAQ also stated that Watauga County is in attainment for the 6 criteria pollutants described by NAAQS (NCDAQ, 2007).

2.1.6 Cultural Resources

The district archaeologist of the USACE, Huntington District, inspected the proposed project area; looking closely at landforms and streambanks. Several areas of historic cut and fill operations extending to the streambank were noted, as evidence of leveling on portions of the present athletic fields. No indications of archaeological remains in the project area were observed. This result mirrors that of a Phase I survey performed for the earlier project,

involving surface inspection, augering and shovel probe excavations in the course of which cut and fill sequences were observed but no cultural resources were found.

2.1.7 Utilities

Some utilities could be affected by the restoration project. Two agencies have been identified as having utilities within the project area. A sanitary sewer line is buried in the left overbank area and crosses the river in an exposed 30-inch pipe upstream of the covered bridge. This sewer line is buried in the right overbank and emerges where it crosses the channel immediately upstream of a pedestrian bridge. Nine manholes for the sewer line exist in the project area; these are elevated approximately five feet above the ground. Six culverts drain the fields directly into the river. There are light poles for the recreational fields on the left overbank. Utility contacts are listed in
Table 11.

Table 11. Utility company contacts, Boone, NC

Company	Type of Utility or Service	Phone Number
North Carolina One Call Center, Inc.	Notifies local utilities of requests for location services	(800) 632-4949
New River Light and Power	Electric	(828) 264-3671
Town of Boone	Water/Sewer	(828) 262-4550

2.1.8 Hazardous, Toxic, and Radiological Waste (HTRW)

The USACE, Huntington District conducted a Limited Phase I HTRW Investigation on the 3,730-foot project reach of the South Fork New River. The purpose of this Limited Phase I HTRW Investigation was to identify environmental conditions and to identify the potential presence of HTRW contamination in the project reach. The investigation was performed based on ASTM E 1527-00 and 1528-00 Standards and USACE HTRW policies. The investigation included an assessment of adjacent properties. This investigation is termed as *limited* because a search of records of regulatory agencies was not performed or reviewed.

An initial field investigation of the area was conducted on January 7, 2004. The conclusions of the first report were verified with another field visit on February 22, 2008. During the physical inspection, the ground surface was examined for signs of contamination. In addition, interviews were conducted with USACE employees and local residents who have extensive knowledge of the area, including its current and past conditions. Neither the field investigation nor the interviews conducted as part of this investigation revealed any potential HTRW concerns within the study area. No impacts were observed on adjacent properties that would have an HTRW and/or environmental impact to the project area.

Based on the results of the field investigation and the interviews, no property ownership history was developed for the project. Also based on these results, records of regulatory agencies were not obtained for review for this project. However, records from the State of North Carolina Department of Environmental Health and Natural Resources pertaining to the project area were available and were reviewed.

The current United States Geological Survey (USGS) 7.5-minute topographic map was available for the project area and it was reviewed. The topographic map is used to identify current and past usages of land that could possibly point to HTRW contamination. This map did not indicate any recent activities that would cause HTRW concerns for the project area.

Based on the investigative findings and the planned activities for this site, no potential HTRW concerns were noted in the project areas. At this time, no additional HTRW Investigations are required.

2.1.9 Noise

Noise is defined as an undesirable or "unwanted sound". Accurately predicting the levels of noise produced during construction is difficult due to variability of several factors, including the distance from the construction site, vegetation, changes in elevation, temperature and humidity. Noise affects the full range of human activities and must be considered in local and regional planning (NYCDEP 2001).

Table 12. Permissible non-Department of Defense noise exposures

Duration/day (hours)	*Noise level (dBA)*
8	*90*
6	*92*
4	*95*
3	*97*
2	*100*
1.5	*102*
1	*105*

Noise levels are measured in units called decibels. Since people cannot perceive all pitches or frequencies equally, noise production is frequently reported in A-weighted decibels, or dBA, where noise is weighted to correspond to human hearing,

While there is no federal standard for allowable noise levels, several agencies have developed guidelines for acceptable noise levels. The Department of Housing and Urban Development (HUD) guidelines denote Day-Night Levels or DNLs (a noise rating developed by the EPA for specification of community noise from all sources) below 65 dBA

as normally acceptable levels of exterior noise in residential areas. While the Federal Aviation Administration (FAA) designated a DNL of 65 dBA as the level of significant noise impact. Several other agencies, including the Federal Energy Regulatory Commission, use a DNL criterion of 55 dBA as the threshold for defining noise impacts in sparse suburban and rural residential areas (Schomer *et al*., 2001). The USACE Safety and Health Requirements Manual provides criteria for temporary permissible noise exposure levels, for consideration of hearing protection or the need to administer sound reduction controls (Table 12).

The project site is composed primarily of open space, athletic fields and wooded areas. The project site is used primarily for recreational purposes including walking, jogging, team sports and fishing. There are no residences within the project area and the closest private home is located 1000 ft away from the project area at an elevation 125ft above the site. Appalachian State University also has facilities 1,000 ft from the project site. Existing noise levels in the area are relevantly low, with peaks usually occurring during sporting events and other outdoor activities. Some vehicles transverse the area, but this occurs infrequently. Within the riparian area and river, sound levels tend to be well below and rarely exceed 40 dBA.

2.1.10 Socioeconomic Resources

Watauga County has four incorporated towns: Beach Mountain; Blowing Rock; Boone, the largest and the county seat; and Seven Devils. Population growth projections between 1990 and 2000 had indicated Watauga County and Town of Boone growth rates of 15.5 percent and 4.1 percent (EDC, 2002), respectively. Population density in the county was approximately 136 persons per square mile in 2000 (USCB, 2008). For Watauga County, median age is 29.9, and 12.3 percent of the population is 65 or older. The total population in Watauga County was 42,700 in 2006 and population of the Town of Boone was 13,472 in 2000. The majority of residents are non-Hispanic whites (95.9%), with African-Americans (2.0%) and Latino and Hispanic (1.9%) forming the second and third largest ethnic and racial groups, respectively.

In 2005, Watauga County had a per capita personal income of $28,323 (USDC, 2008), ranking 44th in North Carolina's 100 counties. Data obtained from the 2004 U.S. Census indicates 14.9 percent of population in the county had incomes below the poverty level (USCB, 2008). In Boone, data indicates 3,199 persons (37 percent of population) had incomes below the poverty level (Region D, 2000).

2.1.11 American Heritage Rivers Initiative

One of the objectives of the American Heritage Rivers Initiative announced in 1997 was to help communities revitalize their rivers and the adjacent banks. Only 14 waterways nationwide were selected as American Heritage Rivers, and the South Fork New River was one of those chosen. The South Fork New River, known historically as the Teays River, has many noteworthy environmental components that make its restoration beneficial to the surrounding community and to those living downstream.

2.2 Problem Summary

2.2.1 The Stream Corridor

The proposed action falls under the designation of a Section 206 aquatic restoration project. The goal of a Section 206 project is to carry out aquatic ecosystem restoration and protection to improve environmental quality that is in the interest of the public and is cost effective. In the past, aquatic restoration has been narrowly defined to include activities that occurred within the river proper only. As science has progressed, a more complete understanding of the stream system has been gained. It is now understood that the aquatic system is an extremely complicated ecosystem that encompasses and interacts with elements far beyond the area covered by water. In fact, water body is essentially linked to the surrounding terrestrial areas. This ecosystem, called the "Stream Corridor", consists of three crucial elements – the stream channel, the riparian zone and the transitional upland fringe. "Water and other materials, energy, and organisms meet and interact within the stream corridor over space and time. This movement provides critical functions essential for maintaining life such as cycling nutrients, absorbing and gradually releasing floodwaters, maintaining fish and wildlife habitats, recharging ground water, and maintaining stream flows". The stream corridor can be distinguished from the surrounding uplands ecosystem by distinct vegetation and soils. In addition, the stream corridor supports "higher levels of species diversity, species densities and a higher rate of biological productivity than other ecosystems" (USFWS, 1998).

The stream channel is the zone traditionally identified as a stream or river. It consists of a sloping bank that reaches to the area of open water. The deepest part of the channel is called the Thalweg. The "baseflow" of water within the stream is created by groundwater percolating up through the substrate; it is the stream flow that occurs during times of low or no precipitation. Water that reaches the channel during short-term rain events is known as "stormflow".

The "Riparian Zone" is the land adjacent to the stream channel that runs laterally to the stream and has "a high water table because of proximity to an aquatic ecosystem or subsurface water" (R.R. Johnson and McCormick, 1979). Because of the influence of the stream, the soils and soil moisture are unique in the riparian zone (Mitsch and Gosselink, 2000). Flooding determines the soil characteristics found in the riparian zone, often resulting in anaerobic conditions, depositing organic material and replenishing nutrients. This area is "characterized by the combination of high species diversity, high species densities, and high productivity". There are different habitat types which can occur within the riparian zone. For example, wetlands are areas with constant or intermittent surface water and contain herbaceous vegetation that is adapted to saturated soil conditions. Bottomlands, which are forested lowlands that are periodically flooded, are another important riparian habitat type found in the eastern United States.

The final component of the stream corridor is the "Transitional Upland Fringe. This zone separates the stream corridor from the surrounding landscape. The transitional upland fringe can be made up of a variety of features, including hill slopes, forests and prairies, but is easily distinguishable as an integrated component of the stream ecosystem. The transitional upland fringe was formed by stream-related hydrologic and geomorphic processes, but these processes are no longer responsible for "maintaining or altering its present form" (USFWS, 1998).

The interrelatedness of the river and the surrounding land necessitates the consideration of the entire stream corridor when determining restoration activities. These relationships were described by Junk et al (1989) with the creation of the Flood Pulse Concept. Junk recognized that river discharge is the most important force controlling life in the riparian zone. River discharge also controls the lateral exchange of material and energy between the river channel and the riparian zone. Junk concluded that the productivity of the river and the riparian zone are directly dependent on the exchange between the river and the adjacent riparian zone. The healthy function of the river is dependent on the health of the adjacent riparian zone and visa versa.

This interrelatedness between the riparian zone and the river can be seen in the many ways. For example, river water quality is dependent upon many processes that take place in the riparian zone. Suspended solids and dissolved chemicals are removed from the water column when stream water enters wetlands and bottomlands. The decrease in water velocity causes sediments to drop out of the water. Chemical contaminants are removed from stream water due to processes that occur when water moves through wetlands and over riparian soils. Minerals are also removed from river water by riparian vegetation and are sequestered in the soil when the plants die (Mitsch and Gosselink, 2000).

The riparian zone is also linked to water quality of the adjacent stream through the cycling of important nutrients, such as nitrogen, and phosphorus. The input of large amounts of some nutrients, especially nitrogen and phosphorus, can be detrimental to the health of aquatic systems. Wetlands and bottomlands act as a sink for nutrients in runoff from uplands, groundwater and in precipitation. In other words, the riparian zone can capture excess nutrients and keep them from entering the adjacent stream (Mitsch and Gosselink, 2000). Peterjohn and Correll (1984) found that a “50 meter-wide riparian forest in an agricultural watershed near the Chesapeake Bay in Maryland removed an estimated 89% of nitrogen and 80% of phosphorus that entered it from upland runoff, groundwater and bulk precipitation.”

In addition to storing nutrients, the riparian soils also transform nutrients that enter from the uplands. Inorganic nitrogen and phosphorus that isn’t sequestered in the riparian zone enters the stream in an organic form. These organic forms can then be utilized by aquatic organisms (Mitsch and Gosselink, 2000).

The riparian zone is important in the cycling of many forms of carbon. Currently, there is considerable concern about the increase in the production of carbon dioxide due to burning of fossil fuels and tree clearing. The riparian zone is a sink for carbon dioxide. At the same time, both dissolved and particulate carbon is important energy sources for the aquatic system. Carbon washed into the stream from the surrounding riparian zone due to flooding is utilized by aquatic organisms. Particulate carbon is used by shredders and filter feeders, while dissolved carbon is taken up by microorganisms that are at the base of the aquatic food chain (Mitsch and Gosselink, 2000). Large woody debris such as fallen trees and broken branches from the riparian zone acts as energy sources once they enter the aquatic system. This material also adds structure that can change current direction and other stream processes, while increasing habitat diversity (Sedell et al, 1980)

The riparian zone supports many plants and animals that use the stream during all or part of their life cycles. This includes amphibians, reptiles, birds, insects and mammals

For example, "virtually all of the fish freshwater species are dependent, to some degree, on wetlands, often spawning in marshes bordering lakes or in riparian forests during spring flooding" (Mitsch and Gosselink, 2000). Common species associated with freshwater wetlands include catfish and bullheads (*Ictalurus sp.*), sunfish (*Lepomis sp., Micropterus sp.*, and *Pomoxis sp.*), carp (*Cyprinus carpio*), buffalo (*Ictiobus sp.*), crayfish (*Procambarus clarkia*), perch (*Perca sp.* and *Istizostedion sp.*), pickerel (*Esox sp.*) and trout (*Salmo sp.* and *Salvelinus sp.*).

Riparian habitats are essential for the survival of a disproportionately high percentage of threatened and endangered species. As many as 50% of all species listed as endangered depend on riparian habitats for their survival.

Another example of the interconnectedness between the river and the riparian zone is seen when examining river hydrology. Water flow within the river determines the character of the riparian zone, while the riparian zone plays an important role in regional water flow regimes. The riparian zone intercepts storm water runoff from the uplands and can store that water. Thus, the duration and magnitude of large runoff peaks will be reduced and the water will instead be released slowly over a longer period of time (Mitsch and Gosselink, 2000). Novitzki (1985) found that an area within the Chesapeake Bay drainage basin that contained wetlands that cover 4% of area experienced flood flow that was 50% less than those experienced in an area that contained no wetlands.

Though difficult to quantify, the surrounding riparian habitat adds to the aesthetic and recreational value of the stream system. A robust riparian zone naturalizes the stream, adding to the experience of being closer to nature and the wilderness. Their ecological diversity makes riparian corridors a valuable site for scientific research to teach natural history. By attracting and supporting game species of both birds and fish, these areas help support valuable fishing and hunting industries. Other recreational activities, such as wildlife photography and bird watching, would not be available without a vegetated corridor to support wildlife.

The value of the riparian zone can be diminished by the invasion of exotic plant species. When exotic species are introduced into an area and they out-compete the native plants for resources, they are classified as an invasive species. Invasive plant species have the ability to impact the aquatic system when they invade the surrounding riparian zone. Once an invasive species has taken over an area, the ecosystem becomes more simplified. As plant species diversity decreases, other ecosystem functions decline as well. When native vegetation is replaced, the functions supplied by the native flora are lost or replaced. The nonnative species typically can only partially replace those functions. For example, productivity decreases, necessary food, shade, and cover become less available, production of organic matter decreases and erosion control is limited when invasive species become established. These changes can indirectly alter erosion and sedimentation rates and change hydrologic conditions within the stream.

2.2.2 Problem Identification

The reach of the New River that falls within the project bounds still contains good quality habitat and species diversity, but the future health of the stream is threatened. The stream supports a diverse population of game and non-game fish species. However, the river is

showing signs of degradation. Although the reach attains the criteria for Class C waters according to the North Carolina Department of Water Quality, it will be listed for the first time as impaired for the maintenance of aquatic life in 2008. For example, many banks are undercut and there is evidence of streambank erosion. In some areas, bottom sediments are covered with a layer of fine sediment, instead of being cleanly swept. There are also signs of damage resulting of over bank traffic by pedestrians and pets. Over usage is causing the banks to become un-vegetated and is resulting in bank failure.

The riparian corridor has been dramatically reduced and plant species composition has been altered from its natural state. Riparian forest along the river has been replaced with urban landscaping, primarily athletic fields and a multi-purpose paved trail. The composition of vegetation in the corridor has been altered by replacement of riparian forest with urban landscaping allowing encroachment of pioneering plants more suited to meadow and disturbed habitats. Portions of this corridor contain much more herbaceous vegetation and much less woody vegetation than would naturally occur within a riparian area in a forested mountainous region. These factors result in substantially less habitat for terrestrial wildlife, and the decrease in the quantity of trees and shrubs reduce shading and woody debris in the river resulting in warmer temperatures and reduced cover for aquatic life. The limited riparian area reduces the capacity of the system to buffer flood events, trap eroding sediment, and cleanse pollutants from runoff, such as fertilizers from the adjacent athletic fields. Furthermore, the lack of root structure in the banks has contributed to bank instability and accelerated bank erosion.

A number of armored storm drains are located along the river banks. These features drain the adjacent athletic fields allowing runoff with fertilizers and pesticides to enter the river directly. Fertilizers from these fields could potentially increase nitrogen in the river, which reduces the oxygen supply for aquatic organisms, and pesticides could be harmful to aquatic organisms in the river. Wildlife, such as the belted kingfisher and the great blue heron, which feed on fish in the river, could be especially susceptible because the toxins bioaccumulate or are concentrated as they move up the food chain. Two exposed sewer crossings also have adverse effects on channel hydraulics by blocking flow area.

Much of the degradation at the site is due to human activities and development that is taking place upstream. The metropolitan area of Boone has developed relatively quickly. This development has led to increased amounts of impervious surfaces, road building, housing construction, and the creation of stormwater management systems. The combination of these contributors results in increased amounts of runoff and discharge into the river. Further development has also resulted in the elimination of forested and vegetated areas, which also causes increased amounts of discharge runoff to surface waters and lowers the water retention capacity of the land. Poor land management practices also impact the New River. Private property owners have replaced the riparian zone with lawns that run right up to the river’s edge. Farmers allow cattle to access the river while in pasture. This practice results in failing banks and increased nutrient input into the stream. Finally, wastewater treatment plants were built upstream of the project site. The discharge from those plants is regulated by the National Pollutant Discharge Elimination System (NPDES) permit system and technology has improved wastewater treatment practices; however these treatment facilities still discharge effluent into the river. Declining water quality upstream of the project has been observed in both the East Fork due to the elimination of riparian area and in Middle Fork due to road widening activities, bridge replacement, installation of water mains and

removal of the riparian zone. As these activities continue in and around the New River, they will continue to degrade the aquatic ecosystem. Increased amounts of discharge into the river will allow nutrients, sediment and other contaminates into the system.

The number and magnitude of peak flow events experienced in the project area has increased with development. The channel is slightly incised and has steep eroding banks. As the channel adjusts to the incised state, it has become over-widened. This has resulted in shallow water depths during normal flows, with the diversity and quality of pools and riffles being significantly reduced. These factors have caused a decrease in quality of fisheries habitat as water temperatures have likely increased and the amount of cover and spawning habitat has been reduced. The natural controls that could buffer the system (i.e. the riparian woodlands and wetlands) against the changing discharge regime are being lost and fragmented due to sustained development.

