Upper French Broad River
Watershed Restoration Plan

Transylvania and Henderson Counties
North Carolina

Prepared for:

CONSERVING CAROLINA
MOUNTAINS • FOOTHILLS • RIVERS • FARMS

NORTH CAROLINA LAND & WATER FUND

Prepared by:

Jennings Environmental

June 2022

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

I. INTRODUCTION

The Upper French Broad River watershed composes approximately 577 square miles in Transylvania and Henderson Counties, North Carolina. Approximately 311 square miles of the watershed are within Transylvania County, with 266 square miles in Henderson County. The watershed includes all or part of the cities of Brevard and Hendersonville, as well as surrounding areas that are heavily influenced by the continued development of land to the south and southwest of the City of Asheville. Within the watershed, urban development and agricultural activity are largely concentrated in valleys and along waterways. In many cases, these land uses extend very close to streambanks, which affect the quality of riparian buffers and lead to increased streambank erosion, reduced water quality, and negative impacts to natural habitats.

Conserving Carolina contracted with Jennings Environmental, PLLC to produce a watershed management plan for the Upper French Broad River watershed. In collaboration with the client, resource agencies, and other stakeholders, the project team identified priority areas for potential preservation and restoration projects within the watershed. These priority areas generally contain inadequate buffers, eroding riverbanks, and are sources of nonpoint source pollution and sedimentation. The identified areas are critical to maintaining and improving water quality and instream aquatic habitat in the French Broad River and its tributaries. Additionally, most priority areas are within flood-prone areas; as a result, preservation and restoration projects in these areas would contribute to increased floodplain resiliency. The following tasks have been completed:

1. Assemble existing watershed and natural resource information in a GIS database and create relevant maps.
2. Conduct hydrology and topography analyses to aid in the identification of potential floodplain restoration sites.
3. Communicate with landowners and stakeholders.
4. Conduct field visits to potential restoration sites to assess nonpoint source pollution sources and restoration uplift potential, with SQT analysis performed at selected sites.
5. Map potential restoration project sites and develop conceptual plans for selected priority opportunities.
6. Create a decision support tool to aid in prioritizing properties for preservation and restoration.

7. Map recreational access sites and develop a French Broad River Blueway Plan with recommendations to improve recreational access and the user experience on the French Broad River.
8. Draft and deliver a final planning report and assist Conserving Carolina with project management, website creation, and reporting to the North Carolina Land and Water Fund.

This watershed planning effort for the Upper French Broad River watershed supports the Basinwide Plan for the French Broad River (NC Department of Environmental Quality, 2011), the French Broad River Restoration Priorities (NC Department of Environmental Quality, 2009), the missions of the French Broad River Partnership, RiverLink, the Land of Sky Regional Council, US Department of Agriculture Natural Resources Conservation and Farm Service Agency Conservation Programs, Henderson County and Transylvania County Soil and Water Conservation District Programs, the NC Wildlife Resources Commission Wildlife Action Plan, and the US Fish and Wildlife Service's Recovery Plans.

Additional planning and design efforts within the Upper French Broad River watershed have been completed in parallel with this project, resulting in several relevant reports prepared by Jennings Environmental, PLLC under separate cover. These are listed below, with selected reports contained in Appendices D, E, F, and G.

- February 2021: Stream Restoration Assessment Report, West Fork French Broad River (prepared for private landowners) (Appendix D)
- June 2021: Pleasant Grove Floodplain Ecosystem Restoration Plan (prepared for Conserving Carolina and US Fish and Wildlife Service) (Appendix E)
- December 2021: Strategic Master Plan for the French Broad River Blueway, Transylvania County (prepared for Conserving Carolina and Transylvania County)
- March 2022: Strategic Master Plan for the French Broad River Blueway, Henderson County (prepared for Conserving Carolina and Henderson County)
- March 2022: Bat Fork Watershed Plan (prepared for Conserving Carolina and the NC Land and Water Fund)
- April 2022: Water Source Protection Plan, Upper Mills River Watershed (prepared for US Forest Service and Resource Institute)
- June 2022: Little River Restoration Master Plan (prepared for Sherwood Forest Homeowners Association) (Appendix F)
- June 2022: Davidson River Assessment and Restoration Plan (prepared for Pisgah Chapter of Trout Unlimited) (Appendix G)

This report summarizes the resulting watershed restoration plan for the Upper French Broad River watershed, provides a roadmap for future watershed improvement projects, and includes the following:

- Watershed characterization data, including land cover and hydrology
- Specific recommendations for restoration and preservation efforts that would protect and improve water resources
- Resources, including conceptual design plans and potential funding sources that can be used to facilitate future watershed restoration projects

II. WATERSHED CHARACTERIZATION

Existing GIS data were acquired and evaluated, including: aerial photography, topography, hydrography, land cover, flood zones, and property boundaries. These data were used to identify areas of impairment and specific parcels that appeared to be important for water quality within the Upper French Broad River watershed. Sheets 1 and 2 in Appendix A show overviews of the watershed with aerial photography and hydrography. Sheets 3 and 4 show overall topography and the extent of FEMA flood zones. Sheets 5 and 6 show an overview of existing land cover within the watershed, while Sheet 7 shows natural areas and management areas provided by the NC Natural Heritage Program. A general description of land cover, hydrology, and gage analysis and floodplain modeling for the Upper French Broad River watershed is presented here. While the following summaries provide an overview, conditions can be highly variable within the watershed. Specific conditions present within individual project areas should be considered as part of any future improvement or restoration project.

A. Land Cover

The 2019 National Land Cover Database (NLCD) was consulted to identify the types of land cover that are present across the 577 square miles of the Upper French Broad River watershed. The NLCD identified 14 different land cover classifications (in addition to open water) within the watershed. A summary of these is included in Table 1. Forested lands cover 69.6% of the total watershed area, and are the dominant land cover. Various types of developed land compose 18.1% of the total. Agricultural uses cover 10.4% of the total area, and are mostly composed of fields for pasture and hay. Despite the relatively low percentages of developed and agricultural lands, these uses still cover 104 and 60 square miles, respectively, which have significant impacts on water quality. Additionally, developed and agricultural lands are primarily found in the lower, flatter areas of the watershed, which coincides with the valleys for the French Broad River and its major tributaries.

Table 1. Land Cover Summary.

NLCD Code	Description	Area (sq mi)	Area (percent)
11	Open Water	1.6	0.3%
21	Developed, Open Space	73.0	12.7%
22	Developed, Low Intensity	18.5	3.2%
23	Developed, Medium Intensity	9.4	1.6%
24	Developed, High Intensity	3.3	0.6%
31	Barren Land	0.3	0.1%
41	Deciduous Forest	209.1	36.2%
42	Evergreen Forest	15.1	2.6%
43	Mixed Forest	178.1	30.8%
52	Shrub/Scrub	3.5	0.6%
71	Grassland/Herbaceous	3.0	0.5%
81	Pasture/Hay	44.6	7.7%
82	Cultivated Crops	15.5	2.7%
90	Woody Wetlands	2.1	0.4%
95	Emergent Herbaceous Wetlands	0.1	0.0%

B. Hydrology

The French Broad River originates at the confluence of the North and West Forks of the French Broad River near the Town of Rosman, North Carolina. From this origin, the river flows approximately 34 miles within Transylvania County, then 18 miles within Henderson County. Beyond this, the river flows through Buncombe and Madison Counties in North Carolina, then into Tennessee. The 52 river miles, and their watersheds within Transylvania and Henderson Counties, comprise the study area for this project. Major tributaries of the French Broad River within the study area include: Little River, Davidson River, Mud Creek, Mills River, and Cane Creek.

The study area comprises the upper portions of the HUC8 basin designated as the "Upper French Broad River" (06010105), which spans from the river's headwaters to Douglas Lake in Tennessee. Four HUC10 basins are wholly contained within the study area: "Headwaters French Broad River" (0601010501), "Davidson River – French Broad River" (0601010502),

"Mud Creek" (0601010503), and "Mills River – French Broad River" (0601010504). Additionally, portions of the HUC10 basin "Cane Creek – French Broad River" (0601010507) are located in the study area (while Cane Creek enters the French Broad River in Henderson County, its watershed includes portions of Henderson and Buncombe Counties).