If no action is taken to reverse the current trend, it is expected that the project area will experience continued sedimentation, streambank erosion, loss of riparian vegetation due to erosion, and the loss of organic (woody and herbaceous) habitat. As the stream continues to widen, water depths will become shallower during normal flows, with the diversity and quality of pools and riffles being significantly reduced. These factors have caused a decrease in quality of fisheries habitat as water temperatures have likely increased and the amount of cover and spawning habitat has been reduced.

The goal of a section 206 aquatic restoration project is to re-establish a healthy, vibrant steam system. This goal ultimately cannot be reached without a comprehensive plan that addresses impairments that occur in the entire ecosystem and not just the area with surface water. Although the scope of this project cannot address many of the destructive practices that are taking place upstream of the project site, actions can be taken within the project area that can halt further degradation and buffer the area from upstream impacts.

2.3 Quantifying Future Habitat Conditions

This feasibility study compares proposed restoration measures to the baseline future condition without the proposed federal project. This baseline is called the “future-without-project” condition. To compare the with- and without-project conditions, it is necessary to quantify the habitat conditions. Although many procedures exist for quantifying habitats, many of these methods are habitat-specific. When dealing with multiple habitat types in one project area, the USACE often uses the Habitat Evaluation Procedure (HEP) developed by the USFWS, which investigates the suitability of habitat for a number of different indicator species.

2.3.1 Habitat Evaluation Procedure (HEP)

To assess overall habitat quality, a HEP (USFWS 1980&81), was performed, based on site reconnaissance and aerial photos, together with assistance from the USFWS office in Ashville, NC. The HEP method chooses different indicator species from the different habitat types present in the project area. Each species has a suitability index (SI) model, each on a 0-1 scale, for various life stages, such as forage, cover, breeding, etc. The SI values are combined by weighted averages to create the overall Habitat Suitability Index (HSI) for each

species. The final HSI is also a number between zero and one, indicating how suitable a particular habitat is for that particular species. An HSI of zero indicates that the location is inhospitable to the species, and an HSI of one indicates that the habitat is ideal and no improvements can be made to increase the number of species that can thrive there.

To assess the HSI values, the entire site was divided into habitat types and native representative species were chosen that have published HSI models. Four species were chosen to represent different habitat types and trophic levels: wood duck, brook trout, veery, and spotted newt. Each of these species is found within the geographic area and is well adapted to the climate and geography of the project area. Due to habitat degradation, however, these species are not common at the project area. Because it is believed that these species would thrive in the project area under fully natural conditions, they represent the potential for restoration of each native habitat type: stream, riparian, bottomland, and wetland. These species and their HSI derivations are described in detail in the USFWS "blue-book" models (1976-84).

Each of the target species utilizes a different but essential part of the aquatic ecosystem that would naturally be found in the area. The aquatic stream ecosystem encompasses the entirety of the stream, the streambanks, the riparian vegetation and hydrologically connected wetlands. A combination of species that utilize all these different parts of the aquatic ecosystem was chosen to represent the overall health and function of the stream corridor. Each of these species requires the aquatic ecosystem to survive, and in turn, the aquatic ecosystem depends on species, such as these, to function.

The wood duck, *Aix sponsa*, inhabits creeks and wetlands in the Eastern United States. It forages on plants, hardwood mast, and aquatic invertebrates. Wood ducks require live tree cavities for nesting and suitable vegetation and woody cover for foraging and brood rearing. Their ideal habitat usually contains wetlands or slow streams surrounded by mature forests. The HIS for this species contains factors measuring density of potential nesting trees, density of vegetation for protective cover, area of suitable water (wetlands or slow streams), and distance between water and vegetation (interspersion). Although wood ducks are present in the geographic area, they have not been sighted in the project area, most likely due to lack of suitable habitat. Because of intense development pressure near aquatic resources and urban competition for flat land, much of the ideal wood duck habitat around the town of Boone has been developed. For example, the project area is one of the few suitable locations for athletic fields in the area. But this area comprises flat floodplain, which, if undeveloped, would be conducive to the formation of bottomland hardwood forests and oxbow wetlands, habitat types that are relatively rare but vitally important to the ecological health of the New River basin. The wood duck HSI was evaluated for wooded and wetland areas. Although it would occasionally utilize stream habitat as well, the HSI does not account for this because the stream velocities during high water would not allow permanent habitation of the stream. For this reason, the present project area was assumed to not contain any suitable wood duck habitat, and this HSI only yields nonzero values for future with-project conditions.

The brook trout, *Salvelinus fontinalis*, is a fish that requires clear, cool, and well-shaded water, and feeds on aquatic macroinvertebrates. Brook trout spawn in gravel, requiring high dissolved oxygen content and low levels of fine sediment. The HSI contains factors measuring water quality, river bed substrate, riparian shading, and quality and density of riparian vegetation. Although brook trout have been sampled in the project area (Table 1),

this area presents marginal habitat for the trout. Eroding banks, impervious surfaces, and loss of runoff catchment, such as wetlands, have contributed to excess sedimentation which leads to silt mantling of the gravel substrate in the stream. Deforestation and bank erosion, reducing overhanging vegetation has increased the amount of sunlight and solar warming, while decreasing available forage. Although the trout HSI accounts for many in-stream factors, such as water clarity, pool-riffle sequences, and substrate, it is assumed that predicting project effects on these parameters would be speculative because these are influenced by watershed-wide factors. Instead, only the suitability indices that depend on riparian vegetation and stable banks were used, because these are changes that can be effected by local restoration. It was assumed for future scenarios that the in-stream properties would not significantly change between the with- and without project conditions, and those associated suitability indices were not investigated, but rather assumed to be ideal (SI =1). This assumption allows for future improvements to the watershed, and although it yields an optimistically biased absolute HSI value, the relative difference between with- and without project HSI values would be conservative with this assumption. Ultimately, this feasibility study will compare the difference between the with- and without-project conditions, so the background assumption will cancel off.

The Veery, *Catharus fuscescens*, inhabits damp forests and shrub thickets, feeding on insects and fruits. Veeries thrive in bottomland forests with lush herbaceous understories or shrub canopies. The veery is a migratory bird that breeds in Canada and the northern United States, but its range extends to the higher elevations of the southern Appalachians, such as the area comprising Watauga County. The HSI for this species contains factors measuring saturation of soils, shrub cover and height, and herbaceous cover and height. The existing riparian habitat in the project area contains a mixture of mature hardwoods with shrub thickets, although many of the shrubs are invasive species, such as multiflora rose (*Rosa multiflora*). Although potential veery habitat exists in the current project area, the riparian area is squeezed onto a very narrow sliver of land that is narrowing because of stream widening and bank failure. The veery HSI was applicable to wetland, riparian, and bottomland habitats.

The red-spotted newt, *Notophtalmus viridescens viridescens*, inhabits either moist woodlands or wetland ponds, depending on its life cycle. Feeding primarily on aquatic macroinvertebrates, the HSI assumes that newts require permanent impounded (wetland) water to complete their life cycle. However, the terrestrial stage of the newt (eft) can thrive in moist uplands, such as bottomland hardwood forests. All life stages require sufficient vegetative cover for forage and protection from predators. The HSI contains factors measuring suitable water availability (wetlands), aquatic vegetation cover, riparian herbaceous vegetation cover, tree canopy cover, and distance between forested and wetland habitats (interspersion). Although the project area contains zones with wetland characteristics, these areas no longer exhibit full jurisdictional wetland function and they do not contain permanently ponded areas sufficient for the newt. An abandoned channel near the project area that currently functions as a wetland, however, is an example of the type of habitat that is likely to occur naturally in the project area, and a good example of prime newt habitat.

Each HSI was analyzed at each existing habitat type, stream, riparian, athletic field, and wet meadow. The riparian and stream areas contained eroded and vegetated banks, which were analyzed separately (Table 13). The mathematical derivation of HSI values was done by

spreadsheet (Appendix B), but an explanation of the habitat suitability of each of the habitat types follows.

2.3.1.1 Stream Habitat

In general, the river within the study area is wide and shallow. The reach contains long run features and the riffle and pool habitat within the reach are not as defined as seen in other parts of the South Fork. Only the brook trout HSI is applicable in the stream habitat. The riparian habitat along the stream provides shade and food for the brook trout. Although the in-stream habitat is described in the following paragraphs, the HSI model only investigated the effect of the riparian habitat on the trout's HSI within the stream.

The upstream reach of the project area contains a series of short riffle/pool/run sequences and then drops into a long pool. The pool contains features such as stones, boulders and wood debris of varying sizes. There are three bends within this reach. A number of gravel bars and vegetated lower terraces are present in this stretch of river.

The downstream reach contains diverse riffle, pool and run sequences in addition to two long, runs. The low-flow channel is very shallow. This reach also includes scour holes located downstream of boulders or adjacent to bedrock outcrops. The banks of this section vary from vegetated and stable to unstable and eroding. The sediment found in this reach is mixed with the deeper holes comprised primarily of sand and fine material with intermittent larger material. The riffles are composed of clean gravel and cobble. The downstream end of the reach includes outcroppings of bedrock.

2.3.1.2 Riparian Habitat

The banks located in the upper stretch of river are quite steep. Some banks are vegetated and stable, while a large number are not vegetated and eroding. Many instances of river bank instability are due to pedestrians and their pets accessing the river over the undeveloped streambank. The substrate consists primarily of clean cobbles and gravel; however, the long pool sediment consists mostly of sand with a mixture of fine deposits and larger gravel, cobble and boulders.

A narrow band of large trees, primarily oaks and smaller black cherry are present, mostly between the covered bridge and the first bend. This band generally consists of only one large tree in width. Downstream, the sizes of trees diminish and are represented by maples and willows with a greater percentage of grasses and weedy herbaceous plants, which are sometimes mowed to the top of the bank. The riparian vegetation corridor on both overbanks is very narrow throughout the reach.

The primary difference between the upper and lower reaches is the left overbank, which is undeveloped and relatively undisturbed due to the steep slopes above the river. Diversity of woody vegetation is higher on the left overbank, and shrub cover is greater, shading the water to a much higher degree. An exception to the diversity occurs at one section of the left bank located under the power lines that has been deforested and is vegetated by grass and intermittent shrubs. A wider riparian zone is evident on the inside of the bend (right overbank) demarking the boundary between the upstream and downstream reaches where a narrow pointbar supports a slightly wider riparian corridor than the rest of the right overbank.

The right overbank downstream of the first bend is largely covered with herbaceous vegetation and has a meadow-like appearance. Trees are largely limited to ornamental plantings surrounded by lawn. The river tends to be narrower and the banks higher in this reach than the upper sub-reach.

Overall, the vegetated riparian habitat contains widely-spaced mature trees and a dense shrub and herbaceous understory. Without wetlands nearby for newt and wood duck breeding habitat, the riparian area is only presently suitable for the veery. In fact, although the present vegetation is invasive, the narrow riparian area contains an ideal shrub canopy for the veery. Studies have shown that invasive vegetation, specifically multiflora rose such as found on the site, does not adversely impact veery habitation (Schmidt et al., 2005).

2.3.1.3 Wet Meadow

There are two low-lying fields within the project area that exhibit regular ponding and moist soils, although they are not dominated by hydric vegetation or soils. They are predominately covered by unmaintained, tall grasses, such as barnyard grass, with occasional shrubs and immature trees. Ponding is not currently sufficient to support obligate aquatic animal species, such as brook trout, wood duck, and red-spotted newt. The shrubs do, however, present sufficient cover and roosting area for marginal veery habitat.

2.3.1.4 Athletic field

The athletic field area contains mowed and maintained turf grass. This not only includes the area within the true, demarcated athletic fields, but also the surrounding lawns alongside the walking path to the edge of the riparian habitat. Due to the mowing, recreation, and lack of suitable cover, the athletic fields are currently not suitable habitat for any of the indicator species.

Table 13. Habitat suitability indices by habitat type. SI values fall between 0 and 1, with a value of 1 representing optimal habitat and 0 representing habitat that can not support the species.

Habitat type	Wood Duck	Veery	Brook Trout	Spotted newt
Eroded stream	N/A	N/A	.77	N/A
Vegetated stream	N/A	N/A	.94	N/A
Eroded riparian	0	0	N/A	0
vegetated riparian	0	1	N/A	0
Athletic field	0	0	N/A	0
Wet meadow	0	.4	N/A	0

na = not applicable

Assumptions were made to simplify the future-without-project conditions. Stream degradation, via erosion, is assumed to reduce some of the land area and disturb some of the riparian habitat. On the other hand, time will allow some habitat types to mature and improve. Also, future land uses and conservation practices are speculative, but the town and University have committed resources to maintain the current use and character of the site as a greenway and recreational area so it is assumed that ecological habitat integrity would be maintained and the area will not be converted to urban developments. For these reasons, it was reasonable to assume that habitat losses and habitat development or improvements for

the indicator species would more or less cancel out over time. Therefore, the present HSI values will also be used as the future HSI values (Table 13). This habitat evaluation is not sensitive enough to measure habitat degradation that may occur, such as increased nuisance species, decreased diversity of total species and loss of sensitive species. These more subtle future conditions will be qualified, rather than quantified, in the comparison of the Preferred Action Alternative (with-project condition) to the No Action Alternative (without-project condition), which is discussed in Section 5.

3 PLAN FORMULATION

This chapter discusses restoration objectives, opportunities and constraints within the study area, primarily in response to the problem summary discussed at the end of Chapter 2. Based on these objectives and opportunities, a series of restoration alternatives have been developed.

3.1 Planning Objectives

3.1.2 Introduction

The general objective of this study is to investigate the feasibility of implementing an ecosystem restoration plan within the study area. This DPR, therefore, seeks to identify an optimal restoration plan based upon an assessment of environmental outputs and incremental costs associated with restoration alternatives. The report also provides a resource impact assessment presented to and coordinated with the public through the completion of an integrated EA. This EA provides compliance with the NEPA of 1969.

3.1.3 Federal Planning Objectives

Plan formulation was conducted in accordance with existing laws, regulations, policies, and the authorizing resolution, which limits the study to aquatic ecosystem restoration and protection projects. Section 206 of the WRDA of 1996 specifically limits the Federal contribution to the project to $5,000,000 or less. The proposed restoration encompasses an area along a 3,730-foot reach of the South Fork New River and already contains small remnants of wetland and riparian habitat, which are suitable for restoration. This corresponds with the purpose of this programmatic authority, which is relatively modest in scope for implementation of projects.

The Corps of Engineers' ecosystem restoration philosophy and guidance gives priority to projects for ecologic restoration of degraded ecosystems. This includes the restoration of an ecosystem's hydrology and its plant and animal communities. Ecosystem restoration projects must examine the condition of the existing ecosystems, or portions thereof, and determine the feasibility of restoring degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Such activities are most likely to address ecosystems associated with wetland, riparian, and aquatic systems.

Plans to address ecosystem restoration should be formulated, and measures for restoring ecological resources may be recommended, based on their non-monetary benefits. These measures do not need to exhibit net NED benefits associated with traditional flood control economic analysis. Rather, they should be viewed based on non-monetary outputs, typically in terms of habitat output units, compatible with Corps Planning Guidance selection criteria. Plans selected for recommendation are then offered for consideration and budgetary support for their National Environmental Restoration (NER) outputs.

3.1.3 Specific Planning Objectives

The overall goal of the Watauga Aquatic Restoration Project is to restore ecosystem functions that are currently lost or degraded on approximately 3,730 feet of the South Fork New River. In order to reach the restoration goal, specific planning objectives were identified through coordination with local and regional agencies, the public involvement process, site assessments, review of prior studies and reports, and review of existing water projects. The specific objectives for the proposed restoration within the project area are presented below.

- Diversify riparian, bottomland, and wetland habitats around stream corridor,
- Improve riparian corridor by planting native vegetation,
- Widen the riparian corridor to create buffer for overland flow and bank stabilization,
- Focus public access away from sensitive river bank areas to improve riparian bank habitat,
- Reduce accelerated erosion of river banks,
- Minimize maintenance and maximize self-sustainability of the system,
- Meet goals of the American Heritage Rivers Initiative of natural resource and environmental protection, economic revitalization and historic and cultural preservation,
- Provide improved community access to recreational opportunities associated with the South Fork New River.

3.2 Restoration Opportunities and Constraints

3.2.1 Opportunities

The South Fork New River, known historically as the Teays River, has been designated as an American Heritage River. One of the objectives of the American Rivers Initiative is to help communities revitalize their rivers and the adjacent banks. This project provides the opportunity to forward to restoration objectives espoused by the American Rivers Initiative. Approximately 3,730 feet of stream would be restored. Specific opportunities for consideration in developing alternatives to restore ecosystem function in the project area are presented below.

- Allow natural river behavior,
- Increase quantity and diversity of fish and wildlife populations,
- Improve water quality for aquatic habitat,
- Increase the quantity of woody debris in the river,
- Increase shading of the river with trees and shrubs,
- Decrease slope of the banks,
- Decrease siltation in the river,
- Provide public access to riverine ecosystem,
- Increase the width of the riparian corridor,
- Increase the quantity and diversity of native trees and shrubs within the riparian corridor,
- Gradually replace large meadow-like patches of herbaceous weeds with a more

diverse assemblage of native riparian vegetation.

*The final three objectives focus on improving the adjacent riparian zone. The necessity of a robust riparian area to an aquatic system is discussed in detail in Section 2.2

3.2.2 Constraints

Consideration of existing constraints is necessary to develop restoration alternatives that will best meet the established objectives. Some constraints may be absolute, while others may be adjusted, or alternatives may be adjusted in order to accommodate the constraints. The limitations of the project have many sources including the development at the site, current site uses, river characteristics, etc. Constraints considered when developing alternatives are presented below.

- Availability of funds: Federal costs may not exceed $5,000,000, with a non-Federal share of 35 percent,
- The water surface of the 100-year flood may not be increased by more than 0.1 feet,
- Existing easements,
- Existing utility, bridge, and other river crossings,
- Existing infrastructure in the floodplain,
- Existing athletic fields,
- Management of upstream fisheries and existing recreational uses may not be adversely affected by project,
- Public safety issues for the pathway,
- Hydrodynamics of river channel not well known,
- Unavailable appropriate reference reach for stream design,
- Sensitive and endemic species in river with unknown consequences of changing river morphology or species assemblages.

3.2.3 Potential Restoration Measures

An array of potential restoration measures was developed as a step towards formulating alternative plans. Measures are identified to show the means to achieve the objectives and goals of the project. A measure is a feature or an activity that can be implemented at a geographic site in order to address one or more planning objectives. Specific measures are presented below:

- Install rock vane and weir structures in the channel bed to maintain a low-flow channel with adequate depths and cover to hold fish and increase macroinvertebrate production,
- Install boulder clusters for velocity breaks and fish cover,
- Augment or replace fine substrates with gravels and cobbles,
- Install large woody debris, such as root wads, to increase habitat diversity and channel stability,
- Slope steep banks to create pointbars or benches on the inside of meander bends,
- Create wetlands along storm drains and at their inlets or outlets,

- Create floodplain and overbank wetlands,
- Plant riparian corridor on each bank to a maximum width practical within project constraints,
- Create riparian benches and plant with native shrubs and trees to provide overhanging cover,
- Remove upper extents of existing hard bank protection and replace with bio-stabilization,
- Remove invasive herbaceous vegetation and revegetate with native mixes,
- Utilize bio-stabilization and vegetate with overhanging cover to reduce erosion rates along banks and provide shade,
- Align hydraulic structures to diversify velocities at bedrock occurrences,
- Install lunker boxes for fish habitat cover,
- Install low-flow fish passage over the diversion dam upstream of the project reach,
- Install informational signage,
- Implement a management plan for the riparian corridor,
- Realign pedestrian path outside of riparian corridor,
- Realign existing recreational fields outside of riparian corridor,
- Eliminate artificial light sources that obscure natural light cycles by relocating light poles from top of eroding banks, away from the stream,
- Install fencing along recreational trail to reduce foot traffic in the riparian area,
- Install access ramps or stairways to river at high-use locations for recreation. Formal river access will control bank failure that is occurring at the high-use locations and reduce the creation of new areas where bank failure will result from pedestrian traffic.

3.2.4 Preliminary Screening of Restoration Measures

The USACE completed a restoration project at a nearby site on the South Fork in 2001. Construction of a restoration project at an adjacent site has produced insight into feasibility of measures. Correspondence with experts from ASU specializing in ecology and hydrology/hydraulics, consultation with the University and local stakeholders has limited the scope of instream measures that would be acceptable for the project. A proper hydraulic model for channel design would require years of hydrologic modeling for proper statistical significance. It was determined that this level of effort would not be cost effective for a stream that is in fairly good condition.

A usable reference reach was not available within the watershed to assist in stream stability analysis and design. The town of Boone is quickly growing, contributing to greater impermeable surfaces in the city, ultimately changing river hydraulics and sediment dynamics within downstream reaches of the watershed. Because the project area is located downstream of the city influence, there are no reference reaches upstream of the city for hydraulic stability. The downstream channel is constricted by topography and also is not an appropriate reference reach

In addition to altering channel hydrodynamics, in-stream structures were also proposed to improve fish habitat, with a focus towards high-gradient game species such as trout. The stream currently fosters a healthy assemblage of smaller, non-game fish, as well as a number of endemic crayfish that may be preyed upon by larger game fish.

This section of the river does contain impairments and conditions upstream of the project will continue to exacerbate the problems, however as previous studies have indicated the river reach does contain some functioning elements of a sensitive stream ecosystem. The risk of causing more damage to the aquatic system within the project reach by implementing large, sweeping changes, such as drastically altering channel form with in-stream structures, is unacceptable. Additionally, without significantly extending the timeframe and scope of the study, a full hydraulics analysis of the stream channel would not be possible. Performing extensive changes in channel morphology without proper hydraulics information would increase the risk of project failure. Due to cost and risk of implementing these features, these alternatives were dropped from consideration. The main non-vegetative alternatives that were considered within the bankfull channel would be "soft" or biotechnical bank stabilization measures at strategic location to reduce loss of riparian habitat and excess sediment load due to bank erosion. Predominately soft bank protection would likely benefit existing species assemblages in the stream by reducing siltation and increasing vegetative cover. Some stone structures still may be beneficial at eroding outside bends in the river where hydraulic forces are at their greatest, but any such effort would be minimal and limited to structures that would not change the channel morphology or harm the project area if they fail.

3.2.5 Final Measures Considered

- *Channel and Streambank Stabilization*
    - Install anchored slab bundles at the toe of unstable slopes,
    - Bank grading and erosion control on over-steepened and barren slopes,
    - Install bendway weirs and hard points with derrick stone (>40" diameter),

The first two measures directly address the failing banks within the project reach. The slope of the banks will be altered; the banks will then be stabilized and vegetated. Restoring the streambanks will eliminate the input of failing soils allowed to enter the system that can result in decrease water quality. In addition, the slab bundles will increase habitat diversity by increasing the amount of woody material in the stream allowing for the colonization by aquatic macroinvertebrates and other organisms. Vegetated streambanks will increase habitat for other creatures dependent on the aquatic system including birds, amphibians, reptiles, insects and small mammal. The vegetated banks will also provide increase shading to the stream for temperature regulation. Increased amounts of overhanging vegetation will improve the supply of food items, such as leaves and insects that fall into the river.

The bendway weirs will redirect the river current away from the eroding bank. At two extreme curves located in the river reach, current directly intercepts the bank, which results in the undercutting and failure of the bank. By directing the flow away from the bank and stabilizing the bank with slab bundles and brush mattresses, the benefits described in the previous paragraph will be achieved.

A more complete discussion of the impacts of channel stabilization is included in Section 7.

- *Wetland Creation*
    - Add wetland outlet control structure such as stoplogs to existing culvert inlets at locations with high overland flow concentration or elevated groundwater table,

- Excavate depressions around natural culvert inlets to deepen and expand ponding area,
- Re-grade or add shallow berms around wetlands to enhance ponding area,
- Design connection to channel to allow periodic overflow of river into wetland areas,
- Add bentonite or other clay material to restored wetland depressions, where needed, to decrease infiltration in areas designated for permanent ponding.

The creation and restoration of wetlands within the project area will have numerous positive benefits for the stream corridor at the site and downstream of the project. The wetlands will capture and reduce the hydraulic loading to the river, reducing the duration and extent of high water events. The wetlands will also collect and filter runoff from the surrounding area. Runoff from athletic field and parking lots contain materials, such as pesticides and pesticide residues, fertilizers and petroleum products that are detrimental to stream water quality and the aquatic community. Wetlands also act as habitat for aquatic waterfowl and other diverse plants and animals.

A more complete discussion of the impacts resulting from wetland creation is included in Section 7.

- *Bottomland and Streambank Vegetation Restoration*.
    - Eradicate and control invasive vegetation in riparian area and revegetate with native species,
    - Increase riparian corridor on each bank to a maximum width practical within project constraints,
    - Provide and encourage overhanging tree and shrub cover for stream inhabitants,
    - Utilize bio-stabilization to reduce erosion rates along banks and provide shade,
    - Realign the pedestrian path outside of riparian corridor,
    - Install split-rail fence and informational signage along path and fields to deter pedestrian egress onto bank,
    - Relocate light poles from top of eroding banks to allow for wider vegetated floodplain,
    - Realign existing recreational fields to allow for wider vegetated floodplain.

The restoration measures within the riparian zone are quite diverse, but each improves the stream system in a unique manner. The eradication and replanting of native species will improve habitat quality of the indigenous species. Increasing the riparian zone through realignment of the pedestrian trail and recreational fields will improve stream conditions in many important ways. These were described in detail in Section 2.2. Realigning the pedestrian path and adding a split-rail fence will discourage pedestrians from accessing the river over the vegetated banks. Damage resulting from this type of foot traffic is evident throughout the project site. Relocating the light poles will have two benefits for the aquatic system. First, moving the lights will allow for a wider vegetated floodplain. Second, moving the poles will eliminate artificial light sources that obscure natural light cycles.

A more complete discussion of the impacts resulting from riparian vegetation is included in Section 7.

- *Recreation*
    - Install informational signage,
    - Create turn-outs from the trail for viewing of stream and wetlands,
    - Utilize existing benches or add new bench locations along trail,
    - Install access ramps at high-use locations for recreation,
    - Relocate impacted recreation facilities.

Recreational measures will indirectly benefit the aquatic system. Signage will inform the public about the project and the value of maintaining a healthy, functional stream ecosystem. Creating formal access to the river, placement of benches and turn-outs for viewing the river will fulfill recreational demands for interactions with the stream. Currently, these demands are not being met, which is evident from the informal trails and damage present throughout the site. Allowing formal, managed access points will eliminate overbank traffic, resulting in bank revegetation and reduction of bank erosion.

3.2.6 Plan Formulation Guidelines

Preliminary measures were initially evaluated according to three criteria: engineering feasibility, economic justifiability, and environmental benefit. For a measure to be feasible from an engineering perspective, it would have to be constructible; able to meet safety regulations; and designable to applicable Federal, USACE, and potentially state criteria. A measure would have to give some indication that its benefits (environmentally) would justify its costs. Restoration measures should generally not have adverse effects that require mitigation.

3.2.7 Analysis of Restoration Measures

Measures that are carried forward are combined in various configurations to a preliminary set of alternatives, which will be subjected to a more rigorous cost effectiveness analysis to identify best buy alternatives that represent a composite of the most cost effective restoration measures. Those alternatives that achieve the desired objectives and are environmentally acceptable, economically justified, and technically feasible are forwarded into the final array of alternatives for determination of the Preferred Action Alternative. As such, the alternatives described in this report are not proposals for actual construction nor are they of sufficient design detail to be constructed. Following completion of the DPR, EA, and public feedback, preparation of detailed plans and specifications would take place.

3.3 Explanation of Measures

These measures have been designed at a number of discrete sections within the planning area. Each section will represent a project increment which can be implemented in conjunction with, or independently of other increments. Cost, in dollars, and benefit, in habitat units, were assigned to each increment (Table 14). To determine the preferred alternative, the increments are analyzed in all possible combinations and permutations during the cost effectiveness incremental cost analysis (CE/ICA). In order to analyze the proposed restoration measures incrementally, the project area was divided into a number of areas that

have distinct ecological function and individual impacts and relocation needs in terms of the surrounding recreational infrastructure. The specific restoration measures are shown (Figure 13) and described below.

3.3.1 Riparian Re-vegetation

R1&R4: These are currently forested riparian areas located within the floodplain that contain invasive vegetation that has compromised the diversity of native vegetation and habitat. The plan is to preserve their riparian and bottomland designation while restoring native vegetation assemblages. Restoration would include selective eradication of invasive species, and replanting with native vegetation. These areas do not overlap on the project area fields or trails, so no further recreational accommodation is necessary. R1 has an area of 1.27 acres (Figure 8) and R4 includes 1.25 acres (Figure 9).

Figure 8. Area R1 identified for exotic vegetation eradication and replanting of the riparian corridor with native plant species.

Figure 9. Area R4 identified for exotic vegetation eradication and planting of the riparian corridor with native plant species.

3.3.2 Wetland Creation

W1: This area (1.61 acres) is a natural depression near the athletic fields with under-maintained and invasive vegetation (Figure 10). The proposal is to restore it to a functional wetland. The trail would be relocated to the outside of the natural depression in the field, with culverts provided to accept drainage from the field. The current culvert would be replaced with a culvert with a controlled outlet. The depression would be excavated deeper and the natural berm enlarged to provide permanent water for year-round aquatic life. Native vegetation would be planted.

Figure 10. Area W1 identified for the creation of riparian wetlands.

W2: This site, with an area of 0.36 acres, is currently a drainage swale that channels overland flows from the fields into a culvert leading to the river. The proposed plan would convert this swale into wetland for habitat benefits and to delay the release of overland flow and thereby reduce hydraulic loading on the river. The plan includes adding a controlled outlet structure to the stormwater culvert, changing the gradation around the fields to maximize stormwater concentration, and some excavation to maximize wetland area. A fence would be included on the trail side of the wetland and a fence-lined earthen causeway with culvert would transverse the middle of the wetland to maximize access to the field from the trail. Exotic vegetation would be eradicated and native vegetation planted.

W4: This area (0.67 acres) is currently a depression containing a channelized drainage stream running through the middle. It contains unmaintained upland and aquatic vegetation, some of which is exotic. The area would be re-graded to allow for stream meander bends and oxbow wetlands. Invasive vegetation would be eradicated and native vegetation planted.

3.3.3 Bottomland Forest Creation

B1-10: These are all currently maintained lawn areas which would be restored back to native bottomland hardwood forests. The physical extents of these areas were carefully selected to minimize encroachment on the recreational fields and trails. Where interference with recreation would be inevitable, relocations are prescribed to minimize impacts to recreation. For example, bottomland areas along the trail will require relocation of the trail to the outside of the restored area, without overlapping on the athletic fields. Area B9 requires relocation of the high-mast lights for the intramural fields. Area B8 requires moving an athletic field and parking lot into a proposed hillside excavation. Measure B4 is on a field that is currently used as an overflow area from the athletic fields. Although the restored area would not be available for recreation, access to the overflow field area would be relocated to the intramural fields on the opposite bank by building a pedestrian bridge and trail extension. Human disturbance of the vegetation and banks is currently a significant contribution to habitat loss and bank failure. A vital part of the restoration project is therefore to discourage recreational and maintenance (mowing) encroachment on the restored area. To minimize human disturbance, the recreational trail would be lined with split-rail fence. As a recreational feature, signage would also be added to explain the ecological importance of riparian and bottomland habitat.

The sizes of these measures are not consistent. B4 is the largest area of bottomland forest to be restored at 1.86 acres. B1 and B2 have a combined acreage of 0.56 acres. B3 is 0.58 acres in size. B5 and B10 both have an area of 0.37 acres, while B6 is 0.70 acres in size. The area of B8 and B9 are 0.63 acres and 0.29 acres, respectively.

Figure 11. Areas W1 and W3 identified for the creation of riparian wetlands.

B7&W3: Similar to the other bottomland areas, the trail will be relocated around a restored area that is currently maintained lawn. This area, consisting of 0.61 acres, contains a drainage culvert, which would be removed and the area re-graded to a lower elevation to create a wetland that would collect runoff from the fields and flood water during sub-bankfull events.

R2/3&S: Although distinct areas on the map, these areas function together as the river channel with riparian banks, upon which the integrity of the adjacent habitats and infrastructure are dependant. This area, which includes 3.46 acres, encompasses a riparian corridor that is currently vegetated with trees, shrubs, and herbaceous vegetation. Many of the shrubs are invasive and would be eradicated and replaced with native plants. The channel has incised downward from its natural configuration, although its elevation has reached bedrock control and the river has ceased to further incise. Approximately 1200 linear feet of bank, however, is unstable and eroding. Because past projects have had success with toe-of-slope treatments, the same measure is prescribed at the eroding locations. Slab bundles will be anchored at the toe of slope with integrated live-logs for stabilization and revegetation. The unstable slopes will be re-graded if necessary and treated with a habitat-appropriate slope stabilizer, such as live willow brush mattresses or coir fabric seeded with native vegetation, which will reduce erosion during flooding and allow vegetation to re-establish. Two stream bends are critically close to athletic fields with minimal room for intervening vegetation. At these locations, stone structures would be prescribed to redirect the thalweg of the river to minimize erosion at the outside bend. The exact design of the slope stabilization features would be created during the designed phase of the project, with minor adjustments occurring in the field during construction under the guidance of a stream channel stabilization expert. Typical structures would be hard points or bend way weirs made of large derrick-size stone (>48” in diameter) lined up and pointing 30 degrees up-channel (Figure 12).

Figure 12. A bend way weir constructed during the previous restoration project on the South Fork New River.

3.4 No Action Alternative

Each restoration measure and combination of measures will be compared to the NAA, which is the future project condition without construction of any restoration measure. The environmental aspects and impacts resulting from the NAA will be described in Section 7.

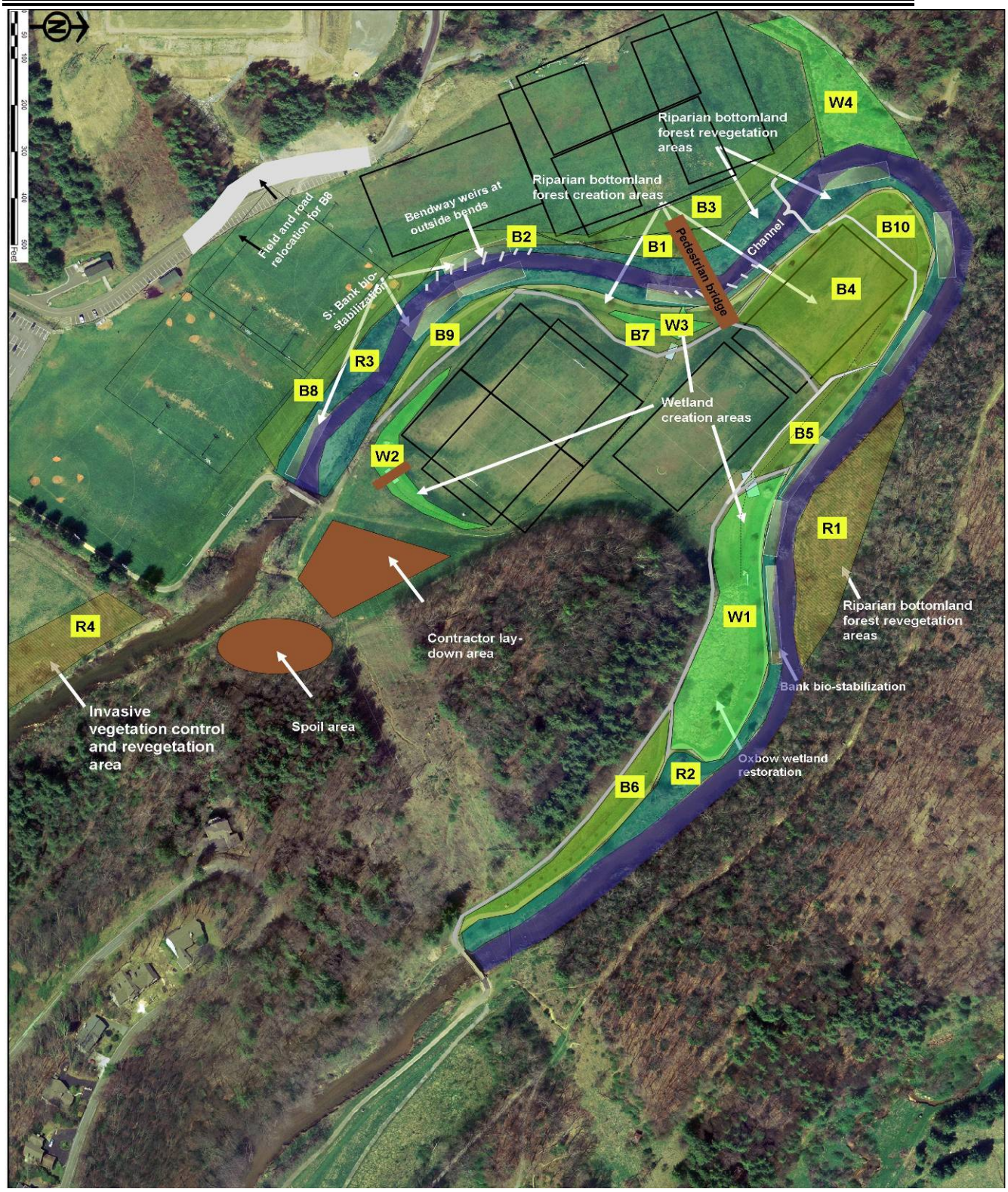


Figure 13. Project Increments. Each increment is a restoration measure that will be analyzed in combination with all other measures to identify cost-effective alternatives.