Long-term streamflow gage records can be valuable for flood frequency analyses, confirming stream morphology parameters, quantifying changes in precipitation patterns over time, and interpreting water quality monitoring data. The USGS operates three gages on the French Broad River within the study area: at Rosman, Blantyre, and Fletcher. Just downstream of the study area, in Asheville, is another USGS gage with a long-term flow record.

Near the Town of Rosman (drainage area = 67.9 square miles), a gage has operated since 1907 (USGS Gage No. 03439000). Daily discharge data and annual peak flows are available since that time, with continuous discharge data available since 1985. Data are available at:

https://waterdata.usgs.gov/nwis/uv/?site_no=03439000

A second gage is located at Blantyre, near the border between Transylvania and Henderson Counties (drainage area = 296 square miles). This gage (USGS No. 03433000) has collected daily discharge data and annual peak flows since 1920, and continuous discharge data since 1985. Data are available at:

https://waterdata.usgs.gov/nwis/uv?site_no=03443000

Finally, a gage is located at the Town of Fletcher, near the border between Henderson and Buncombe Counties (drainage area = 640 square miles). This gage (USGS Gage No. 03447687) has been operational, with continuous discharge data, since 2001. In addition to discharge, water quality parameters have been continuously monitored at this gage since 2019. These parameters include: temperature, specific conductivity, dissolved oxygen, pH, and turbidity. Discharge and water quality data are available at:

https://waterdata.usgs.gov/nwis/uv?site_no=03447687

Additionally, USGS operates gages on three major tributaries to the French Broad River within the study area: on the Davidson River (USGS Gage No. 03441000), the Mills River (USGS Gage No. 03446000), and on Mud Creek (USGS Gage No. 0344632850).

C. Gage Analysis and Flood Modeling

Data from the aforementioned long-term gage records were combined with the most recent LiDAR topographic data to perform hydrologic analyses and flood modeling for locations along the French Broad River and its floodplain. Findings from this effort were used to aid in the identification and validation of potential floodplain restoration sites based on expected floodplain inundation frequencies and extents.

Specifically, historic gage data and topographic floodplain models were used for the following:

- Peak flow and flood frequency analyses (for gages at Rosman, Blantyre, and Asheville) to identify annual peak flows and flood return intervals (i.e., 2-year up to 500-year), then investigations of how the intensity and frequency of flooding has changed over the historical record.
- Analyses (for gages at Blantyre and Asheville) of lower return period events to statistically determine if the frequency of these smaller events has changed over the historical record.
- Floodplain modeling, using HEC-RAS, for selected reaches of the French Broad River near Brevard and Blantyre. This resulted in a series of cross-sections and maps showing the extents and depths of flooding for flows associated with specific return intervals.

Appendix B contains a report with procedures and results summarized for each of these analyses, along with figures and maps of floodplain inundation and depths for selected return intervals.

III. WATERSHED RESTORATION PROJECTS

The project team evaluated potential projects that had been identified from GIS data review, field reconnaissance, landowner contacts, and partner/stakeholder suggestions. These potential projects include areas critical to improving water quality, reducing streambank erosion, and providing floodplain resilience within the Upper French Broad River watershed (e.g., areas with severe streambank erosion and limited riparian buffers). Most potential projects were visited in order to ground-truth baseline information and evaluate restoration need and opportunity. The resulting 32 potential watershed restoration projects are shown in Table C1 and Sheets C1 through C4 in Appendix C. Transylvania County contained 22 of these projects, while Henderson County contained ten. A subset of 14 of these projects were designated as higher-priority projects, due to a combination of landowner interest and potential ecological benefit. These higher-priority projects include three for which advanced assessment and design has been completed under separate cover:

- Pleasant Grove, Henderson County (Appendix E): Engineering design plans have been submitted to the property owner, Conserving Carolina, to comprehensively address the ecological restoration of approximately 97 acres. Among other components, the project would include preservation/ stabilization of approximately 4,300 feet of French Broad riverbank and the restoration of approximately 5,000 linear feet of tributaries to the French Broad River.
- Horseshoe Hollow, Transylvania County (Appendix D): Assessment results and conceptual design information have been submitted to owners of this property along the West Fork French Broad River. The conceptual design addressed streambank stability and riparian buffer conditions along approximately 2,000 feet of the river.
- Sherwood Forest, Transylvania County (Appendix F): Assessment results and conceptual design information have been submitted to the Homeowners' Association for the Sherwood Forest community, which manages approximately 4,100 linear feet of the Little River, a major tributary to the French Broad River.

The remaining 11 higher-priority projects are listed in Table 2, with potential restoration approaches described in more detail below and in Appendix C.

Table 2. Selected Potential Watershed Restoration Projects.

Name	Parcel Size (acres)	PIN	Owner
Deerwoode Reserve	166.44	8585-60-4875	Hodgson
Brevard Community Park	28.81, 21.86	8585-76-0653, 8585-86-0476	City of Brevard
Witherspoon Property	61.15	8595-24-0085	Witherspoon
Scott Properties	26.14, 24.57	8596-44-7045, 8596-34-9250	Scott
Merrill & Cantrell and Bridges Properties	124.72	9507-40-2521	Merrill and Cantrell, Bridges
Platt Properties	23.85, 9.38, 3.51	9516-09-5388, 9517-00-4126, 9516-19-1610	Platt
Besancon Property	20.41	9528-13-9941	Besancon
Kiser Property	44.92, 72.21	9528-33-9943, 9528-34-9979	Kiser
Freer Properties	21.37, 9.84, 2.72	9528-64-6321, 9528-74-6617, 9528-74-9211	Freer
King's Bridge Property	85.27	9640-69-8997	State of North Carolina
Broadmoor Golf Links	189.21, 94.14	9642-75-2558, 9642-84-4544	Asheville Airport Authority, Big J Small J Partnership

A. Project Details

The design approaches for these 11 higher-priority projects are described below. Appendix C contains basemaps and/or conceptual design plans for the projects (Sheets C5 through C15).

Deerwoode Reserve (Sheet C5): This project addresses approximately 38.5 acres within the property that are held in a conservation easement by Conserving Carolina. Approximately 4,200 feet of French Broad riverbank is included in this easement, along with additional water resources. A project on this property could include the following components:

- Near the eastern extent of the property, grade approximately 450 feet of eroding riverbank to a stable slope. To the extent possible, preserve existing mature trees near the riverbank.
- Along the 4,200 feet of riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- Create and/or enhance approximately 6.3 acres of wetlands in the vicinity of existing surface water features.
- Excavate a fish habitat slough (approximately 1.5 acres in area) that is hydrologically connected to the French Broad River.
- Create pollinator areas (approximately 3.3 acres in area) in existing open areas in the western portion of the property.
- Throughout much of the property (15.6 acres), plant and/or enhance a floodplain forest of native trees.
- To the extent possible, maintain existing trails throughout the property.
- Manage invasive plants throughout the project area.

Brevard Community Park (Sheet C6): This project addresses approximately 50.7 acres that are owned by the City of Brevard and currently used for public recreation. A project in this area could include the following components:

- Along the 2,200 feet of French Broad riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- As needed within the riparian buffer, stabilize eroding streambanks by grading to a stable slope. To the extent possible, preserve existing mature trees on the riverbank.
- Restore approximately 2,000 linear feet of a tributary to the French Broad River that flows through the property. This stream channel could be realigned as a meandering riffle-pool channel with appropriate dimension, pattern, profile, and floodplain access.
- Create and/or enhance approximately 3.4 acres of wetlands in two locations on the property.

- Create approximately 21.5 acres of pollinator areas in selected existing open areas on the property.
- Throughout approximately 7.9 acres, plant and/or enhance a floodplain forest of native trees.
- Enhance existing paths and create new trails to form a trail system, approximately one mile in length, that meanders through wooded and open areas of the property.
- Manage invasive plants throughout the project area.