3.5 Costs of Restoration Measures

Table 14 provides a preliminary construction cost summary for each restoration measure. The present value, if the measures were to be constructed today, is defined as the project's "first cost." The cost can also be described as an annualized figure over the 50-year lifetime of the project. In addition to the costs shown per measure, fixed costs of $277K for real estate, supervision and administration, and construction fixed costs would be added to the final alternative that is made of a combination of measures. The development of these costs is outlined in Appendix A. The planning costs for the feasibility study, cost contingencies, and recreational improvements are not included in the preliminary analysis. Construction is cost-shared between the Federal government and the non-federal sponsor; lands, easements, right-of-ways, relocations and disposal costs (LEERDs) and OMRR&R costs are 100 percent the responsibility of the non-federal sponsor.

Table 14. Project measures for developments of alternatives and cost effectiveness incremental cost analysis.

Increment	Present Type	Target Type	Acres	First Cost	Annual Cost
R1	Riparian/Bottomland	Restored riparian /Bottomland	1.27	$28,919	$1,554
R4	Riparian/Bottomland	Restored riparian /Bottomland	1.25	$28,435	$1,528
W1	Field/wet meadow	Restored wetland	1.61	$146,825	$7,888
W2	field	wetland	0.36	$26,390	$1,418
W4	Stream/wet meadow	Stream/wetland	0.67	$33,063	$1,776
B3	field	Bottomland	0.58	$68,400	$3,675
B4	field	Bottomland	1.86	$378,057	$20,310
B5	field	Bottomland	0.37	$33,292	$1,789
B6	field	Bottomland	0.70	$68,563	$3,683
B8	field	Bottomland	0.63	$769,241	$41,325
B9	field	Bottomland	0.29	$43,370	$2,330
B10	field	Bottomland	0.37	$36,210	$1,945
B7&w3	field	Bottomland & wetland	0.61	$87,299	$4,690
R2/3&S	Channel & riparian	Restored channel & riparian	3.46	$492,481	$26,457
B1&B2	field	Bottomland	0.56	$12,958	$696

3.6 Benefit of Restoration Measures

The HEP analysis used to describe the future-without-project conditions (Table 13) was also used to quantify the value of each habitat type after applying the proposed restoration measures. The future-with-project conditions used reasonable assumptions to simplify the assessment. The HSI criteria drive the with-project design, so it was assumed that the relevant suitability indices for each species would be ideal (SI=1) where possible for all habitat types in the with-project condition. Most of the SI values for each species depended on designable and manageable factors, such as percent canopy cover. For example, the veery receives an SI=1 for deciduous shrub cover greater or equal to 70%. Such ideal deciduous canopies exist in high quality habitats near the project area and would be expected in the restored project area 50 years after restoration. The final HSI values, as a product of the SI values, are not always ideal, however, because certain areas, such as wetlands and forests do not contain all necessary habitat types for the species. For example, the HSI for the newt eft stage in upland habitat depends on distance to wetlands; different habitat plots are different distances to wetlands (HSI as low as 0.41) and some have no wetland access (HSI=0). The HSI derivations for the future-with-project conditions were calculated by spreadsheet, which is shown in Appendix B.

Because the HSI values for all the species depend to some extent on mature shrubs, trees, and functioning wetlands, which are slow to develop in time, it was assumed that the with-project restoration would develop linearly in time from the current conditions to the calculated future conditions, reaching their maximum values at 50 years.

The output of each restoration measure was expressed in Average Annual Habitat Units (AAHU). The AAHU output for each measure was based on the change of habitat units between the “future without project” and the “future with project.” The habitat unit value for each measure was calculated by multiplying the HSI value for each indicator species by the area the species occupies within that measure and summing the result for each species to create habitat units. This calculation was performed on the “without-project” condition (Table 15) and the “with-project” condition (Table 16). The difference between the with- and without-project conditions was calculated in HU values and then averaged over the project lifetime with the assumption of a linear progression from present to future conditions to produce AAHU (Table 17). Mathematically, the AAHU values are simply half of the difference of the before- and after-project HU values due to the linear progression of the restoration value.

Table 15. Habitat unit calculations for without-project conditions.

Measure	land acres	stream acres	Newt HSI	Woodduck HSI	Veery HSI	Trout HSI	Total HU
B1	0.38		0	0	0		0
B2	0.19		0	0	0		0
B3	0.58		0	0	0		0
B4	1.86		0	0	0		0
B5	0.37		0	0	0		0
B6	0.70		0	0	0		0
B7	0.46		0	0	0		0
B8	0.63		0	0	0		0
B9	0.29		0	0	0		0
B10	0.37		0	0	0		0
R1	1.27	0.32	0	0	1	0.94	1.57
R2	2.18	0.75	0	0	1	0.94	2.89
R3	0.82	0.11	0	0	1	0.94	0.93
R4	1.25		0	0	1		1.25
S	0.51	1.01	0	0	0	0.77	0.78
W1	1.61		0	0	0.4		0.64
W2	0.36		0	0	0		0
W3	0.15		0	0	0		0
W4	0.67		0	0	0.4		0.27

Table 16. Habitat unit calculations for with-project conditions.

Measure	land acres	stream acres	Newt HSI	Woodduck HSI	Veery HSI	Trout HSI	Total HU
B1	0.38		0.56	1	1		0.96
B2	0.19		0.47	1	1		0.46
B3	0.58		0.56	1	1		1.49
B4	1.86		0.56	1	1		4.75
B5	0.37		0.56	1	1		0.95
B6	0.70		0.56	1	1		1.79
B7	0.46		0.56	1	1		1.17
B8	0.63		0.41	1	1		1.52
B9	0.29		0.56	1	1		0.74
B10	0.37		0.56	1	1		0.96
R1	1.27	0.32	0	1	1	1	2.85
R2	2.18	0.75	0.49	1	1	1	6.18
R3	0.82	0.11	0.41	1	1	1	2.09
R4	1.25		0	1	1		2.49
S	0.51	1.01	0.49	1	1	1	2.27
W1	1.61		0.8	1	0.6		3.86
W2	0.36		0.8	1	0.6		0.87
W3	0.15		0.8	1	0.6		0.36
W4	0.67		0.8	1	0.6		1.61

Table 17. Development of Average Annual Habitat Units from the difference of the with- and without-project conditions.

Measure	HU without project	total HU with project	HU change	AAHU
B1	0	0.96	0.96	0.48
B2	0	0.46	0.46	0.23
B3	0	1.49	1.49	0.75
B4	0	4.75	4.75	2.38
B5	0	0.95	0.95	0.48
B6	0	1.79	1.79	0.89
B7	0	1.17	1.17	0.58
B8	0	1.52	1.52	0.76
B9	0	0.74	0.74	0.37
B10	0	0.96	0.96	0.48
R1	1.57	2.85	1.29	0.64
R2	2.89	6.18	3.29	1.65
R3	0.93	2.09	1.17	0.58
R4	1.25	2.49	1.25	0.62
S	0.78	2.27	1.49	0.74
W1	0.64	3.86	3.22	1.61
W2	0	0.87	0.87	0.44
W3	0	0.36	0.36	0.18
W4	0.27	1.61	1.34	0.67

4 EVALUATION OF ALTERNATIVE PLANS*

4.1 Combining Restoration Measures

Environmental outputs for the difference of the without- and with-project condition were evaluated in terms of AAHU values as described in Section 0. Many of these measures build off of other measures or require them for stabilization. For example, bank vegetation restoration (R1 and R2) requires stream stabilization (S) to be effective. Similarly, the forested riparian areas build off of the adjacent banks and therefore require them for stability and habitat continuity to achieve their restored habitat values. The restoration measures with their dependencies are presented with their change in AAHU in Table 18.

As shown above in Table 18 there is substantial improvement in habitat quality when comparing without-project to with-project conditions for any of the action alternatives. These changes would begin immediately after project completion (Year 1) and would increase until approximately Year 50. Taking no action would likely result in no improvement in habitat quality in the project area.

Table 18. Increase in benefit (habitat) units of resulting from each restoration measure.

Measure (dependency)	Acreage	Present type	Future type	Benefit (AAHU)
B1 (R3)	0.38	field	Bottomland	0.48
B2 (R3)	0.19	field	Bottomland	0.23
B3 (B1)	0.58	field	Bottomland	0.75
B4 (B10)	1.86	field	Bottomland	2.38
B5 (W1&R2)	0.37	field	Bottomland	0.48
B6 (W1&R2)	0.70	field	Bottomland	0.89
B7 (R2&W3)	0.46	field	Bottomland	0.58
B8 (R3)	0.63	field	Bottomland	0.76
B9 (R2)	0.29	field	Bottomland	0.37
B10 (R2)	0.37	field	Bottomland	0.48
R1	1.27	Riparian/Bottomland	Riparian/Bottomland	0.64
R2 (S)	2.18	Riparian	Riparian	1.65
R3 (S)	0.78	Riparian	Riparian	0.58
R4	1.25	Riparian/Bottomland	Riparian/Bottomland	0.62
S	0.51	Eroded	Riparian	0.74
W1	1.61	wet meadow	wetland	1.61
W2	0.36	field	wetland	0.44
W3 (B7)	0.15	field	wetland	0.18
W4	0.67	Wet meadow	wetland	0.67

4.2 Cost Effectiveness Incremental Cost Analysis (CE/ICA)

Cost effectiveness analysis combines all combinations and permutations measures to identify combinations that represent the project alternatives that are most cost effective. When these combinations are plotted on a cost versus benefit graph, the lower-rightmost options along the scatter plot are the most cost effective. Moving up on the plot increases cost, and moving left decreases benefits. A computer package (IWR Plan) was used to find all project combinations and identify the cost effective plans (Figure 14).

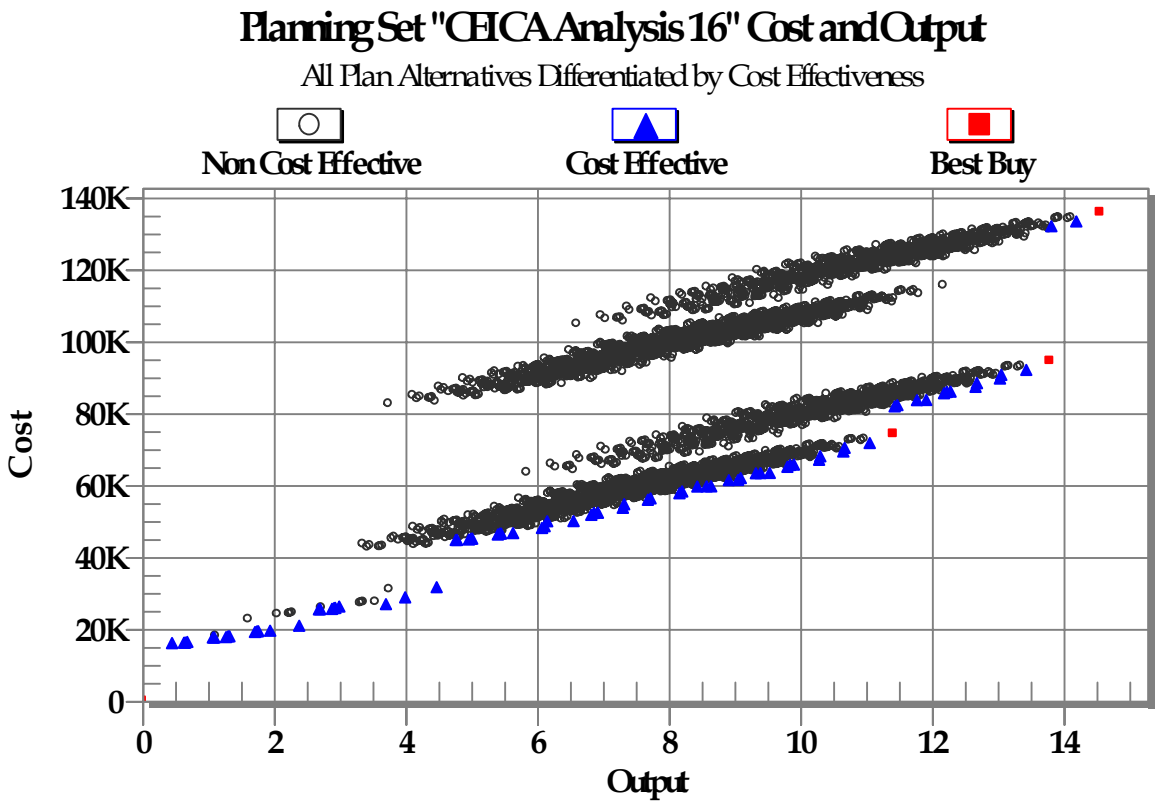


Figure 14. Cost effectiveness analysis chooses the most cost effective combination of measures into "best buy" alternatives.

After the best buy alternatives are identified, incremental analysis is used to examine the incremental increase of cost per unit increase in benefit for the next best buy alternative of greater expense (Table 19). At each incremental increase, the planner should ask whether that increase is “worth it” for meeting project objectives and budgetary constraints. The planning and guidance criteria of completeness, efficiency, effectiveness, and acceptability, will be used to help determine the need and value of a more expensive project increment.

Alternative 1 (A1) No Action

The No Action Alternative (NAA) is the most efficient alternative because it incurs no additional cost. It is not complete because it requires outside forces to effect any further restoration and is not expected to restore on its own. It is not effective because none of the restoration goals are met. Although the future recreation goals would be acceptable under the NAA, the environmental conditions in the project area would not be acceptable because the area does not provide sufficient habitat or diversity for the target species. The NAA is always the first “best buy” alternative in a CE/ICA analysis.

Table 19. Best buy alternative plans from combining all restoration measures. In each subsequent alternative, an additional measure (bold) is added to the total combination.

Alternative	Best Buy Alternatives	Cost	Benefit (AAHU)	50-Year Annualized cost	Benefit per $10,000	Incremental benefit per $10,000 increment
A1 (No Action)	No Action	$0	0	0	N/A	N/A
A2	**R1,R2,R3,R4,W1,W2,W3,W4, B1,B2,B3,B5,B6,B7, B9,B10**	$1,383,000	11.4	$74,300	1.53	1.53
A3	R1,R2,R3,R4,W1,W2,W3,W4, B1,B2,B3,**B4**,B5,B6,B7,B9,B10	$1,674,000	13.8	$89,900	1.53	1.52
A4	R1,R2,R3,R4,W1,W2,W3,W4, B1,B2,B3,B4,B5,B6,B7,**B8**,B9,B10	$2,266,000	15.0	$121,700	1.19	0.24

Alternative 2 (A2)

The second best buy alternative achieves channel restoration with wetland creation and additional bottomland forest restoration. It is the most efficient of the action alternatives because it has the least cost per environmental benefit. Alternative A1 is complete because it requires minimal future input to maintain ecological integrity. It is effective because the major restoration goals are met. It is acceptable from a recreation standpoint as all of the recreational opportunities are still preserved. The alternative is also acceptable from an environmental standpoint because it provides high-quality habitat and diversity for target species. A2 meets all project objectives and Planning and Guidance criteria.

Alternative 3(A3)

The third best buy alternative adds the B4 bottomland area to the combination. This area alone is a great benefit in area gain, but because of the loss of functional playing fields, the bridge required to relocate field access and pathway to the opposite bank adds monetary expense. Alternative A3 is still complete because it does not require further restoration. The added cost per benefit makes this alternative less efficient than A1 or A2, however. This alternative may also be less acceptable from a recreational standpoint because although it relocates access to fields, these fields are still further away and may be in use when needed. The alternative is still acceptable from an environmental standpoint because environmental project goals would be met. It is more effective than the previous alternatives because more area is preserved. The incremental cost per benefit and the total cost are higher than the previous alternatives. Due to the added expense and impact on recreation, the additional gain in area may not be worth it.

Alternative 4 (A4)

The final best buy adds area B8, which requires field and road relocation into the hillside. Unlike the previous best buy, the incremental cost increase is very large in comparison to the gain in benefit. This is evident by the tall skinny nature of the graphical representation of this increment (Figure 15). This alternative is therefore much less efficient than the previous alternatives. It is still complete and acceptable as the previous alternative. The final

alternative is more effective than all the previous alternatives because more area is restored. Because of the necessary increase in incremental cost to affect this small increase in project effectiveness, this option would not be worth the additional cost. This spike in cost for additional land area is a graphical representation of the value of flat land in Watauga County. It underscores the importance of preserving athletic fields in one of the few areas suited for such use. It also demonstrates the cause for the rarity of wetland and floodplain habitat and the importance of finding a balance between natural and urban resources.