Witherspoon Property (Sheet C7): This property, 61.1 acres in size, contains approximately 3,800 feet of French Broad riverbank. A project on this property could include the following components:

- Selectively breach existing levees along the French Broad River to promote floodplain access.
- Along the riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- As needed within the riparian buffer, stabilize eroding streambanks by grading to a stable slope. To the extent possible, preserve existing mature trees on the riverbank.
- Restore portions of an existing stream channel by realigning it as a meandering riffle-pool channel with appropriate dimension, pattern, profile, and floodplain access.
- Near the outlet of the restored stream, excavate a fish habitat slough (approximately 4.0 acres in area) that is hydrologically connected to the French Broad River.
- Create a waterfowl impoundment with microtopography and wetland hydrology and vegetation on approximately 10.1 acres of the floodplain.
- Create pollinator areas (approximately 17.2 acres in area) in existing open areas across the floodplain.
- In the upper portions of the property, plant and/or enhance a forest of native trees, totaling approximately 10.1 acres.
- Manage invasive plants throughout the project area.

Scott Properties (Sheet C8): These properties, totaling 50.7 acres, contain approximately 5,500 feet of French Broad riverbank. Additionally, they include a reservable paddle-in campsite known as Riverbend, which is administered by MountainTrue. A project on this property would address ecological and recreational issues, and could include the following components:

- Continue farming row crops in upper areas of the properties, away from the river. In lower, wetter areas, convert existing row crops to hay fields.
- As needed within the riparian buffer, stabilize eroding streambanks by grading to a stable slope. To the extent possible, preserve existing mature trees on the riverbank.
- Along the 5,500 feet of riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- In non-agricultural areas, improve wildlife habitat through selected tree clearing and creation of surface water features, as appropriate.
- Maintain and improve the existing campsite, river access, and recreational area. This could include installation of hardened tent platforms and improved access for boats and swimming.
- Manage invasive plants, including privet, multiflora rose, and Bradford pear throughout the project area.

Merrill & Cantrell and Bridges Properties (Sheet C9): This project would primarily take place on the 124.7 acre property owned by Merrill and Cantrell, though some actions would affect the neighboring Bridges property. Approximately 2,800 feet of French Broad riverbank is included on these properties, along with approximately 3,000 feet of Glade Creek, a tributary to the French Broad River. A project on these properties could include the following components:

- Near the western extent of the property, grade approximately 800 feet of eroding riverbank to a stable slope. To the extent possible, preserve existing mature trees near the riverbank.
- As needed elsewhere within the riparian buffer, stabilize eroding streambanks by grading to a stable slope and installing toe wood revetment. To the extent possible, preserve existing mature trees on the riverbank.
- Along the entire riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.

- Restore approximately 3,000 feet of Glade Creek by realigning it as a meandering riffle-pool channel with appropriate dimension, pattern, profile, and floodplain access.
- Excavate a fish habitat slough (approximately 3.1 acres in area) that is hydrologically connected to the French Broad River. This slough would be located near the outlet of existing water channels.
- Enlarge the existing waterfowl depression to an approximate size of 4.0 acres.
- Create pollinator areas (approximately 4.5 acres in area) in existing open areas near Glade Creek in the northern portion of the property.
- Manage invasive plants throughout the project area.

Platt Properties (Sheet C10): The three Platt properties total 36.7 acres, and include approximately 1,500 feet of French Broad riverbank, along with additional water resources. A project on these properties could include the following components:

- As needed within the riparian buffer, stabilize eroding streambanks by grading to a stable slope. To the extent possible, preserve existing mature trees on the riverbank.
- Plant and/or enhance a native riparian buffer of trees and shrubs along the French Broad River. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- Excavate a fish habitat slough (approximately 1.2 acres in area) that is hydrologically connected to the French Broad River. An existing channel could be plugged and realigned for 250 feet to flow into the slough.
- Improve and enlarge (through grading and plugging existing channel outlets) two existing waterfowl depressions totaling 2.7 acres in size.
- Enhance approximately 1.3 acres of bog turtle habitat along the toe of a hillslope.
- Create 4.0 acres of pollinator areas in open areas near the waterfowl depressions.
- Along the riverbank, adjacent to the riparian buffer, plant 5.4 acres of floodplain forest of native trees.
- Manage invasive plants throughout the project area.

Besancon Property (Sheet C11): This property includes 20.4 acres of mostly open land, along with approximately 1,600 feet of French Broad riverbank. A project on this property could include the following components:

- Selectively breach existing levees along the French Broad River to promote floodplain access.
- Along the riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- As needed within the riparian buffer, stabilize eroding streambanks by grading to a stable slope. To the extent possible, preserve existing mature trees on the riverbank.
- In the stream along the eastern edge of the property, stabilize the existing head cut using grading and in-stream boulder structures. Plant/enhance a vegetated buffer along this stream, at least 25 feet in width on each side.
- Excavate a fish habitat slough (approximately 0.4 acres in area) that hydrologically connects the existing stream channel to the French Broad River.
- Create a waterfowl impoundment with microtopography and wetland hydrology and vegetation along an existing ditch on approximately 3.5 acres of the floodplain.
- Create pollinator areas (approximately 2.5 acres in area) near the road along the southern boundary of the property.
- Preserve approximately 2.5 acres of upland areas for future use.
- Throughout remaining portions of the property (5.5 acres), plant a floodplain forest of native trees.
- Manage invasive plants throughout the project area.

Kiser Property (Sheet C12): The Kiser properties compose 117 acres that include approximately 3,100 feet of French Broad riverbank and multiple unnamed tributaries. A project on these properties would address bank stability along all waterways, and could include the following components:

- Along the 3,100 feet of riverbank, maintain and enhance the existing wooded buffer. Ensure that the buffer is at least 100 feet in width, as measured from the top of the riverbank.
- At the tributary near the eastern side of the properties, stabilize existing minor bank erosion using grading and vegetation.

- For the tributary in the middle of the properties, stabilize the existing head cut using grading, in-stream boulder structures, and vegetation.
- Along all tributaries, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 25 feet in width on each side of the streams.
- Manage invasive plants throughout the project area.

Freer Properties (Sheet C13): The three Freer properties total 33.9 acres, and include approximately 800 feet of French Broad riverbank, multiple tributaries, and a pond. A project on these properties could include the following components:

- As needed within the French Broad riparian buffer, stabilize eroding riverbanks by grading to a stable slope and installing toe wood revetment.
- Along the 800 feet of riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- Around the banks of the pond, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 25 feet in width.
- Create approximately 4.9 acres of wetlands along existing ditches and in poorly-drained areas of existing fields.
- Restore approximately 600 feet of stream channel that flows through existing fields and 400 feet of stream channel that serves as the pond outlet. This restoration would likely include realigning the streams as meandering riffle-pool channels with appropriate dimension, pattern, profile, and floodplain access.
- Create pollinator areas (approximately 4.2 acres in area) in existing open areas around wetland areas.
- Throughout the remainder of the floodplain (2.9 acres), plant a floodplain forest of native trees.
- Manage invasive plants throughout the project area.

King's Bridge Property (Sheet C14): This project addresses 85.3 acres that are owned by the State of North Carolina in the vicinity of the NC Highway 191 bridge over the French Broad River. Approximately 3,400 feet of French Broad riverbank is included on this property, along with additional water resources. In addition to ecological components, this property has great potential to serve as a new recreational access area for the French Broad River. A project on this property could include the following components:

- As needed within the French Broad River riparian buffer, stabilize eroding streambanks by grading to a stable slope and installing toe wood revetment. To the extent possible, preserve existing mature trees on the riverbank.
- Along the 3,400 feet of riverbank, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 100 feet in width, as measured from the top of the riverbank.
- Install infrastructure needed to create a new recreational access on the French Broad River, as suggested in the 2022 Strategic Master Plan for the French Broad River Blueway, Henderson County.
- Restore approximately 2,500 feet of stream channels that flow through existing fields. This restoration would likely include realigning the streams as meandering riffle-pool channels with appropriate dimension, pattern, profile, and floodplain access.
- Excavate a fish habitat slough (approximately 6.7 acres in area) that hydrologically connects the restored stream channels to the French Broad River.
- Create and/or enhance approximately 8.9 acres of wetlands in headwater areas of the restored stream channels.
- Create pollinator areas (approximately 9.6 acres in area) in existing open areas along NC Highway 191.
- Throughout the remainder of the property (35.1 acres), plant and/or enhance a floodplain forest of native trees.
- Manage invasive plants throughout the project area.

Broadmoor Golf Links (Sheet C15): The Broadmoor Golf Links is located on a 189.2 acre property owned by the Asheville Airport Authority, and is located just south of the airport. This property is bounded on the west by approximately 3,200 feet of the French Broad River and on the south by approximately 5,900 feet of Cane Creek, including its confluence with the French Broad River. The opposite side of Cane Creek is on a 94.1 acre property owned by Big J Small J Partnership. A project on these properties could include the following components:

- Maintain the existing wooded buffer along the 3,200 feet of the French Broad River.
- Realign approximately 1,600 feet of Cane Creek (in three areas with severe streambank erosion) into a stable planform location, with a design bankfull width of approximately 80 feet. Grade streambanks to a stable slope (3:1 or flatter) and install in-stream boulder and log structures for bank protection, grade control, and bedform diversity. Fill the remnant channel to the design floodplain elevation.
- For the reaches of Cane Creek without stream realignment (approximately 4,300 feet), stabilize eroding streambanks by grading to a stable slope and/or installing toe wood revetment. As needed, install in-stream boulder and log structures for bank protection, grade control, and bedform diversity.
- Along both sides of Cane Creek, plant and/or enhance a native riparian buffer of trees and shrubs. Ideally, this buffer would be at least 50 feet in width, as measured from the top of the streambank.
- Manage invasive plants throughout the project area.

B. Estimated Costs and Project Prioritization

Following the assessment of restoration opportunities and conceptual planning for the aforementioned projects, the project team determined the estimated cost and relative priority for implementation of each project. Table 3 contains estimated costs for project implementation, including engineering design/permitting, construction, and planting to achieve river bank stabilization and ecological enhancement objectives. Cost estimates are based on typical fees for design, permitting, and implementation of similar river restoration projects in Western North Carolina. Cost estimates are applicable at the time of writing of this report, in June 2022. Additional costs may be required for land acquisition and infrastructure improvements associated with stream crossings or utilities. These estimated costs should be used only for general planning purposes.

Table 3. Estimated Project Costs.

Name	French Broad length (feet)	Estimated Costs			
		Engineering	Construction	Planting	Total
Deerwoode Reserve	4,200	$ 120,000	$ 480,000	$ 60,000	$ 660,000
Brevard Community Park	2,200	$ 120,000	$ 600,000	$ 80,000	$ 800,000
Witherspoon Property	3,800	$ 120,000	$ 440,000	$ 60,000	$ 620,000
Scott Properties	5,500	$ 160,000	$ 840,000	$ 100,000	$ 1,100,000
Merrill & Cantrell and Bridges Properties	2,800	$ 120,000	$ 760,000	$ 80,000	$ 960,000
Platt Properties	1,500	$ 120,000	$ 540,000	$ 80,000	$ 740,000
Besancon Property	1,600	$ 100,000	$ 320,000	$ 40,000	$ 460,000
Kiser Property	3,100	$ 60,000	$ 120,000	$ 20,000	$ 200,000
Freer Properties	800	$ 120,000	$ 600,000	$ 80,000	$ 800,000
King's Bridge Property	3,400	$ 100,000	$ 360,000	$ 40,000	$ 500,000
Broadmoor Golf Links	3,200	$ 140,000	$ 520,000	$ 60,000	$ 720,000

In order to prioritize projects, a decision support tool was developed as a spreadsheet based on a Multi-Criteria Decision Analysis (MCDA) framework. Project information was input to the decision support tool for determining priority status of each potential project. The MCDA framework allows for project prioritization based on ratings for 12 project objectives. These project objectives that were evaluated for each project are:

Risk Management

- Public Safety
- Infrastructure Protection
- Flooding Reduction

Ecosystem Health

- Habitat Enhancement
- Water Quality Improvement
- Floodplain Functions
- Buffer Enhancement
- Streambank Stability
- Geomorphic Equilibrium

Community Values

- Public Access and Education
- Aesthetics
- Recreation

The resulting project prioritization is presented in Table 4 and Table C2 in Appendix C. This prioritization was calculated as MCDA points per unit cost, where the unit cost is based on the approximate French Broad River frontage within the project. While the total estimated costs take into account all project components, the unit cost was simply calculated as the total project cost divided by river frontage. As a result, unit cost does not fully take into account beneficial actions that would take place within the interior of the properties. Interpretation of this prioritization, as well as future decision-making, should carefully consider all project components.

The Kiser property emerged as the highest ranked project, due to a relatively high river length (3,100 feet) and relatively low total project cost ($200,000). This project cost is the lowest of the 11 due to the limited actions that would take place within the interior of the property. Beyond the Kiser property, the remaining ten projects generally fall into two tiers of prioritization. The first tier includes the higher priority projects (between 0.58 and 0.91 points per unit cost) of: King's Bridge Property, Deerwoode Reserve, Witherspoon Property, and Broadmoor Golf Links. The second tier includes the remaining six projects (between 0.10 and 0.38 points per unit cost). These lower-ranked projects should not be dismissed because of the lower rankings, as they would still achieve many overall objectives related to risk management, ecosystem health, and community values. For example, the Brevard Community Park project would achieve the greatest benefit of all 11 projects (i.e., it has the highest MCDA score), but is ranked sixth due to the relatively high cost per linear foot of the French Broad River.

Table 4. Project Prioritization Summary.

Name	Unit Cost ($/linear foot)	MCDA Score (points)	Points per Unit Cost	Project Rank
Deerwoode Reserve	$ 157	99	0.63	3
Brevard Community Park	$ 364	137	0.38	6
Witherspoon Property	$ 163	102	0.63	4
Scott Properties	$ 200	73	0.37	7
Merrill & Cantrell and Bridges Properties	$ 343	95	0.28	9
Platt Properties	$ 493	95	0.19	10
Besancon Property	$ 288	95	0.33	8
Kiser Property	$ 65	117	1.81	1
Freer Properties	$ 1,000	99	0.10	11
King's Bridge Property	$ 147	134	0.91	2
Broadmoor Golf Links	$ 225	131	0.58	5

C. Funding Opportunities and Permitting

Funding opportunities have been identified for the potential projects described above. Based on the specific details of the potential projects, a variety of funding sources would likely be required to achieve restoration goals. Potential funding sources include the following grant programs, most of which require local matching funds:

- NC Land and Water Fund:
  - https://nclwf.nc.gov/
  - Applications are due annually in February.

- NC DEQ Water Resources Development Grant Program:
  - https://deq.nc.gov/about/divisions/water-resources/water-resources-grants/financial-assistance
  - Applications are due semi-annually in June and December.

- NC DEQ 319 Grant Program:
  - https://deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/319-grant-program
  - Applications are due annually in May.

- NC Streamflow Rehabilitation Assistance Program (StRAP):
  - https://www.ncagr.gov/SWC/watershed/StRAP.html
  - The previous application window closed on March 31, 2022.

- USFWS Partners for Fish and Wildlife Program:
  - https://www.fws.gov/southeast/our-services/partners-program/
  - The application process can be initiated by contacting USFWS.

- NRCS Environmental Quality Incentives Program (EQIP):
  - https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/
  - The application process can be initiated by contacting the local NRCS conservationist.

- NC Community Conservation Assistance Program (CCAP):
  - http://www.ncagr.gov/SWC/costshareprograms/CCAP/index.html
  - The previous application window closed on March 25, 2022.