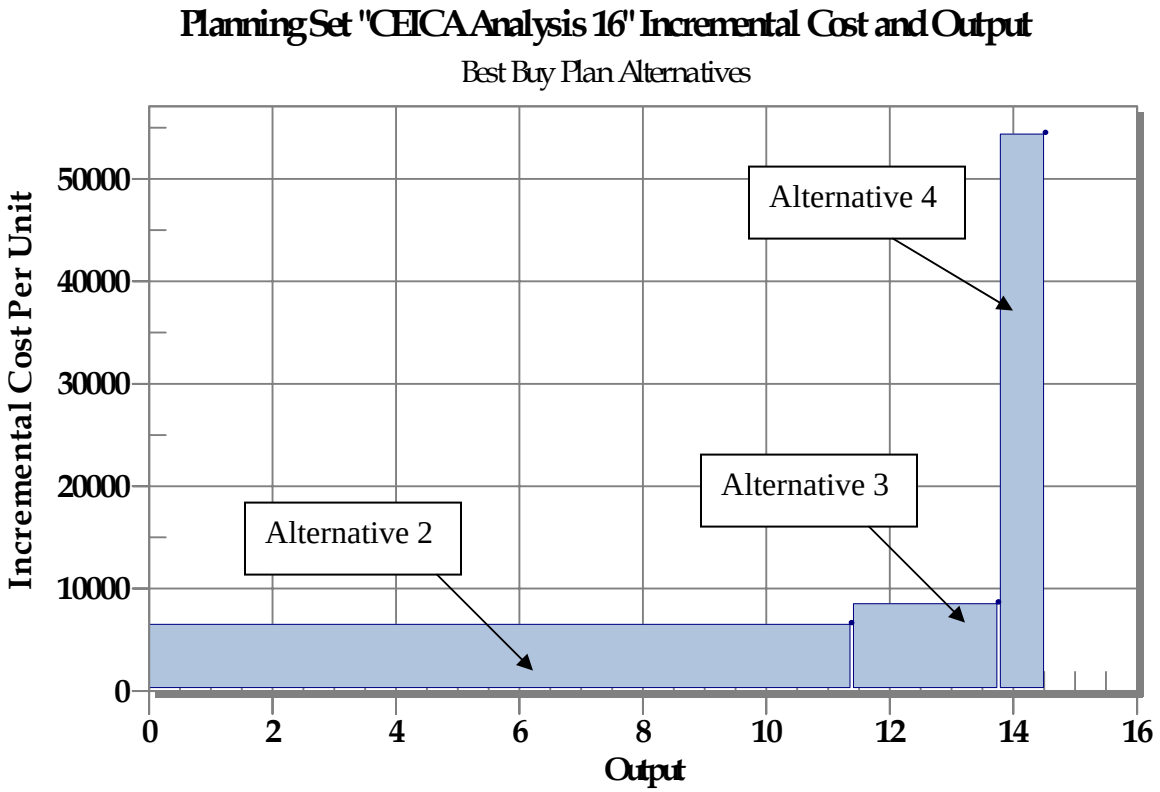


Figure 15. Incremental cost and benefit plot for best buy alternatives.

4.3 Identification of the Preferred Action Alternative

Based on the results of the CE/ICA and consultation with the local sponsor, Alternative 2 was identified as the Preferred Action Alternative. Alternative 2 is one of the "best-buy" alternatives and costs 17% less than the next "best-buy," Alternative 3 (Table 19). Alternative 2 meets all the project objectives and maximizes the restoration area with minimal impacts to recreation. It is expected to provide a total increase of 11.4 habitat units over the fifty-year period of analysis and does not include the excessive costs to avoid recreational impacts associated with Alternatives 3 and 4. Because Alternative 2 is a "best buy" plan, and it meets the Planning and Guidance criteria and planning constraints at the lowest incremental cost, it is considered the NER plan, and will be carried forward in environmental analysis together with the other "best buy" alternatives, including the No Action Alternative.

5 THE PREFERRED ACTION ALTERNATIVE*

5.1 Plan Description

5.1.1 Engineering Design

The Preferred Action Alternative development was based on technical and economic feasibility, Corps of Engineers determinations of environmental soundness and compliance with environmental statutes; and agency, non-Federal sponsor, and Appalachian State University input to plan formulation. Alternative 2 is the recommended plan.

The PPA encompasses 3,730 feet of the main river channel of the South Fork New River. The restoration measures that are included in the alternative include riparian re-vegetation, creation of wetlands, bank stabilization, bottomland forest creation and other activities. Sections R1 and R4 rehabilitation will include the eradication of invasive species, and replanting with native vegetation in order to restore native vegetation assemblages. Functional wetlands will be created at areas W1, W2 andW3. W4 exhibits some wetland characteristics, but it has been altered by channelization. This area will be re-graded to allow for stream meander bends and oxbow wetlands and invasive vegetation would be eradicated and native vegetation planted. Currently maintained lawn areas would be restored to native bottomland hardwood forests at sites B1, B2, B3, B5, B6, B7, B9 and B10. Area B9 requires relocation of the high-mast lights for the intramural fields. To minimize human disturbance, all bottomland areas would be lined with attractive fence, such as split-rail fence, and signage explaining the ecological importance of riparian and bottomland habitat. Toe-of-slope treatments would be installed on approximately 2200 linear feet of bank which is unstable and eroding. Slab bundles will be anchored at the toe of slope with integrated live-logs for stabilization and re-vegetation. 1100 linear feet of unstable slopes will be covered with erosion stabililzation material such as brush mattresses or coir fabric with seeding, which will reduce erosion during flooding to allow vegetation to re-establish. At the two bends in the stream, some stone structures would be prescribed to redirect the thalweg of the river to minimize erosion at the outside bend.

A total of 8,400 cubic yards of material would be excavated under this plan and placed and graded in a spoil area within 1,000 feet of the project area. Approximately 200 tons of boulders would be imported. Manufactured and bio engineering materials to be installed in the project include planting fabrics, filter fabric, GeoWeb, slab bundles, earth anchors, live logs, live stakes, and brush mattresses. Over 2200 feet of toe-of-slope protection would be installed with 1100 feet of bank protection. A total of approximately 1 acre of stream and 12 acres of riparian and wetland vegetation would be restored.

Heavy equipment such as excavators, tractors, end loaders, and dump trucks may be required for the construction of the project. Access to the staging, construction and spoils areas would be on Hunting Lane (paved) and a constructed access road on the right overbank of the river

(gravel or recycled asphalt). Other temporary haul routes in the project area can be field located by the contractor with approval from the Contracting Officer. The wet river channel would be utilized by heavy equipment. Access to the river channel would be from three designated and constructed ramps for heavy equipment. Two staging areas are located on upland properties managed by the Town of Boone or Appalachian State University.

5.1.2 Fish and Wildlife Habitat

Wetland, bank morphology, and overbank riparian plantings would enhance the riparian fringe on each side of the channel. A total of 2.8 acres of wetland and 4.3 acres of bottomland hardwood would be created. 5.9 acres, which are currently riparian and bottomland areas, will be re-vegetated with native willows, shrubs and riparian vegetation after the eradication of invasive species. The project would create an additional 11.4 average annual habitat units (AAHU) over the without-project condition.

5.1.3 Recreational Features

According to Engineering Regulation (ER) 1105-2-100, limited recreational features compatible with the ecosystem outputs for which the project is designed are permissible as part of a Section 206 Aquatic Ecosystem Restoration Project. Recreation features must be justified, cost-shared 50-50, and not increase the Federal cost of the ecosystem restoration project by more than 10%. Recreational features were proposed to enhance public knowledge, access, and observation of the restored habitat features (Table 20). An informational kiosk at the entrance to the project area and signage along the trails would be installed for educational purposes and to explain the project. Benches at pull-out points would allow observation of the project area without intrusion into the restored habitat. Access ramps built during construction would be stabilized with a geoweb base and converted into permanent access points to the river for recreational enjoyment. This will encourage people to access the naturalized parts of the project at select locations, rather than try to circumvent the restoration fencing. This aspect of the project will result in recreational benefits compatible with the ecosystem restoration purpose of the project, such as improved fish and wildlife viewing.

Table 20. Recreational features and cost.

Feature	**Price per item**	**Quantity**	**Cost**
Benches	$150	10	$1,500
Signage	$350	10	$3,500
Kiosk	$1,100	1	$1,100
Geoweb access ramp	$500	2	$1,000
		total recreation	**$7,100**

5.1.4 Real Estate Requirements

The real estate contained within the project boundaries is mostly owned by the State of North Carolina, with a small portion owned by the Town of Boone. A non-standard environmental

restoration easement is recommended for the project. The Real Estate total project cost is $151,000. The Real Estate Plan (REP), which encompasses all of the real estate needed to construct the project, is included in Appendix D.

5.1.5 Hazardous, Toxic, and Radioactive Waste

The Preferred Action Alternative requires excavation and grading in the vicinity of the stream channel and banks to create the ecological restoration area and other project features. Although no known hazardous material waste sites would be affected by this project, the potential exists to encounter previously undocumented hazardous materials and wastes, originating from previous uses of the project area. If contamination is encountered during construction, construction will cease in the vicinity of the contaminated area until the extent and type of contamination has been determined, and an appropriate containment or disposal plan has been developed. The full HTRW report is available in Appendix C.

5.1.6 Operation and Maintenance

The non-Federal sponsor will be entirely responsible for OMRR&R of the Watauga Aquatic Restoration Project once the project is completed. Generally, design of projects under the Corps of Engineers' Section 206 authority seeks to provide an environmentally sustainable project emphasizing minimal long-term OMRR&R activities. The objective of OMRR&R procedures is to maintain structures or project features to "as-built" conditions, or conditions that provide for acceptable project performance consistent with project objectives. OMRR&R activities would mainly involve modifying fluvial structures if they cause adverse hydraulic effects on the channel banks as they shift over time. Also associated with OMRR&R is maintaining access to the in-stream structures, and monitoring and adaptive management of the wildlife facilities. Maintenance of recreational features has not been included in this analysis because this is an existing cost of the without-project condition and the changes to recreational features would not be expected to change their current maintenance costs.

Table 21. OMRR&R costs.

Project Year	**OMRR&R Costs**
Present value at 4.875% interest	$53,000
Years 1 –5	$9000/year
Years 6 – 50	$1000/year

In compliance with authorizing legislation and cost-sharing requirements, the non-Federal sponsor must assume responsibility for operation and maintenance of project features for as long as the project remains authorized. The total OMRR&R cost was estimated to be 5% of the construction cost, or a present value of $53,000 with contingency (Table 22). It is assumed that this cost is heavily front-weighted, as the first 5 years of the project require ecological monitoring as well as contingency for structural repairs. After 5 years, the

restoration is expected to become stable and the features will be less prone to operation and maintenance needs (Table 21).

5.1.7 Monitoring and Adaptive Management

A monitoring and adaptive management program shall be developed and implemented after construction for aspects of the project such as riparian plantings, in-channel structures, fish and invertebrate effects, and overall functionality. Monitoring and adaptive management has been determined to be an essential element in the overall implementation of the proposed restoration plan since it provides an opportunity to review and evaluate the performance of the project, after construction is complete, and implement minor revisions to the overall project based upon evaluations. Although monitoring and adaptive management would include long-term maintenance of vegetation and eradication of invasive vegetation, the bulk of the work necessary to achieve habitat stability would be made the Contractor's responsibility by designing a two-phase planting contract, where the second phase includes replanting, monitoring, and eradication of invasive vegetation after the first critical year of primary planting establishment. Approximately 12% of the planting and vegetation part of the construction costs is designated as adaptive management, which comes to approximately $18,000 of the total construction costs (Appendix A). Additional and long-term monitoring and adaptive management is the responsibility of the Local Sponsor. Subsequent monitoring and adaptive management of habitat is estimated to be 30% of the total Operation and Maintenance budget (Table 21), as described in the previous section.

5.1.8 Project Costs

Table 22 outlines project study and implementation costs with contingency included. As shown, this DPR/EA was accomplished with Federal funding. The total project cost includes the DPR/EA, design, plans and specifications and construction/ implementation phases, real estate costs, contingencies, and supervision and administration costs and is subject to cost sharing as specified in Section 0.

5.1.9 Cost-Sharing Requirements

The Town of Boone has agreed to serve as the local cost-sharing sponsor for this project. The cost-sharing requirements and provisions would be formalized with the signing of the Project Cooperation Agreement (PCA) between the local sponsor and the U.S. Army Corps of Engineers prior to initiation of contract award activities. In this agreement, the local sponsor will agree to pay:

- 35% of the total implementation costs, which amount includes provision of all LERRDs (lands, easements, rights-of-way, relocations, and disposal);
- 100 percent of any OMRR&R (operations, maintenance, repair, rehabilitation, and replacement) costs in accordance with the decision document and the PCA.
- 50% of recreational features (kiosks, signs, benches, and access paths).

Table 22. Project costs for the Watauga Aquatic Restoration Project.

Account	Contract cost	Contingency (25%)	Project cost
Lands and Damages	$127,000	$32,000	$159,000
Relocations	$271,000	$68,000	$339,000
Fish and Wildlife Facilities	$390,000	$97,000	$487,000
Recreation Facilities	$7,000	$2,000	$9,000
Bank Stabilization	$285,000	$71,000	$356,000
Engineering and Design*	$213,000	$53,000	$266,000
Supervision and Administration**	$64,000	$16,000	$80,000
Operations and Maintenance***	$43,000	$11,000	$53,000
Total	**$1,398,000**	**$350,000**	**$1,748,000**
*Assumed 25% for Engineering and Design (E&D)			
**Assumed 7.5% for Supervision and Adminstration (S&A)			
***Assumed 5% for Operations and Maintenance (O&M)			

Based on the above cost-sharing requirements, the total project cost and pertinent cost-sharing information is summarized in Table 23.

5.1.10 Financial Analysis

Further project engineering, design, and construction would be conducted in accordance with the cost sharing requirements provided above. The non-Federal sponsor, the Town of Boone, has indicated its ability and willingness to participate in the planning, engineering, and design of the recommended plan, as well as to participate in construction of the project. The non-Federal sponsor has the capability to fund its portion of implementation responsibilities. The Letter of Intent from the Town of Boone stating its continued support and willingness to cost share the total project cost is presented in Appendix D.

Table 23. Cost sharing requirements.

Phase and Feature	Cost	Federal	Non-federal
DPR/EA*	$208,000	$208,000	$0
Construction and managmenet	$1,536,000	$999,000	$538,000
Recreation	$9,000	$4,000	$4,000
LEERD**	$159,000	$0	$159,000
O&M	$53,000	$0	$53,000
total	$1,956,000	$1,205,000	$751,000
*Initially 100% Federally-funded. Subject to cost sharing once the project is implemented.			
**Costs are based on July 2003 dollars and include a contingency of 25%			

6 PLAN IMPLEMENTATION

6.1 Federal Responsibilities

The estimated Federal share of the total first cost is $1,205,000 (FY 08 price levels at 4.8 percent). In addition to its financial responsibility, the Federal Government would:

- Administer contracts for construction and supervision of the project after authorization, funding, and receipt of non-Federal assurances;
- Conduct all necessary cultural resource investigations and coordinate and implement any necessary preservation or mitigation measures; and
- Conduct periodic inspections with the non-Federal sponsor to determine adherence to the post-construction maintenance requirements.

The execution of a Project Cooperation Agreement (PCA) depends on the availability of federal funding and when non-Federal funding becomes available.

6.2 Non-Federal Responsibilities

The current estimated non-Federal share of the total first cost of the project is $751,000. This does includes LERRD's requirements and operation and maintenance (OMRR&R). The LEERDs costs of $159,000 may be counted as an in-kind service credited to the Sponsor.

Local cooperation requirements for this project are as follow:

- Provide easements, rights-of-way, access to fill disposal areas; and
- Negotiate and implement the protection of all utilities.

7 ENVIRONMENTAL IMPACTS*

NEPA requires the consideration of impacts to the human environment (e.g. the physical setting, water resources, air quality, and recreation) that would result from the construction of the Watauga Project. The unique affects caused by the No Action Alternative (NAA), Proposed Action Alternative (PAA) and the other considered alternatives (Alternative 3 and Alternative 4) are described in this section. This chapter also describes how a resource would be affected and what mitigation measures, if any, would be implemented to reduce any adverse affects to less than significant. The project goal is ecosystem restoration, and any adverse effects are expected to only occur during construction of the preferred plan, being localized and temporary.

7.1 Physical Setting

Long-term healthy function of geomorphic processes directly relates to health of the aquatic ecosystem. Each one of the proposed measure would have an impact on the geomorphology.

7.1.1 Preferred Action Alternative

7.1.1.1 Long-Term Impacts

Streambank and Channel Stabilization

Alterations to the physical setting would result from restoration measures which focus on streambank and channel stabilization. These measures include bendway weir construction, streambank slope regrading and the installation of slab bundles and slope erosion protection.

Long term changes to the project site would be beneficial to the aquatic system within the project area and downstream of the site. The proposed stone bendway weirs would permanently move the thalweg away from the eroding bank, allowing the bank to stabilize. In areas where the streambank is failing, the geometry of the bank would be shaped to have a shallower slope. These areas would then be further stabilized with slab bundles and habitat-appropriate slope stabilization. In addition to a fundamental change in structure, bank stabilization measures would allow the failing banks to become vegetated. The goal of these measures is to slow or completely stop bank erosion within the project site. If successful, the project would reduce the deposition of fine sediments onto the gravel substrate, halt the widening of the stream channel and stop loss of land due to erosion. This project, however, does not change the net balance of sediment transport though the reach and no long-term aggradation or degradation trends are expected.

Wetland Creation
Long term impacts to the physical setting include minor elevation changes resulting from berm construction and excavation in areas that would become wetlands. The character of the

wetland sites would be changed completely. Drainage swales and mowed grassy areas would become areas of standing water throughout most of the year, fostering obligate wetland vegetation. Measure W4 would also include the re-grading of a stream to allow meandering bends and oxbow wetlands. Measure W1 would also necessitate the relocation of the pedestrian trail and W2 would require the construction of an earthen causeway for pedestrian access to the soccer field.

Bottomland and Streambank Vegetation Restoration

Long term impacts resulting from the restored bottomland and streambank vegetation would include the alteration of manicured, athletic fields to riparian bottomland forests. In addition, measure B8, which is included only in Alternative A4, would require the relocation of a parking lot and the excavation of a cliff face. Many of these measures would require the relocation of the pedestrian path and installation of split rail fencing.

7.1.1.2 Short term impacts

During the construction of these features, large equipment would be used in the stream channel, on the streambanks, and in areas that are currently used for recreational activities. Earth-moving would expose soils and other material, which could be released into the aquatic system. Construction that takes place in the stream channel would churn up bottom sediments. These activities would result in a temporary increase in water turbidity due to overland flow from rain washing loose soils into the river bed. This material would eventually be pushed by the current downstream and resettle in areas of low energy. Exposed sediment on the river bank would be re-vegetated or covered with brush mattresses to reduce the amount of material entering the system. Best Management Practices (BMPs) would be used to control the amount sediment entering the river system.

Overall, the PAA would have long-term beneficial effects on natural geomorphic processes and sediment transport. The only short-term adverse impacts that would result from project construction would be temporary in nature, lasting only during the construction phase of the project. The magnitude of the adverse impacts can be reduced through the use of BMPs.