Other private foundation grants available for watershed restoration are described on the NC Department of Environmental Quality web site:

https://deq.nc.gov/about/divisions/water-resources/planning/basin-planning/use-restoration-watershed-programs/funding

Stream restoration projects require permitting at the federal, state, and local levels for environmental and floodplain impacts. Environmental permitting is coordinated by the NC Division of Water Resources and US Army Corps of Engineers using the web-based Pre-Construction Notification (PCN) Form for Nationwide Permits along with corresponding Water Quality Certifications:

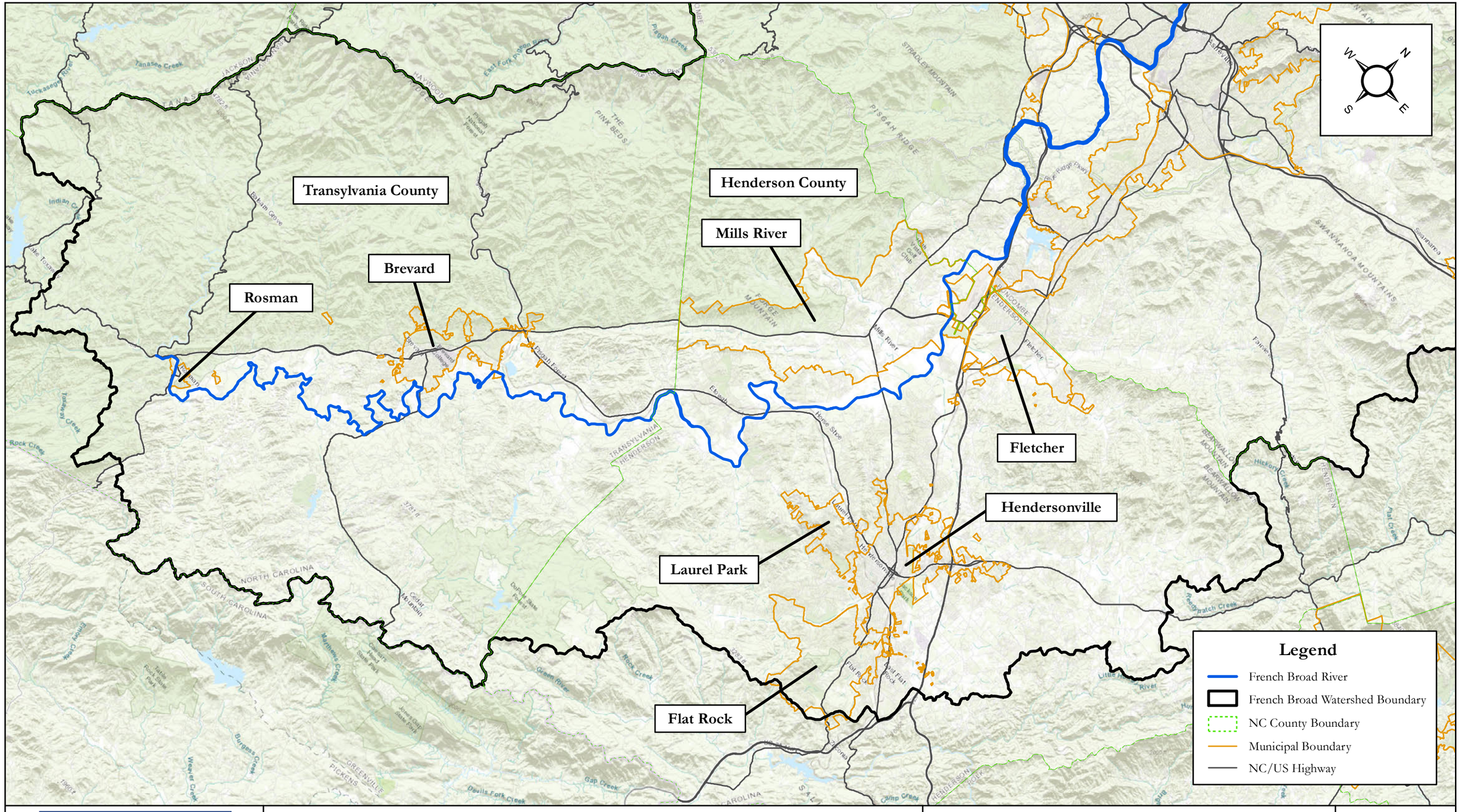
https://edocs.deq.nc.gov/Forms/Pre-Construction_Notification_Form

Once the application is complete, the Corps will process it within 45 days for a Nationwide or General Permit, and the NC DWR will process the 401 Certification within 60 days. Other permit approvals may be required by NC Wildlife Resources Commission, US Fish & Wildlife Service, and the State Historic Preservation Office.

If a Floodplain Development Permit is required, the stream restoration project may require coordination with NC Department of Public Safety Floodplain Management Branch to obtain a "No-Rise" Certification or a Letter of Map Revision (LOMR). Project managers should work closely with permitting agencies to determine specific requirements for implementation.

APPENDIX A

REFERENCE MAPS



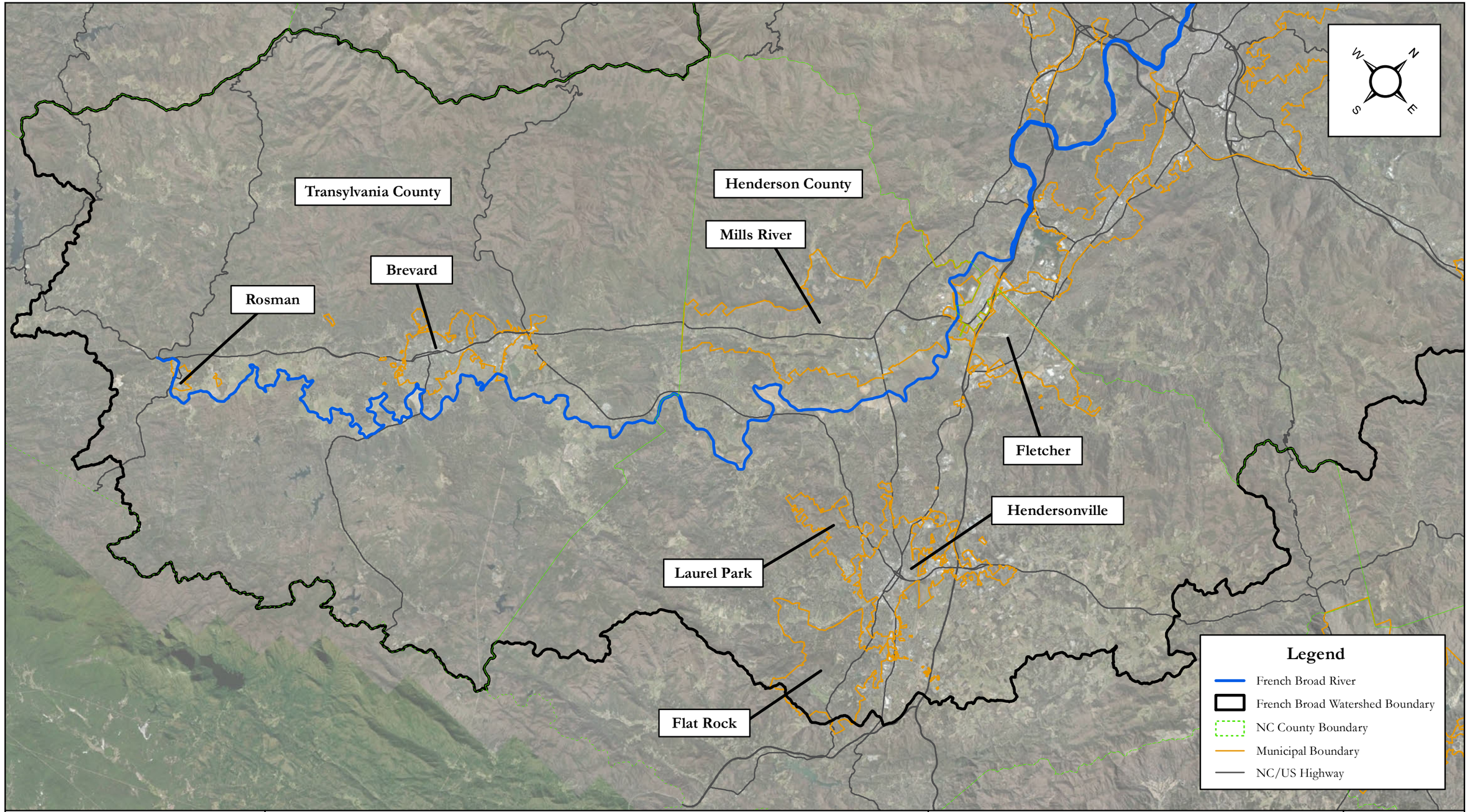
Jennings Environmental

Watershed Overview

0 1.5 3 6 9 12 Miles

Upper French Broad River Watershed Restoration Plan

Sheet A1



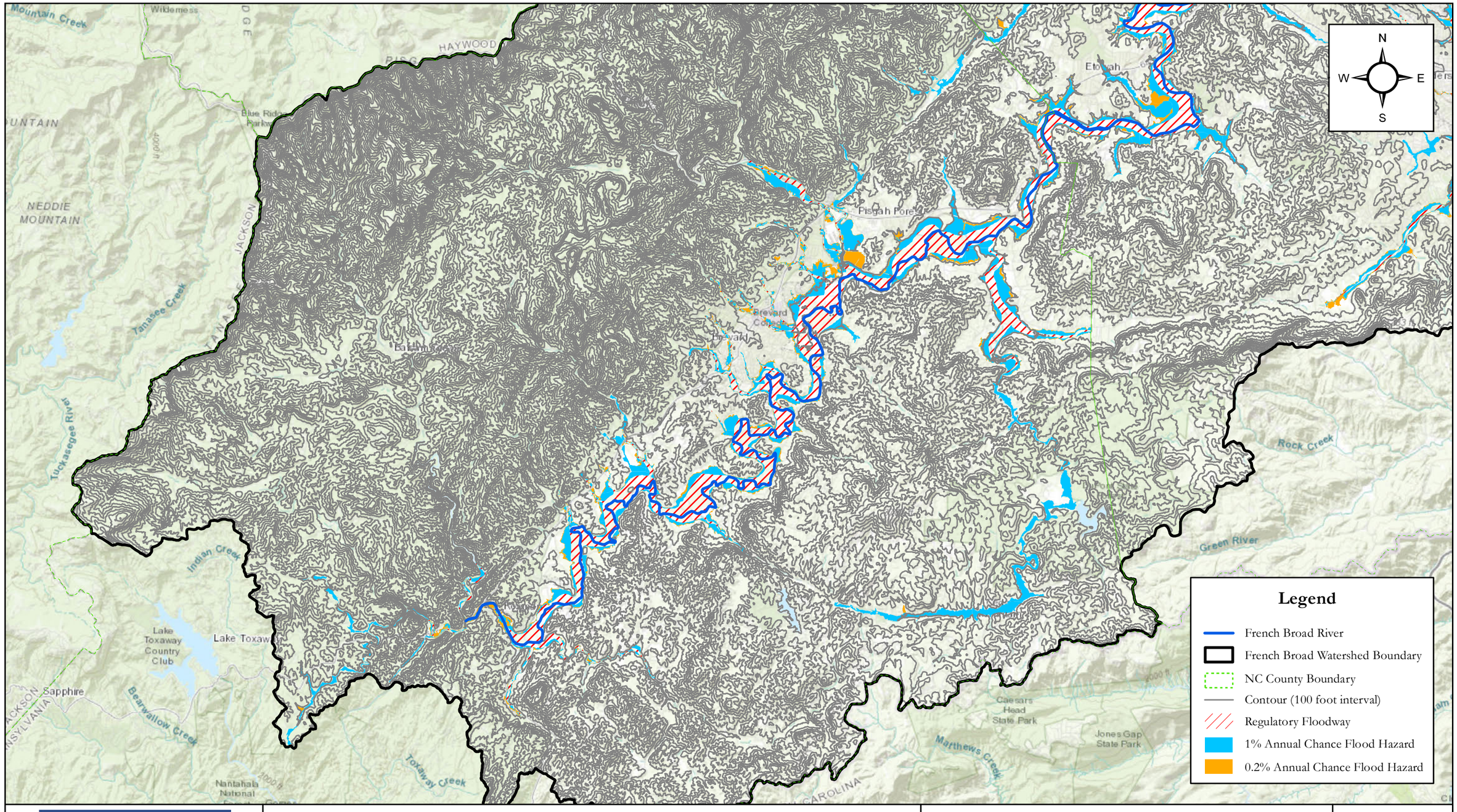
Jennings Environmental

Aerial Photography

0 1.5 3 6 9 12 Miles

Upper French Broad River Watershed Restoration Plan

Sheet A2

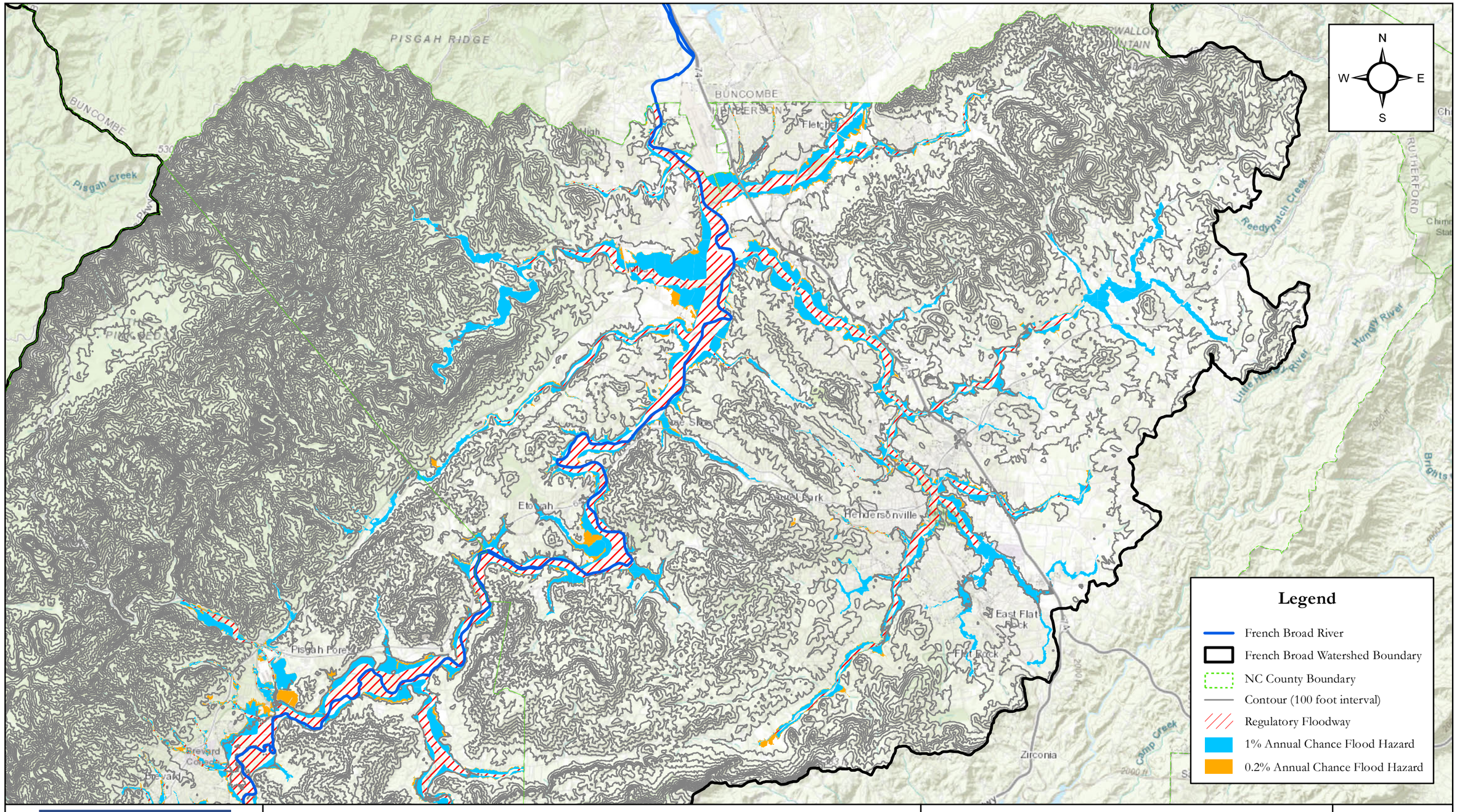


Jennings Environmental

FEMA Flood Zones - Transylvania County

Upper French Broad River Watershed Restoration Plan

Sheet A3



Jennings Environmental

FEMA Flood Zones - Henderson County

0 1 2 4 6 8 Miles

Upper French Broad River Watershed Restoration Plan

Sheet A4

N
W E
S

Legend

- French Broad River
- French Broad Watershed Boundary
- NC County Boundary
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