7.1.2 Other Considered Alternatives

The impacts resulting from the implementation of Alternative A3 would be very similar to those described for the PAA. The only difference between the two alternatives is that more bottomland forest area would be created in alternative A3 than for the PAA. A4 would require the excavation of a cliff face to facilitate the relocation of a parking area. The impacts of this action have been previously described in Section 0.

7.1.3 No Action Alternative

Implementation of the NAA would not address the problems observed within the river reach, including the widening of the channel and the accelerated bank erosion

Increased hydraulic forces, coupled with the reduced riparian zone, would continue bank erosion and channel migration, as well as increased sediment loading. The widened low-flow channel with increased sediment loading would continue sedimentation of the channel during low flows that would choke the coarse substrates until the more frequent floods mobilize the fines. This, along with the accelerated bank erosion, would increase the turbidity of flood flows. These effects are already obvious in the channel, as observed by fine sediment mantling on the coarse substrate. In a fully naturalized watershed, cobbles and gravel would be clean and less embedded in silt than is observed today. It is expected that this condition would not improve in the future without changes to watershed and riparian management.

The athletic fields and pedestrian paths in the project area limit the available space for the channel to move and reach this new equilibrium in response to the changes that are occurring upstream. The exact configuration the natural channel would take is unpredictable; however, it would eventually require a wider footprint in the historic floodplain. In some places, a net loss of existing riparian vegetation and encroachment on recreational resources would be inevitable. In other locations, however, land that is currently disturbed would eventually stabilize and mature.

7.2 Biological Resources

7.2.1 Preferred Action Alternative

7.2.1.1 Long-Term Impacts

Streambank and Channel Stabilization

Streambank and channel stabilization would produce many long-term benefits for the biological resources within the stream corridor. The primary purpose of these measures is to prevent further streambank erosion. Eroding banks allow failing soils to enter the river, which degrades habitat quality and increasing stress on the aquatic community. Material that enters the stream settles out of the water column and buries the gravel and cobble that make up the river bottom. Clean bottom substrate is essential for the feeding and spawning of many stream fish species. Controlling the amount of failing soils entering the system would also decrease turbidity and suspended solids levels in the stream. The land lost due to erosion is mainly riparian. This habitat type, which is essential for a fully functioning aquatic ecosystem, is already extremely limited in the project bounds.

Streambank stabilization would result in the revegetation of denuded streambanks. Increased density of adjacent vegetation would be beneficial to the aquatic community. The amount of material dropping into the river from the overhanging vegetation, such as insects, fruit and leaves, is an important food source. The overhanging vegetation would also shade the stream, regulating water temperature. And the vegetation would act as essential habitat for organisms that inhabit the riparian zone during part or all of their life cycle.

The slab bundles, used to stabilize the streambank, would increase habitat diversity and structure within the stream. This material would be colonized by aquatic organisms, such as benthic macroinvertebates and juvenile fish.

The preferred plan would have no adverse effect upon threatened and endangered species. No federally listed threatened or endangered species are known to exist in or adjacent to the South Fork New River. The Kanawha Minnow, which is described as a species of special concern by the Wildlife Resources Commission, could be benefited from the project. The preferred habitat of this species is riffle/ run over hard bottoms. The rehabilitation of the river banks would reduce the amount of failing soils entering the river. By controlling erosion, the amount of fine sediments deposited over clean gravel habitat located within and downstream of the project reach would be decreased.

Wetland Creation

The creation and restoration of wetland habitat would also have long term positive benefits for the biota within the project site. Many animals, including fish and aquatic insects, spend their entire lives in wetlands and many others, including amphibians, reptiles and small mammals, utilize wetlands during specific life stages, such as spawning and feeding. Migrating birds use wetlands as a resting place between flights. Forty-three percent of species, both plant and animals, which have been identified as threatened or endangered live in or depend on wetlands.

The indirect positive impacts that wetlands have on the biota include the ability to trap and hold water, which can moderate water flow. This characteristic can cause a reduction in the duration and scope of high water events. Capturing water also provides time for sediments to settle out of the water column before the water enters the riverine system, resulting in less turbid waters. Wetlands act as natural filters and can absorb nutrients and pollutants while improving the quality of water that enters the river proper.

Bottomland and Streambank Vegetation Restoration

The expansion and rehabilitation of the riparian zone would have several long-standing benefits to the biological resources. Urban grasslands, which possess low habitat and foraging diversity, would be replaced by robust bottomland forest consisting of native plant species. The bottomland system would be much more complex, providing diverse food and shelter opportunities to a wide variety of insects, amphibians, reptiles, songbirds, mammals and fish during part or all of their life cycles. Expansion of the riparian zone would develop a wildlife corridor, greatly increasing wildlife habitat in the project area and providing wildlife access to the stream. A larger riparian zone would increase the amount of shading of the stream and the amount of food items, such as leaves, insects and fruit, entering the aquatic system.

A robust riparian corridor will also support the aquatic community indirectly. A healthy riparian area can reduce the amount of sediment and soils entering the system, thus

decreasing turbidity and sedimentation. Riparian plants can filter toxic chemicals from runoff and capture nutrients before the chemicals can enter the aquatic system.

Moving the high powered lights that are now located next the stream would also benefit the stream community. Many organisms depend on natural changes in light levels that occur annually and daily to maintain regular live cycles, activity levels, spawning events and feeding. Moving the lights away from the stream would allow nature light/dark patterns to occur.

Areas within the project that are currently monotypic stands of exotic vegetation would be replaced by diverse mixes of native species; this would increase the complexity of the ecosystems, supporting a greater diversity of plant and animal species within the site. In addition, native plants would fully support the needs of the indigenous animal species, including food, cover, nutrient cycling, nesting material, which exotic species were only partially fulfilling.

Recreation

Direct impacts that would result from the installation of recreational measures include the elimination of failing and un-vegetated banks that were created by pedestrian traffic. Creating formal access points to the river and installing fencing would allow vegetation to reestablish and stop bank erosion.

Installation of the proposed recreational measures would also have indirect impacts that would promote a healthy aquatic ecosystem. Signage installed along the pedestrian walkway would inform the public about the importance of riparian habitat and the measures that can be taken to improve the function of the aquatic system. This project would promote future restoration and preservation projects. By encouraging similar projects within the watershed, the long-term positive benefits realized by this restoration effort would be extended far beyond the project reach. As a result, significant changes can be made to counter the negative impacts caused by upstream development and poor land management practices.

7.2.1.2 Short-term Impacts

Some negative transitory impacts to the aquatic community would occur during construction while heavy equipment accesses the channel bed to place the stone and wood structures. These activities would bury or dislodge sessile organisms within the construction zone, while scaring motile organisms away from the area. With heavy machinery working in the river channel, the river sediment would be stirred up and would increase suspended solids and turbidity in the water column.

A few impacts resulting from the construction and restoration of the wetlands would be temporary but detrimental in nature. The earth moving that is required to build berms and evacuate the wetland areas would loosen and expose soils which can make their way into the stream, reducing water quality. As described in previous section, these impacts can be

reduced using BMPs. In addition, wildlife would be driven away from the area due to the noise and activity of construction. This impact would end as soon as construction has been completed.

Terrestrial activities would also have limited negative impacts. For example, clearing of invasive vegetation would scare away local wildlife away from the construction zone and reduce the amount of available habitat until the native plants become established and mature.

Effects from construction would be minimized by timing, access coordination, and the use of BMPs. Construction would occur during low-flow periods, and the construction access would be minimized to occur only in small areas necessary to construct structures. Construction timing would also be scheduled not to interfere with fish spawning periods. The effects of construction would be temporary and therefore a non-significant impact. The natural flow of the river would refresh the alluvium and invertebrates would quickly recolonize the new substrate shortly after construction is completed.

7.7.2 Other Considered Alternatives

The other considered alternatives would have very similar impacts as described for the PAA. The positive benefits to the biota would be increased in alternative A3 and A4 because more area would be restored to riparian habitat.

7.2.3 No Action Alternative

The NAA would result in no improvements to the riparian zone or the aquatic environment. The riparian zone would continue to diminish with the migration of the river, reducing terrestrial and aquatic cover. The eroding banks would continue to be a source of sediment entering the river, impacting water clarity and increase sedimentation.

Without restoration measures in the project area, the number of existing large trees in the riparian area would likely decrease as continued bank erosion causes tree located on the banks to fall into the river. The resulting reduction in root structure in the banks would exacerbate bank erosion. The width of the riparian area would likely decrease, banks would continue to erode, and the river channel would encroach on the surrounding athletic fields. Less desirable vegetation, such as blackberries and multiflora rose along the banks, would continue their dominance in the disturbed conditions with less shading, out-competing more desirable species, thereby reducing regeneration of trees and shrubs. These conditions decrease the quality and quantity of available terrestrial wildlife habitat, reducing flood control function, reducing pollution-filtering function, and decreasing quality of fisheries habitat.

In time, the stream would eventually reach a new equilibrium and trees and riparian vegetation would begin to re-establish on previously disturbed banks absent of additional

influences in the watershed. The location of the athletic fields and walking trail would be less adaptive to changes in channel morphology. As the stream widens and stabilizes, there would be a net loss of terrestrial area. Some sensitive species may not be able to survive habitat disturbances. The loss of and changes to vegetation would therefore result in less quantity and diversity of wildlife habitat.

Although some channel and riparian recovery would be possible in the future, the net loss of riparian corridor width, establishment of invasive vegetation, and loss of species diversity would make improvement in habitat quality impossible, even if there is recovery in quantity. It can therefore be assumed that an improvement in habitat value would be impossible without a restoration project. The total HSI values for the indicator are therefore estimated to remain at their present number (
Table 13).

The Kanawha minnow, a state species of concern, is known to exist in the project area. The species is usually associated with riffles over gravel and small rubble (Kuene and Barbour, 1983). Continued degradation of riffle habitat would likely continue without the project and could be detrimental to the local population of the species (NatureServe, 2002).

7.3 Water Resources

7.3.1 Preferred Action Alternative

7.3.1.1 Long-Term Impacts

Streambank and Channel Stabilization

The primary long-term affect that would result from the stabilization of the failing streambanks within the project site would be the cessation of bank erosion, which in turn would reduce the amount of sediment entering the aquatic system. As described earlier, the result would be the decrease in water turbidity, decrease in biological oxygen demand, and reduction of the deposition of fines over coarser substrates. In addition, re-vegetating the streambank would increase shading that would regulate water temperature.

Wetland Creation

Healthy wetlands can significantly increase water quality in the adjacent stream connected in a number of ways. The wetland vegetation acts as a nutrient sink by taking up phosphorus and nitrogen. Nutrients are then stored in the live plant material and are not allowed to enter the river. High nutrient concentrations adversely affect aquatic systems, as previously described in Section 2.2. Wetland soils capture or facilitate the degradation of contaminants from run off and other sources. These chemicals, such as pesticides and herbicides residues used to maintain the athletic fields and petroleum products from parking lots, are not allowed to enter the aquatic system. Wetland vegetation causes water velocities to slow. Suspended

solids within the water are then released into the wetland and are not allowed to enter the stream. Wetlands also capture and retain runoff which can diminish the magnitude of high water events. The impacts that high water events would have on the stream are reduced as the retained water is slowly released back into the river.

Bottomland and Streambank Vegetation Restoration
Healthy bottomland forests positively impact water quality of adjacent streams in ways similar to those describing wetlands in the previous section. Bottomland vegetation acts as a nutrient sink, while bottomland soils can capture contaminants before they enter the aquatic system.

Recreation
Both direct and indirect impact to the water quality of the New River would be realized by the installation of the recreational measures. They are similar to those previously described in Section 7.2.1.

7.2.1.3 Short-Term Impacts

Some temporary disturbance to water quality may result from construction activities. Site preparation, excavation, grading and construction activities would disturb soils and channel sediments in the project area. Soil discharged into storm water runoff or directly into stream channels or other water bodies can increase turbidity, increase biological oxygen demand, and increase deposition of fines over coarser substrates. Heavy equipment would also be temporarily present in the wetted channel and the potential exists for discharge of fuel, oil, greases and other petroleum directly into surface and ground waters. To minimize the impact of these potential discharges, BMPs such as dewatering areas, silt fences, mulching, vegetation establishment periods, equipment specifications, construction limits and procedures in the event of a spill, will be followed during construction.

7.3.2 Other Considered Alternatives

Since the other alternatives considered for the Watauga Restoration project are similar to the PAA, the impacts to water quality would be comparable. Only small variations would be expected due to the amounts of riparian bottomland that would be restored. In addition, Alternative A4 would require the removal of a cliff face for the relocation of a parking lot. This activity requires a large construction effort; however, the use of BMPs should lessen the short-term negative impacts resulting from the construction.

7.3.3 No Action Alternative

With the NAA there would be no changes in water quality, groundwater, hydraulic, flooding or sediment transport. The channel would likely continue to widen via bank erosion causing somewhat elevated levels of turbidity and deposition of fine sediments.

As the upper basin continues to experience urbanization, impervious areas would increase. According to Dewberry and Davis (2000), approximately 50% increase in impervious area above the project area would occur by the year 2020. This increase in impervious areas would cause higher peak flows and more frequent flooding as lower intensity rainfall would result in runoff being more concentrated. The City of Boone is currently addressing watershed management issues; for example, the City plans to build a detention wetland to address runoff from impervious surfaces around the project area. Although urban development is expected to continue to increase the magnitude of hydrologic events, growing awareness of watershed issues indicates that watershed management would also improve in the future, which may eventually lead to hydrologic stabilization in the future watershed.

As the flood magnitudes increase with the future changes in hydrology and the increase of flood flows, the hydraulic forces acting on the channel would increase in frequency and duration. This would accelerate the widening of the channel, causing it to seek new equilibrium dimensions.

7.4 Air Quality

7.4.1 Preferred Action Alternative

Watauga County is in attainment for all six criteria pollutants described by NAAQS. Currently, the only criteria pollutant the North Carolina Division of Air Quality (NCDAQ) monitors in Watauga County is fine particles (particles with aerodynamic diameters of less than 2.5μm). The NAAQS for fine particles is 15 $\mu g/m^3$ annually and 35 $\mu g/m^3$ daily. The annual design value (2004 to 2006) for Watauga County for fine particles is 12.1 $\mu g/m^3$ and the daily design value is 31 $\mu g/m^3$. Therefore, Watauga County is in attainment with the fine particle NAAQS. Since the project area is in attainment for all criteria pollutants, the Federal government does not have to make a conformity determination to assure that their actions would conform to the Sate Implementation Plan for those pollutants.

The preferred plan would have no adverse, long term effects on air quality. Minor, temporary effects on local air quality may occur during construction and OMRR&R activities associated with the recommended plan. Such impacts would be temporary and primarily caused by increased emissions of carbon monoxide, hydrocarbons, and nitrous oxides from vehicles entering and exiting the site along the operation of the necessary equipment. Vehicle travel along unpaved road surfaces, and excavation of bare ground surfaces would create fugitive dust emissions. All construction-related activities on unpaved roadways, bare and dry soil, would need to employ dust-suppression control measures, such as watering, to limit fugitive dust emissions. The project area is adjacent to an urbanized area, and the additional daily equipment emissions and fugitive dust associated with project construction and O&M activities, even during maximum-intensity work periods, would be relatively minor. Overall, no significant adverse effects on air quality are expected.

7.4.2 Other Considered Alternatives

The impacts that would result from the other two alternatives considered for this project would be similar to those created by the PAA. Only small variations in quantity produced and duration would be expected due to the different amount of riparian bottomland that would be restored in each Alternative. Alternative A4 includes the removal of a cliff face for the relocation of a parking lot. This activity requires a greater construction effort, so the adverse impact to air quality would be expected to increase relative to the size and duration of the activity.

7.4.3 No Action Alternative

The NAA would have no effects on air quality.

7.5 Cultural Resources

7.5.1 Preferred Action Alternative

A Phase 1 Cultural Resources Assessment has been preformed by the Huntington District cultural resource specialist. The project area was examined and no cultural resources or historic properties were found to be located within the project area. The USACE Cultural Resource specialist has coordinated with the State Historic Preservation Officer (SHPO). The correspondence with the SHPO and their concurrence with the findings of the USACE are included in Appendix F.

The PAA would have no impacts on any cultural or historic resources.

7.5.2 Other Considered Alternatives

The other alternatives considered during this analysis would have no impacts on any cultural or historic resources.

7.5.3 No Action Alternative

No historic or cultural resources were located within the project area. The NAA would have no impacts on any cultural or historic resources

7.6 Utilities

7.6.1 Preferred Action Alternative

Construction of the PAA calls for existing utilities to be protected in place. Heavy equipment access pads, approved by the Town of Boone Public Works, would be constructed over the buried utilities to prevent damage. These pads would be removed and stockpiled after construction. All areas used for access would be reclaimed to the previously existing

condition. The three utility agencies with utilities in the project reach, Bell South, New River Light and Power, and the Town of Boone, would be notified and consulted regarding the construction timing and techniques to ensure no damage to utilities. The restoration of the riparian zone in area B9 would require the relocation of the high-mast lights for the intramural fields. The contractor would be responsible for informing the appropriate utility agency and gaining the necessary permits. Utility protection costs have been included in the cost estimate.

No significant adverse effects to utilities are expected with the implementation of the PAA because appropriate measures will be taken to ensure that the utilities present at the project site will not be damaged.

7.6.2 Other Considered Alternatives

The other two alternatives, A3 and A4, would result in identical impacts to those created by the PAA.

7.6.3 No Action Alternative

The NAA would not have any effect on existing utilities.

7.7 Hazardous, Toxic, and Radiological Waste

7.7.1 Preferred Action Alternative

No potential HTRW concerns were noted for the project area based upon Limited Phase I investigations. The first field investigation was conducted on January 7, 2004 and the most recent survey took place on February 19, 2008. The complete HTRW survey report is included in Appendix C.

No HTRW impacts associated with PAA would be expected. Construction of the preferred plan would involve some earth moving and re-grading of a number of streambanks to create the ecological restoration area and other project features. Although no known hazardous material waste sites would be affected by this project, the potential exists to encounter undocumented hazardous materials and wastes, originating from previous uses of the properties that would be affected by the project. Signs of potential contamination would include buried underground storage tanks or other containers, soil discoloration, and unusual odors. Although contaminated areas may be encountered, there is no documentation that any exist in the project area. However, if contamination is encountered during construction, construction would cease in the vicinity of the contaminated area until the extent and type of contamination has been determined, and an appropriate containment or disposal plan has been developed.

7.7.2 Other Considered Alternatives

Similar to the PAA, no HTRW impacts would be associated with the construction of the other three alternatives. The same precautions as described in Section 7.7.2 would apply if one of the other options were built.