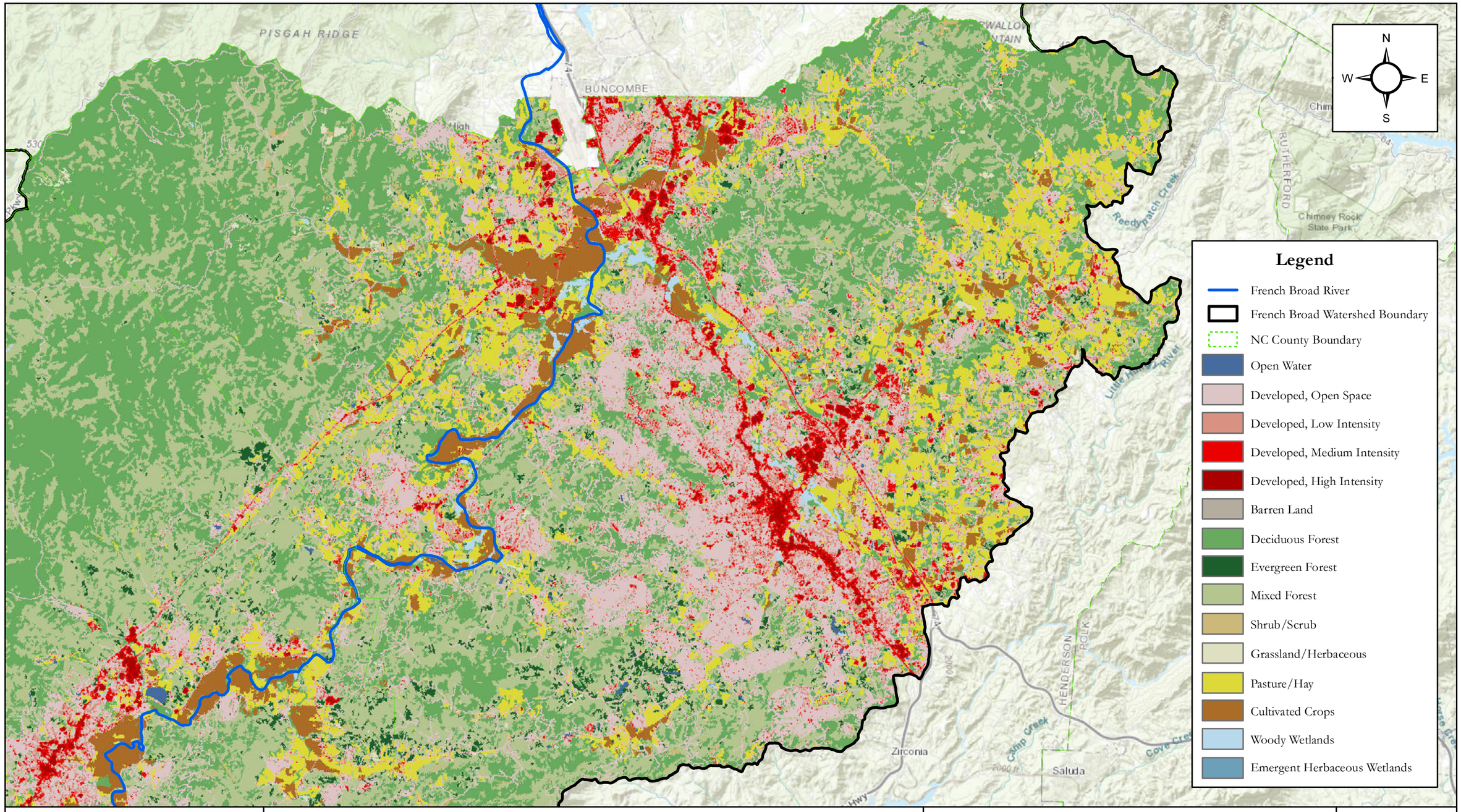
Jennings Environmental

Land Cover - Transylvania County

0 1 2 4 6 8 Miles

Upper French Broad River Watershed Restoration Plan

Sheet A5



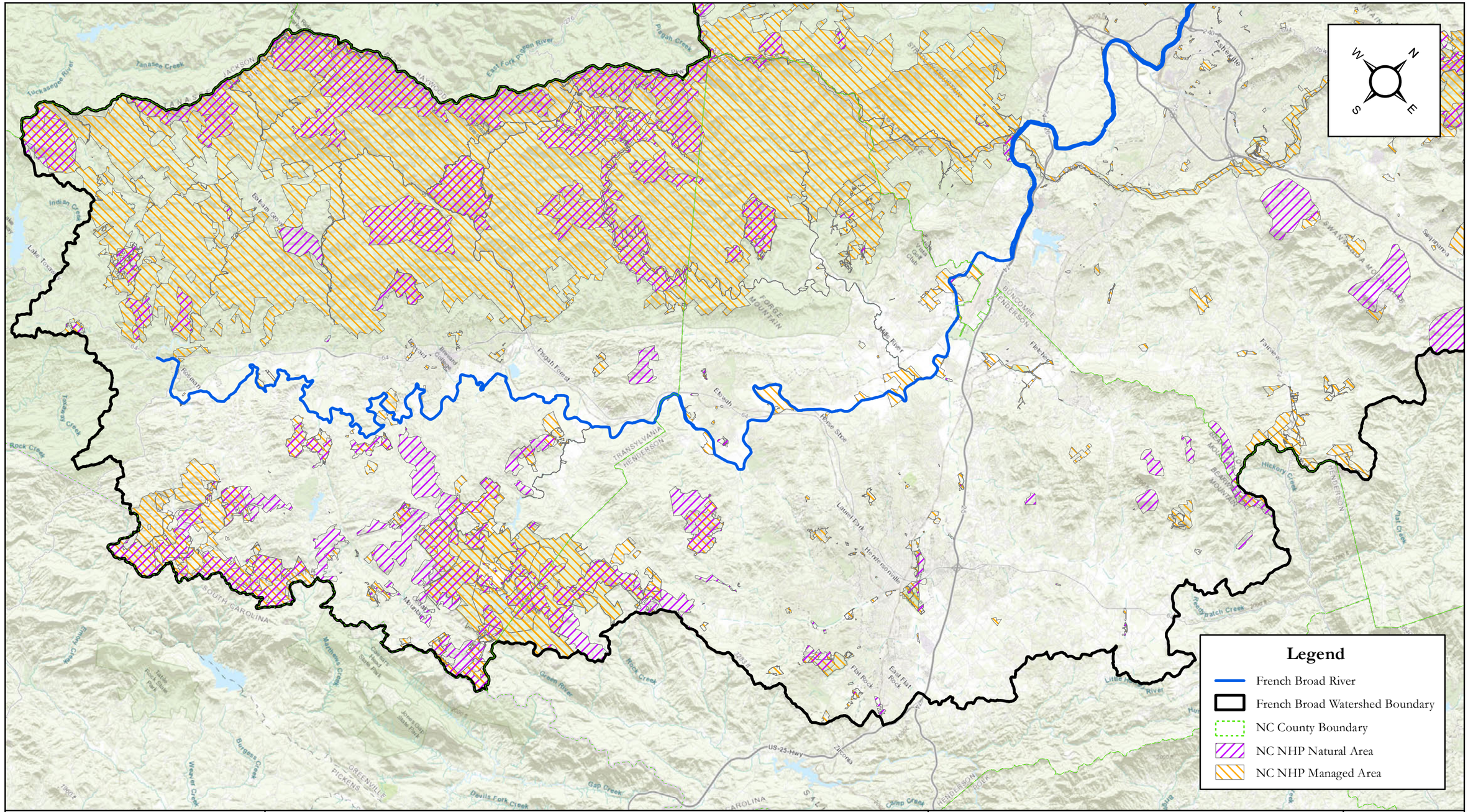
Jennings Environmental

Land Cover - Henderson County

0 1 2 4 6 8 Miles

Upper French Broad River Watershed Restoration Plan

Sheet A6



Jennings Environmental

NC Natural Heritage Program Areas

Upper French Broad River Watershed Restoration Plan

Sheet A7

APPENDIX B

FLOOD MODELING RESULTS

Flood Modeling Procedures and Findings

Flood Modeling Procedures and Findings

Flood Frequency Analysis

Methodology: Peak discharge data from the US Geological Survey (USGS) were downloaded for three gages along the French Broad River (Rosman, Blantyre, and Asheville). The USGS PeakFQ software was used to develop flood frequency estimates for different time periods. The analysis was completed for: (1) a historical period from the beginning of recorded measurements to 1980 (approximate time the floodplain mapping models were developed), (2) the period from 1980 to present (2021), and (3) the combined period from the beginning of recorded measurements to present.