7.7.3 No Action Alternative

Under the NAA, the potential exposure to hazardous materials would not occur.

7.8 Noise

7.8.1 Preferred Action Alternative

Large, motorized equipment would be required for the implementation of each restoration measures. The specific equipment that would be needed for each measure and average noise production of each machine as measured at 50 feet from the source is listed in Table 24. The construction equipment used to complete the PAA would produce between 76 and 100 dBa of noise. When numerous pieces of construction equipment are run at the same time, the amount of noise experienced at 50ft would be greater than a single machine run alone. The cumulative amount of noise produced during each restoration measure range from 88 to 100 dBa (Table 24). Construction machinery would be operated for approximately 8 hours, generating noise during the daytime (7am-6pm).

A reasonable exposure time of 2 hours would be expected. Elevated noise levels for residents and users could be anticipated for 4 to 6 months, an average provided by the Civil Design Branch of the USACE Huntington District.

Sound levels changes in inverse proportion to the square of the distance from the sound source. The greatest noise level which would occur during the construction is estimated to be 100 dBA at 50 ft from the source. At 800 ft a person would experience would same noise at 76 dBa. The project site possesses elements which would influence the noise levels experienced by local residents. Vegetation and steep changes in elevation would reduce sound levels, while open grassy fields and paved areas would do little to change noise levels encountered by local residents.

During the implementation of the PAA, the primary source of short-term noise impacts would be construction related activity. Peak outdoor noise levels ranging from 88 to 100 dBa could occur during construction of the rehabilitation measures. The noise projections do not account for screening objects, such as trees, outbuildings or other objects that muffle and reduce the noise emitted. In addition, the closest private home and college facility is located about 1000 ft away from the project site. This distance would reduce the largest estimated noise to 64 to 76 dBa.

Table 24. The average noise produced by the construction equipment need to construct the environmental improvement measures included in selected alternative as received at 50 ft. Cumulative noise production represents the potential amount of noise produced during the construction of each measure if all of the necessary machinery is operated at the same time.

Restoration Measure	Equipment	Average Noise Production at 50 ft dBa	Cumulative Noise Production dBa
Wetlands Creation	Excavator	80	
	Hydro Seeder (16 HP)	81	
	Dozer	85	
	Dump Truck	88	91
Re-vegetation	All Terrain Vehicle w/ sprayer	80	
	Hydro Seeder (16 HP)	81	
	Tractor	86	
	Dump Truck	88	91
Spot control after initial work	All Terrain Vehicle w/ sprayer	80	
Bank Stabilization	Excavator	80	
(Vegetate Streambank)	Dozer	85	
	Dump Truck	88	88
Bank Stabilization	Air Compressor	81	
(Bank Protection)	End Loader	85	
	Jack Hammer	88	
	Box Truck	88	92
Bank Stabilization	Irrigation Pump (16 HP)	76	
(Brush Mattress)	Hydro Seeder (16 HP)	81	
	Chainsaw	100	100
Bendway Weirs	Excavator	80	
	End Loader	85	
	Dump Truck	88	88
Trail	Roller	74	
(Paving)	Excavator	80	
	Truck	88	
	Paver	89	92
Trail	Mini Excavator	80	
(Removal)	End Loader	85	
	Tractor	86	
	Dump Truck	88	92
Split Rail Fence	Tractor	86	
	Concrete Mixer (16HP)	85	89

Construction would occur during normal working hours and not increase noise outside of those time periods. Overall, the proposed project would not significantly adversely affect noise levels in the project area. While some of the construction noise generated would be

considered unacceptable according to HUD and FAA standards, these limited exposures and time intervals are still within allowable Corps safety levels (USACE 2003).

The PAA would not result in long-term adverse impacts. Once the construction phase has been completed, the restoration project would not emit sound.

7.8.2 Other Considered Alternatives

The impacts caused by the installation of the two other alternatives considered during this analysis would be similar to those created by the PAA. Only variations in quantity and duration of noise produced would be expected due to the different amount of riparian bottomland that would be restored in each Alternative. Alternative A4 includes the removal of a cliff face for the relocation of a parking lot. This activity requires a large construction effort; as a result the adverse impact to air quality would be expected to increase relative to the size and duration of the activity.

7.8.3 No Action Alternative

With the NAA, no changes to ambient noise conditions in the project area would occur.

7.9 Environmental Justice

7.9.1 Preferred Action Alternative

Under Executive Order (EO) 12898 "Federal Action to Address Environmental Justice in Minority Populations and Low Income Populations," Federal agencies are directed to identify, address, and avoid disproportionately high and adverse human health or environmental effects on minority and low income populations.

Restoring the New River would have a positive impact upon the socioeconomic resources of the area as it restores the river and riparian area as a focal point and a resource for the community. The aquatic restoration project on the South Fork New River is expected to result in improved riparian and aquatic resources. The proximity of the project to the Town, the University, and the Greenway would increase interest in the river and its natural amenities. Non-consumptive environmental, educational, and recreational uses along the South Fork New River are likewise likely to increase with the recommended plan. Other significant socioeconomic resources such as population, transportation, housing, employment, and public services are not expected to be affected by the proposed project.

The PAA would create a positive impact and would benefit everyone in the community equally as the restoration effort would occur in a public area designated for recreational use and available to all residents. The short-term impacts would be also be shared by the users of the area. No disproportionately high and adverse impacts would be experienced by the minority and low income populations of the Town of Boone.

7.9.2 Other Considered Alternatives

The impacts to the minority and low income populations resulting from other alternatives considered during this assessment would have identical to those of the PAA.

7.9.3 No Action Alternative

The NAA would have no changes on the socioeconomic resources in the project area.

7.10 Recreation

7.10.1 Preferred Action Alternative

7.10.1.1 Long-Term Impacts

The restoration measures proposed for the restoration of the New River would cause long term impacts on the recreational activities in the project area. Most of the impacts will improve the recreational opportunities within the project are. The creation of wetlands and the expansion of the bottomland forests would require that sections of walking trail be relocated away from the river bank. The quality and length of the trail would be maintained, however the view of the river would be reduced. These measures would also reduce the area that can be used as athletic fields, which is the primary land usage within the site.

Although the expansion of the riparian zone would reduce view of the water, formal access points leading to the stream would allow easier access to the river for recreational activities, such as fishing, without the incurring damage which is now occurring within the project site.

Measures to repair the failing river banks would improve water quality, which would improve the size and health of the local fishery. Currently, four species of sport fish are known to inhabit the project reach. Improved water quality may increase the fishing opportunities available at the project site. In addition, the stabilization of the streambanks, with the expansion of the riparian zone would stop land erosion and the continued loss of land in the area. This would make the area more visually appealing, enhancing the passive recreation experience.

New recreational alternatives could be established due to the project. Wetlands and a healthy riparian zone would attract wildlife to the area, creating opportunities for wildlife photography and bird watching.

7.10.1.2 Short-Term Impacts

Minor, short-term negative impacts to recreational usage of the area would be caused by construction and maintenance activities. Initial construction and occasional maintenance could preclude an ideal recreational experience by temporarily affecting the character of the area. These effects may include disturbances to wildlife, removal of debris, excavation of the

wetlands and grading the river banks, creation of dust and air emissions, and generation of noise. These activities could disrupt passive and active recreational use of the study area for hiking, wildlife viewing, athletics and aesthetic enjoyment. The temporary impacts are considered non-significant and necessary to create the long-term benefits of the project.

In addition to restoring the aquatic system, a primary concern of the project sponsor was to maintain the current level of recreational usage that the site. On-site erosion would eventually impact the athletic fields bordering the stream. The sponsor was interested in halting the consistent loss of land due to erosion. The sponsor also preferred that the chosen alternative would not alter the site capacity to maintain the current number of regulation sized soccer fields. If necessary, the layout of the fields could change, but the number of field that could be sustained at the site must remain constant. Not only are the number of fields maintained with the installation of the PAA, but field relocation is not required. The measures included in the PAA would reduce the grassy field surrounding the intramural fields, but would not impact the fields themselves.

All of the long- and short-term impacts described in the previous section would be realized.

7.10.2 Other Considered Alternatives

Alternative A3 and A4 include a bottomland restoration measure that would eliminate a large portion of an existing intramural athletic field. This loss was addressed in the plan design by installation of a bridge over the New River that would allow recreational users access to another currently unutilized athletic field.

7.10.3 No Action Alternative

Erosion would continue to occur if no actions are taken in the project area. This would result in the continued loss of land in the area which would possibly reduce the number of usable athletic fields.

7.11 Aesthetic

7.11.1 Preferred Action Alternative

7.11.1.1 Long-Term Impacts

The proposed restoration would have long-term impacts on the aesthetic quality for the project site. Although it is assumed that most people who use the project site would find the long term changes to the area appealing, the impression of the project outcome would be completely subjective. The riparian zone would be widened and replanted with indigenous species. This action would make the area appear more naturalized, with increased amounts of vegetation. However, a thicker riparian zone would obstruct and limit the views of the river. In addition, the new wetlands that would be created on the project site would also make the area seem more naturalized, with the creation of pools of standing water and

establishment of wetland plants. However, some may consider the current condition (i.e. manicured lawns and ornamental trees) visually more appealing than a natural wetland.

7.11.1.2 Short Term Impacts

Aesthetics in the study area could experience temporary adverse effects associated with construction and maintenance activities. Such disturbances would result from earth moving, eradication of exotic vegetation and the staging of heavy construction equipment and storage of materials in or near the project area. These impacts are expected to be non-significant because the activities would take place during brief periods and would affect only limited areas.

7.11.2 Other Considered Alternatives

The impacts to the aesthetic quality of the site resulting from the other alternatives would be similar to those described for the PAA. The extent of those impacts would vary. Both Alternative A3 and A4 would have greater impacts because a greater area would be altered from urban grassland to naturalized riparian zone. This is true to a greater extent for Alternative A4 since the alternative requires the excavation of a hillside.

7.11.3 No Action Alternative

With the NAA, the existing aesthetics would not be affected.

7.12 Cumulative Effects

Cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7)". A series of eleven steps have been developed to assess the cumulative effects of each project pursued by the USACE. The first four steps consist of scoping for the cumulative effects.

The first step involves identifying the significant cumulative effects issues associated with the proposed action. In order to fulfill this step three elements must be defined. These are:

- The direct and indirect effects of the proposed action,
- Which resources, ecosystems, and human communities, are affected, and
- Which effects on these resources are important from a cumulative effects perspective.

In the case of this project, the direct and indirect effects that would result from the implementation of the PAA have been outlined in Section 7.1 through 7.11. These impacts would affect many elements within the local area. The PAA would have the largest influence on the systems within the New River corridor, including both biotic and abiotic elements. Segments of the human community would also be affected by the project. The majority of

this population is comprised of individuals who use the area for recreation, including students of ASU and local residents. The effects of the project that should be considered in the cumulative effects analysis are:

- Erosion control
- Public education (on the stream ecology and land management practices),
- Improved water quality (decrease turbidity, biological loading, water temperature and decrease nutrients and contaminant discharge into the aquatic system via runoff),
- Prevention of stream channel widening,
- Increased water retention capacity which would normalize the duration and magnitude of high water events,
- Increased input of edible material, such as leaves and insects, consumed by the aquatic community,
- Increased the size and complexity of available habitat types,
- Creation of a wider variety of recreational opportunities for the site.

Step 2 establishes the geographic scope that would limit the range of the cumulative effects assessment (CEA). The North Carolina Department of Water Quality (NCDWQ) as established subbasins of the New River. These groupings contain streams that are geographically contiguous and share physical characteristic. The project site falls within New River Subbasin 05-07-01. This region includes East Fork South Fork New River, the Middle Fork South Fork New River and Winkler Creek that are upstream of the site and Naked Creek, Peak Creek and Cranberry Creek that are downstream of the Watauga Site.

Step 3 establishes a timeframe for the analysis. The timeframe for the effects assessment would extend from 1970 to 2058. The stream health has been influenced by human activity probably since European descendants settled the area. However, large scale impacts were being realized in the 1970's. This project is designed to have a life span of fifty (50) years.

The final scoping step, Step 4, requires the identification of "other actions affecting the resources, ecosystems, and human communities of concern". In this section all past, present and reasonably foreseeable future actions that may act cumulatively with the impacts of the USACE project should be identified. Pertinent actions are listed below:

Past

- Development of project site into recreation fields by the University,
- Development of the metropolitan Boone area (which included creating impervious surfaces, road building, construction, houses, creation of stormwater management systems),
- Elimination of forested and vegetated areas (resulting in the increase of discharge runoff to surface waters and lower water retention capacity),
- Previous land management practices,
- Development of a trout fishery upstream of the site,
- Establishment of the Christmas tree industry 15 years ago,

- Legislation of environmental laws in the 1970's (including the Clean water Act that mandated regulation of point source discharge),
- Construction and then upgrades made to Waste Water Treatment Plant in the area,
- Continued use of the project site by the public for recreational activities.

Present

- Continued impacts due to development and land management practices in the New River Basin listed above (e.g. urban or impervious surface runoff, construction sites, road building, agriculture and forestry),
- Continued Non-Point and Point source discharges,
- Federal and Local management of water quality protection initiatives,
- Declining water quality upstream in Middle Fork due to road widening activities, bridge replacement, installation of water mains and a non-existent riparian zone.
- Continued regulation of activities in and around the stream system and monitoring by the Federal, state and local agencies,
- Continued use of the project site by the public for recreational activities.
- Education of the Public about land management practices.

Future

- Continues impacts due to development and land management practices in the New River Basin listed above (e.g. urban or impervious surface runoff, construction sites, road building, agriculture and forestry),
- Continued regulation of activities in and around the stream system and monitoring by the NCDWQ.
- Continued Non-Point and Point source discharges,
- Education and implementation of restoration projects
- BMPs, implementation of sediment and erosion control plan
- Continued regulation of activities in and around the stream system and monitoring by the Federal, state and local agencies,
- The Town of Boone is drafting a Stormwater management plan to limit stormwater discharge into the New River.

The conclusion drawn from the scoping information is that the impacts for the proposed project would not act cumulatively with the other actions that are occurring within the New River Subbasin. All of the measures of this aquatic restoration project would have long-term impacts that would be beneficial to the resources within the Subbasin. These positive impacts would counter the existing and future detrimental stressors.

8 ENVIRONMENTAL COMPLIANCE*

8.1 Federal, State, and Local Agency Coordination

As required under the Fish and Wildlife Coordination Act, this project has been coordinated with the North Carolina Wildlife Resources Commission, the U.S. Fish and Wildlife Service, and the North Carolina Department of Cultural Resources. Appalachian State University (ASU) owns the lands in the project area, and coordination with ASU was extensive throughout plan formulation including the development of alternatives, the procedures for modeling benefits, and preliminary design considerations. Officials from the Town of Boone, the non-federal partner of the project, leases the land that makes up the green way from ASU was also involved during all phases of project planning.

8.2 Environmental Laws, Executive Orders, and Other Policies

Table 25 provides a summary of the environmental laws, executive orders, and other policies that are applicable to the PAA and the NAA. The following sections provide detailed descriptions of compliance with selected laws and executive orders.

8.2.1 Department of the Army, U.S. Army Corps of Engineers (USACE) Regulations

ER 200-2-2, 33 C.F.R. 230, March 1988, provides guidance for implementation of the procedural provisions of NEPA for the Civil Works Program of the USACE. It supplements Council on Environmental Quality (CEQ) Regulations 40 C.F.R. 1500-1508, November 29, 1978, in accordance with 40 C.F.R. 1507.3, and is intended to be used in conjunction with the CEQ regulations. This regulation is applicable to all USACE personnel responsible for preparing and processing environmental documents in support of civil works program. ER 1105-2-100 (April 2000) provides a set of procedures that are used for evaluating the effects of alternative water resources plans on environmental quality. This DPR/EA has been prepared in accordance with these Army regulations. Appropriate and responsible USACE officials have been involved in the preparation and review of this document.

8.2.2 National Environmental Policy Act (NEPA) of 1969

This DPR/EA has been prepared in accordance with the requirements set forth in Section 102 of NEPA (USC §§ 4321 – 4347, as amended). NEPA is the nation's broadest environmental law, and it applies to all Federal agencies and most of the activities they manage, regulate, or fund that may affect the environment. NEPA requires that environmental consequences and project alternatives be considered before a decision is made to implement a Federal project. A reasonable array of alternatives has been considered during the planning process. Potential environmental effects have been included in the evaluation of the proposed project actions, and all procedural review requirements of the aforementioned regulations have been met.

Table 25. Relationship of Selected Alternatives to Environmental Requirements and Protection Statutes

FEDERAL STATUTES		
STATUTE	**COMPLIANCE STATUS**	
	PAA	**No Action**
Archeological & Historic Preservation Act	A	A
Clean Air Act of 1977, as amended	A	A
Clean Water Act of 1977, as amended	A	A
Coastal Zone Management Act	NA	NA
Endangered Species Act of 1973, as amended	A	A
Estuary Protection Act	NA	NA
Federal Water Project Recreation Act, as amended	A	A
Fish & Wildlife Coordination Act, as amended	A	A
Land & Water Conservation Fund Act, as amended	A	A
Marine Protection, Research & Sanctuaries Act, as amended	NA	NA
National Environmental Policy Act of 1969,as amended	A	A
National Historic Preservation Act of 1966, as amended	A	A
Rivers and Harbors Act	A	A
Watershed Protection & Flood Protection Act, as amended	NA	NA
Watershed Protection & Flood Protection Act, as amended	NA	NA
Wild & Scenic Rivers Act, as amended	NA	NA
Floodplain Management (E.O.11988)	A	A
Protection of Wetlands (E.O.11990)	A	A
Environmental Effects Abroad of Major Federal Actions (E.O.12114)	NA	NA
Analysis of Impacts on Prime & Unique Farmlands (CEQ Memorandum, August 11,1980)	NA	NA
Protection & Enhancement of Environmental Quality (E.O. 11514, as amended by E.O.11991)	A	A
Protection & Enhancement of the Cultural Environment (E.O. 11593)	A	A
Environmental Justice E.O. 12898	A	A

A = applicable NA = not applicable

8.2.3 Clean Water Act (CWA) of 1977

Federal and State laws for the control of water quality establish requirements for adequate planning, implementation, management, and enforcement of actions designed to improve the quality of the nation's water resources, including penalties for non-compliance. The CWA (as amended, 33 USC 1251 *et seq.*) governs pollution control and water quality of waterways throughout the U.S. Its intent, in part, is to restore and maintain the biological integrity of the nation's waters. The goals and standards of the CWA are enforced through permit provisions. Section 401, and 404 of the CWA pertain directly to the proposed project. Section 401 of the CWA requires certification from the State or interstate water control agencies that a proposed water resources project is in compliance with established effluent limitations and water quality standards. Section 404 of the amended Act authorizes a separate permit program for the disposal of dredged or fill material in the Nation's waters, administered by the Secretary of the Army, acting through the Chief of Engineers. The USACE does not issue itself a Section 404 permit if dredged or fill materials are involved in a project. Despite this, the USACE must complete the certification procedures and the proposed work must be specified through the application of the EPA 404(b)(1) Guidelines.

The proposed action meets both the general and specific conditions of a Nationwide Permit (NWP) #27, "Aquatic Habitat Restoration, Establishment and Enhancement Activities" as described under the March 19, 2007 Federal Register, Final Notice of Issuance of Nationwide Permits (72 FR 11092). The proposed project must comply with all conditions (general, specific and regional) of the NWP #27. Conditions that are applicable to this project, but are not limited to, include the trout waters moratorium that restricts work on the stream channel and in a 25ft buffer zone surrounding the stream between October 15th and April 15th, use of soil erosion and sediment controls and the placing of heavy equipment on pads for work in wetlands to minimize soil disturbance.

The North Carolina Division of Water Quality requires that all activities that are eligible for a NWP #27, including modification of wetlands and/or water, including streams and streambanks, require application for 401 Water Quality Certification and written approval from DWQ regardless of the activities are for restoration, enhancement, or stabilization. All permits required by the CWA will be obtained before the initiation of construction.

8.2.4 Clean Air Act (CAA) of 1970

The purpose of the CAA (USC §§ 7401 – 7601, amendments of 1977, 1990, and 1993) is to protect public health and welfare by the control of air pollution at its source, and to set forth primary and secondary National Ambient Air Quality Standards (NAAQS) to establish criteria for States to attain, or maintain, these minimum standards. Section 118 specifies that any Federal activity that may result in discharge of air pollutants must comply with Federal, state, interstate, and local requirements regarding control and abatement of air pollution. Section 176(c) requires that all Federal projects conform to EPA-approved or promulgated State Implementation Plan. Potential impacts resulting from the proposed alternatives have been assessed in this EA. Minor, short-term construction-related and long-term

maintenance-related air quality impacts have been identified. Watauga County is in attainment for the 6 criteria pollutants described by NAAQS and a conformity determination is not necessary for this project.

8.2.5 Endangered Species Act (ESA) of 1973

The purposes of the ESA (as amended, 16 USC 1531 *et seq.*) are to provide a means whereby the ecosystems upon which endangered and threatened species may be conserved and to provide a program for the conservation of such species. The ESA requires that consultation regarding protection of such species be conducted with the U.S. Fish and Wildlife Service (USFWS) prior to project implementation. The tentatively selected plan would have no adverse effect upon threatened and endangered species.

8.2.6 Fish and Wildlife Coordination Act (FWCA)

The FWCA (16 USC § 661 *et seq.*) directs the Department of the Interior (DOI) to provide assistance to and foster cooperation among Federal, state, and local agencies in order to promote wildlife conservation in water resource development programs. Agencies must consult with the section of the DOI that has jurisdiction over this project, in this case USFWS, on wildlife conservation measures to be implemented during construction and maintenance of the project. This DPR/EA will be submitted to the USFWS and North Carolina Wildlife Resources Commission for their comment during the public review period.

8.2.7 National Historic Preservation Act (NHPA)

A key provision under the NHPA (16 USC §§ 470 *et seq.*) is Section 106, which requires a Federal agency to take into account the potential effect of a proposed action on properties listed on or eligible for listing on the National Register of Historic Places. Under NHPA, the State Historic Preservation Officer and the Advisory Council on Historic Preservation (ACHP) are part of the consultation process. Regulations of the ACHP (36 CFR § 800) outline the procedures used by a Federal agency to meet the requirements of Section 106 of the NHPA. In accordance with 36 CFR 800, a records search and an archaeological survey of the project area have been performed. Based on the records and literature search and archaeological field survey, there are no known cultural resources present in the Area of Potential Effect. A Phase I Cultural Resources assessment was completed and no effects are anticipated to occur to National Register of Historical Places resources as a result of construction of this project. The USACE has sent a coordination letter to the SHPO.

8.2.8 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (1916) (16 USC § 703, as amended), agreed between the U.S. and Canada; the Convention for the Protection of Migratory Birds and Animals (1936), agreed between the U.S. and Mexico; and subsequent amendments to these Acts provide legal protection for almost all breeding bird species occurring in the U.S. These acts restrict the killing, taking, collecting, and selling or purchasing of native bird species or their parts, nests, or eggs. Certain gamebird species are allowed to be hunted for specific periods of time

determined by Federal and state governments within designated areas and applicable laws. The intent of the Migratory Bird Treaty Act is to eliminate any commercial market for migratory birds, feathers, or bird parts, especially for eagles and other birds of prey. The proposed project is in compliance with this Act because the project would not facilitate the commercial market of any bird species.

8.2.9 Executive Order 11988, Floodplain Management

Under this Executive Order (42 FR 26951, 1997), the USACE must take action to avoid development in the 100-year floodplain unless it is the only practicable alternative; to reduce hazard and risk associated with floods; to minimize the impact of flood on human safety, health, and welfare; and to restore and preserve the natural and beneficial value of the base floodplain. The selected project is consistent with this Executive Order.

8.2.10 Executive Order 11990, Protection of Wetlands

Section 2 of this Executive Order (42 FR 26961, 1977) states that each agency shall avoid undertaking new construction in wetlands unless there is no practicable alternative and that the proposed action shall include all practicable measures to minimize harm to wetlands. Both the survivability and quality of wetlands at the Watauga aquatic restoration project area would be protected if the proposed project is constructed.

8.2.11 Executive Order 11593, Protection and Enhancement of the Cultural Environment

Section 1 of this Executive Order (36 FR 8921, 1971) states that the Federal Government shall provide leadership in preserving, restoring, and maintaining the historic and cultural environment of the U.S. The alternatives considered are consistent with this Executive Order.

8.2.12 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC §§ 3001 *et seq.*) provides for the protection of Native American and Native Hawaiian cultural items and establishes a process for the authorized removal of human remains, funerary objects, sacred objects, and objects of cultural patrimony from sites located on lands owned or controlled by the Federal government. A Phase I Cultural Resources assessment was complete to ensure that the project complied with NAGPRA.

8.2.13 Executive Order 12898, Environmental Justice

In sum, environmental justice is the goal to be achieved for all communities and persons across this Nation. Environmental justice is achieved when everyone, regardless of race, culture, or income, enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in

which to live, learn, and work. This project complies with Executive Order 12898 since the activities do not unfairly burden minority or lower income populations.

9 PUBLIC INVOLVEMENT, REVIEW, AND AGENCY COORDINATION*

9.1 Preparation and Review

Tetra Tech, Breckenridge, Colorado, prepared the initial report for the Watauga Project in 2004 for the U.S. Army Corps of Engineers, Huntington District. The project was significantly changed and the base report written by Tetra Tech was modified by the Planning Branch, Environmental Analysis Section of the USACE.

Huntington District Interdisciplinary Study Team:

Project Manager	Mark Kessinger
Planning, Environmental Assessment	Janet Cote, Jeff Zylland
Cost Estimation	Jeff Zylland,
Cultural Resources	Brantley Jackson
Real Estate	Elizabeth Cooper
HTRW	Nickolas McHenry
Internal ITR	John Preston

Tetra Tech:

Project Manager	Peggy Bailey, P.E.
Engineering and Design	William Fullerton, P.E.
	Jason Carey, P.E.
Biological Resources/HEP Analysis	David Batts
	Craig Miller

Huntington District Quality Control/Technical Review Team:

External Technical Review	Sue Ferguson, Ray Hedrick
Legal	Terry Clarke
Cost Engineering	Russ Craddock
Geotechnical	Michael Spoor

Tetra Tech Technical Review Team:

Design	Peggy Bailey, P.E
Policy and Planning	Ira Artz, P.E.
Hydraulic Engineering and Design	Peggy Bailey, P.E.
Biology	Merri Martz

9.2 Non-Federal Views and Preferences

The non-Federal views and preferences regarding the environmental restoration project were obtained through coordination with the non-Federal sponsor and with various local and regional agencies and organizations, Appalachian State University (ASU), and the general public. These coordination efforts consisted of agency meetings, phone calls, and site visits. ASU supports the implementation of the Preferred Action Alternative with continued coordination and regard for ASU management of lands adjacent to the project area.

9.3 Views of the Local Sponsor

The Town of Boone has expressed willingness in continuing to be the non-Federal sponsor through project implementation. The Town has indicated its support for a project and a willingness to assume cost-shared financial obligations for its implementation (see attached letter).

9.4 Coordination and Consultation with Other Agencies

Agencies and other entities contacted formally or informally in preparation of this DPR/EA included:

Appalachian State University
North Carolina Wildlife Resources Commission
North Carolina Department of Environment and Natural Resources
U.S. Fish and Wildlife Service
North Carolina Department of Cultural Resources (pending)
Town of Boone
Bell South
New River Light and Power
National Committee for the New River

9.5 Public Review and Comment

A Notice of Availability has been published in the local newspaper, the Mountain Times concerning this document. This DPR/DEA will be made available for public review and comment for a 30-day period to appropriate resource agencies, local interest groups, and individuals (see Section 9.6, "Distribution List"). Review copies will be made available for public inspection at the Watauga County Public Libraries and other public facilities throughout the towns of Boone and Blowing Rock. Comments and recommendations received during the thirty day review period will be included in the Final Environmental Assessment document.

10 CONCLUSIONS

In this study, a solution was proposed to restore aquatic habitat along a heavily visited reach of the South Fork New River. The purpose and need of the study was to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. The planning objectives required that the restoration solution be cost effective and balance the environmental needs with the impacts to the human environment. The Preferred Action Alternative (PAA), alternative A2, satisfied the purpose and need of the study while best meeting the planning objectives identified during the study. The PAA satisfies a synergistic balance between fostering the recreational and habitat needs at the project site. Not only does the alternative preserve the existing recreational facilities, but it enhances recreation by adding natural vistas and interpretive signage overlooking restored areas. In turn, the education and viewing opportunities are designed to inspire environmental stewardship within and beyond the project area. These are just the ancillary benefits of a project designed to restore aquatic habitat.

The feasibility study determined that environmental degradation was due to direct human encroachment on aquatic habitat and due to stream instability caused by watershed influences of a growing urban area. The loss and degradation of on-site habitat would be managed by protecting and restoring the aquatic habitat corridor around the river. A widened and fenced riparian corridor restores and protects endemic habitat essential to the health of the stream. Additionally, restored wetlands would reintroduce habitat types that have been lost from the project area, while lending diversity and beauty to the heavily visited area. Because the proposed project was limited in size, this restoration would only comprehensively counteract local habitat loss. Remedial measures for the eroding streambanks, although required initiate stability necessary for restoration, would not directly fix the source of the instability.

Ultimately, the watershed issues in Boone County require large-scale restoration of critical riparian habitats and comprehensive management of stormwater runoff. Such a comprehensive watershed restoration program is beyond what a Section 206 restoration project achieve alone. However, the proposed project would serve to initiate and contribute to watershed reform. Small restoration projects such as this one, in areas with high public visibility, educate locals on preserving habitat and watershed integrity, empowering and inspiring them to initiate further restoration. The cumulative effect of restored riparian and wetland habitats would contribute to a healthy watershed with flood-reducing runoff detention and ecologically important habitat connectivity. For example, the first Section 206 restoration project performed by the Corps in the Watauga area began this endeavor. The success of the original project set an example of successful restoration and enabled the current study. The City of Boone is raising awareness of the importance of habitat and watershed stewardship and is actively supporting such projects. As a result of the original restoration project, the City is planning on building a complimentary detention wetland nearby, an example of how one project of limited scope can motivate the creation of more restoration projects. The current proposed project would continue the endeavor and is

expected to trigger more restoration projects that will ultimately contribute to a comprehensive restoration solution to the area's watershed issues.

11 RECOMMENDATIONS

As District Engineer, Huntington District, U.S. Army Corps of Engineers, I have weighed the fish and wildlife benefits to be gained from implementing the selected habitat restoration plan for the Watauga Aquatic Restoration on the South Fork New River against the cost, and have considered the alternatives, impacts, and scope of the proposed project. In my judgment, the proposed project is a justified expenditure of Federal funds. I recommend that the Secretary of the Army approve the South Fork New River Habitat Restoration project.

The total first cost of the project is currently estimated at $$1,956,000. The Federal share is currently estimated at $$1,205,000. The project sponsor, the Town of Boone, would provide 35%, that is, $$751,000, of the total project costs, thus meeting the requirement of non-Federal money for Section 206 program projects. All future operation and maintenance responsibilities for the structures and features implemented in the recommended plan would be borne by the project sponsor, the Town of Boone. These and other pertinent details have been included in the draft Project Cooperation Agreement negotiated with the sponsor.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

_____
Colonel Dana Hurst, Corps of Engineers
District Engineer

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13 ACRONYMS AND ABBREVIATIONS

AAHU	average annual habitat units
ACHP	Advisory Council on Historic Preservation
ASU	Appalachian State University
BMP	best management practices
CAA	Clean Air Act
CEA	cumulative effects assessment
CE/ICA	cost effectiveness incremental cost analysis
CEQ	Council of Environmental Quality
CFS	cubic feet per second
CO	carbon monoxide
CWA	Clean Water Act
dBA	A-weighted decibels
DEA	draft environmental assessment
DNL	day-night levels
DOI	Department of the Interior
DPR	detailed project report
EA	environmental assessment
EO	executive order
EPA	see USEPA
ER	engineer regulation
ESA	Endangered Species Act
ET	evapotranspiration
FEA	final environmental assessment
FAA	Federal Aviation Administration
FIS	flood insurance study
FPPA	Farmland Protection Policy Act
FWCA	Fish and Wildlife Coordination Act
HEP	habitat evaluation procedure
HSI	habitat suitability index
HTRW	hazardous, toxic, and radiological waste
HU	habitat unit
HUD	Department of Housing and Urban Development
LERRDs	lands, easements, rights-of-way, relocations, and disposal
LPP	locally preferred plan

MCL	maximum contaminant level
MSL	mean sea level
NAA	no action alternative
NAAQS	national ambient air quality standards
NAGPRA	Native American Gras Protection and Repatriation Act
NAVD88	North American Vertical Datum of 1988
NCDAQ	North Carolina Division of Air Quality
NCDENR	North Carolina Department of Environment and Natural Resources
NCDWQ	North Carolina Division of Water Quality
NCIBI	North Carolina Index of Biological Integrity
NCWRC	North Carolina Wildlife Resources Commission
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Environmental Restoration
NGS	National Geodetic Survey
NHPA	National Historic Preservation Act
NO2	nitrogen dioxide
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NRHP	National Register of Historic Places
NTU	national turbidity unit
O3	ozone
OMRR&R	operation, maintenance, repair, replacement, and rehabilitation
ORW	Outstanding Resource Water
PAA	proposed action alternative
Pb	lead
PCA	Project cooperation agreement
PM10	particulate matter with an aerodynamic size less than or equal to 10 micrometers
PM25	particulate matter with an aerodynamic size less than or equal to 25 micrometers
PRP	preliminary restoration plan
REP	real estate plan
SHPO	State Historic Preservation Office
SI	suitability index
SIP	State Implementation Plan
S&A	supervision and administration
TKN	total kjedahl nitrogen

TMDL	total maximum daily loads
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRDA	Water Resources Development Act

14 GLOSSARY OF TERMS

100-year flood A major destructive flood event that has the capacity to occur on average every 100 years.

A-weighting Process in which noise measurements are weighted more heavily within those frequencies of maximum human sensitivity.

bed The bottom of a channel.

degrade The lowering of a stream channel bed with time due to the erosion and transport of bed materials or the blockage of sediment sources.

failure Collapse or slippage of a large mass of bank material into a stream.

Federal Register An index of all the public notices of all the departments in the Federal government.

floodplain The land adjacent to a channel at the elevation of the bankfull discharge, which is inundated on the average of about 2 out of 3 years. The floor of stream valleys, which can be inundated by small to very large floods.

ford An at-grade stream crossing that uses the bottom of the channel in lieu of a bridged or culverted crossing.

geomorphic Relating to the form of the earth.

geomorphology A science that deals with the land and submarine relief features of the earth's surface.

hydrologic Dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

incised channel A stream that has degraded and cut its bed into the valley bottom. Indicates accelerated and often destructive erosion.

meander A sinuous channel form in flatter river grades formed by the erosion on one side of the channel (pools) and deposition on the other (point bars).

National Ambient Air Quality Standards The specified average concentration of an air pollutant in ambient air during a specified time period at or above which undesirable effects may be produced.

overbank flows Water flow over the top of the bankfull channel onto the floodplain.

point bar A bank on the inside of a meander bend that has built up due to sediment deposition opposite a pool.

pool A location in an active stream channel, usually located on the outside bends of meanders, where the water is deepest and has reduced current velocities.

reach A section of a stream's length.

riffle A shallow rapids, usually located at the crossover in a meander of the active channel.

riparian Referring to the riverside or riverine environment next to the stream channel, e.g., riparian, or streamside, vegetation.

riprap Heavy stones used to protect soil from the action of fast-moving water.

scour The erosive action of flowing water in streams that removes and carries away material from the bed and banks.

sediment Soil particles that have been transported from their natural location by wind or water action.

sediment deposition The accumulation of soil particles on the channel bed and banks.

sedimentation The action or process of forming or depositing sediment.

sinuosity The degree to which a watercourse varies back and forth across its flow centerline.

streambank The side slopes of an active channel between which the streamflow is normally confined.

terrace An abandoned floodplain that is located at a higher elevation than the current active floodplain.

threatened The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

toe The break in slope at the foot of a streambank where the bank meets the bed.

top of bank The break in slope between the bank and the surrounding terrain.

waters of the United States Broadest category of regulated water bodies under the Clean Water Act. Includes wetlands along with non-wetland habitat, including streams, rivers, lakes, ponds, bays, and oceans.

watershed An area confined by topographic divides that drains a given stream or river

weir A barrier placed in a channel to divert fish or water

Appendix A Cost
Appendix B Habitat Assessment
Appendix C HTRW
Appendix D Real Estate
Appendix E Site Photos
Appendix F Correspondence
Appendix G Mailing list