Summary of Findings: The magnitudes of discharges for a given return period were greater for the historical period than the current period for all three gage locations (Figure B1. However, the wide confidence intervals indicated no significant difference between the periods. Flood flow frequency analysis is very sensitive to extreme values and the highest peak discharges along the French Broad were recorded prior to 1980.

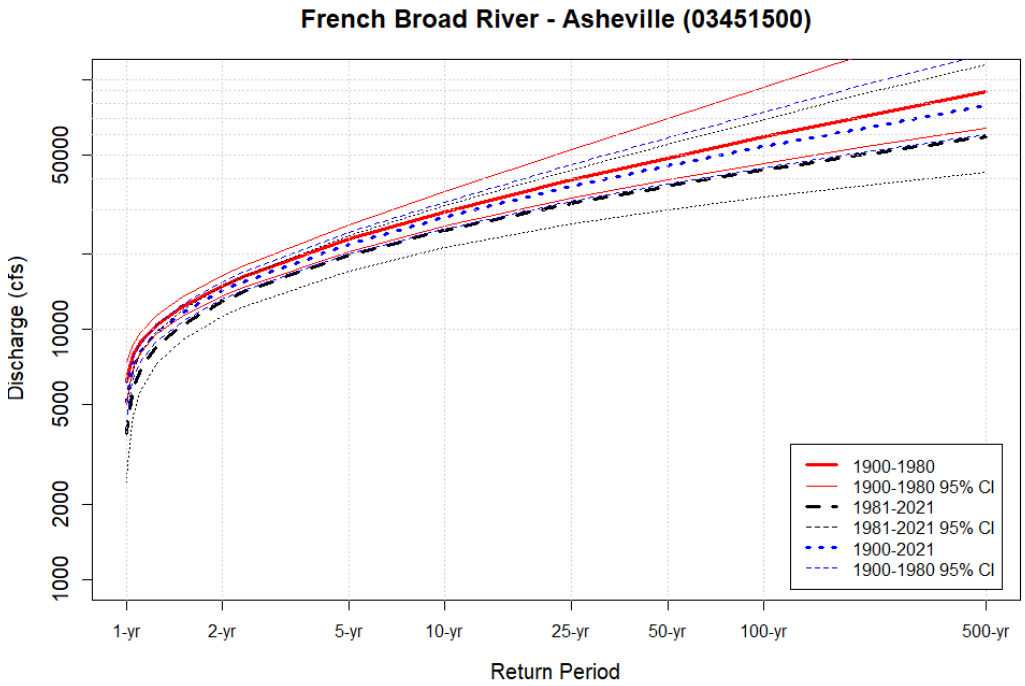


Figure B1. Flood Frequency Analysis for the French Broad River at Asheville.

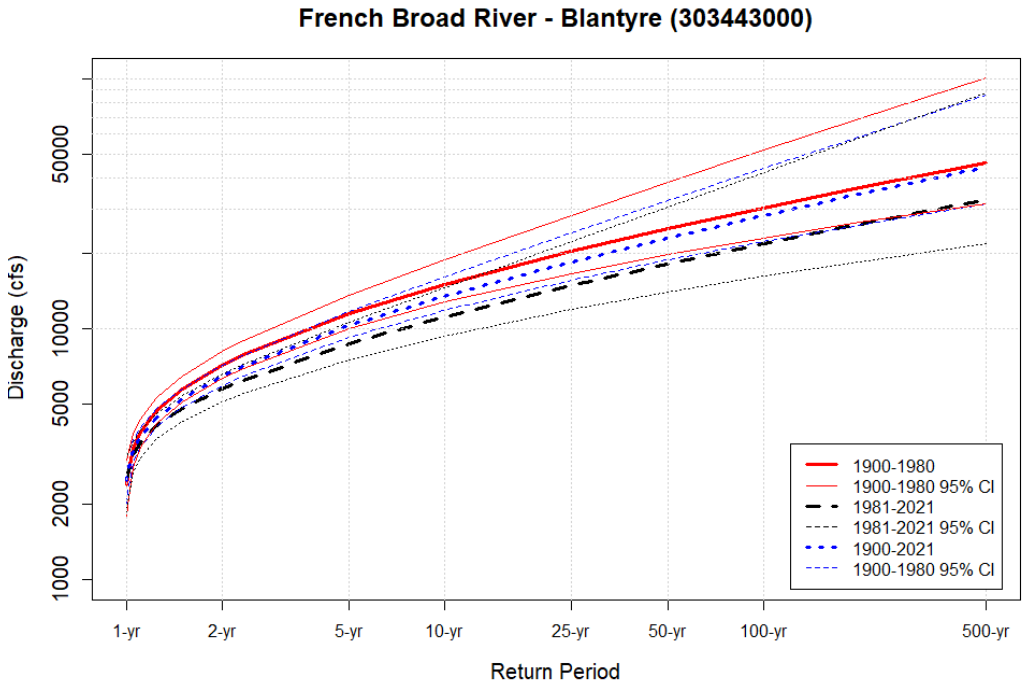


Figure B2. Flood Frequency Analysis for the French Broad River at Blantyre.

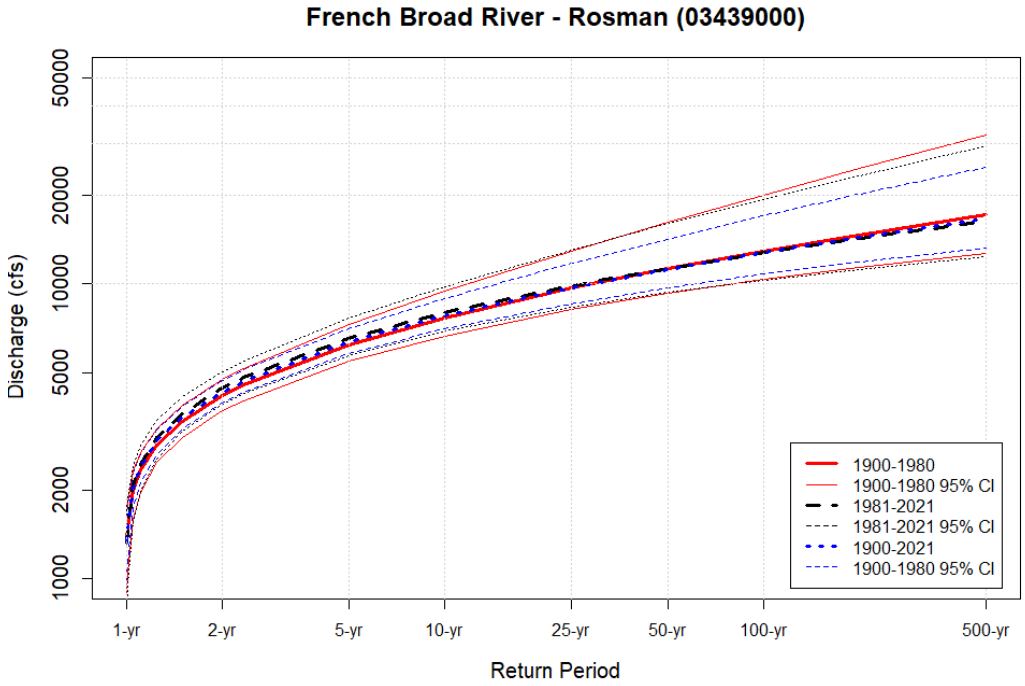


Figure B3. Flood Frequency Analysis for the French Broad River at Rosman.

Peak Flow Analysis

Methodology: Annual peak discharge data from the US Geological Survey (USGS) were plotted for each gage and the Mann-Kendall Test for Monotonic Trend was used to test for a trend in the peak flows.

Summary of Findings: There was a statistically significant increasing trend (p = 0.026) for annual peak flow at the Rosman gage (Figure B4). There were no statistically significant trends in annual peak flow at the Blantyre and Asheville gages (Figure B5).

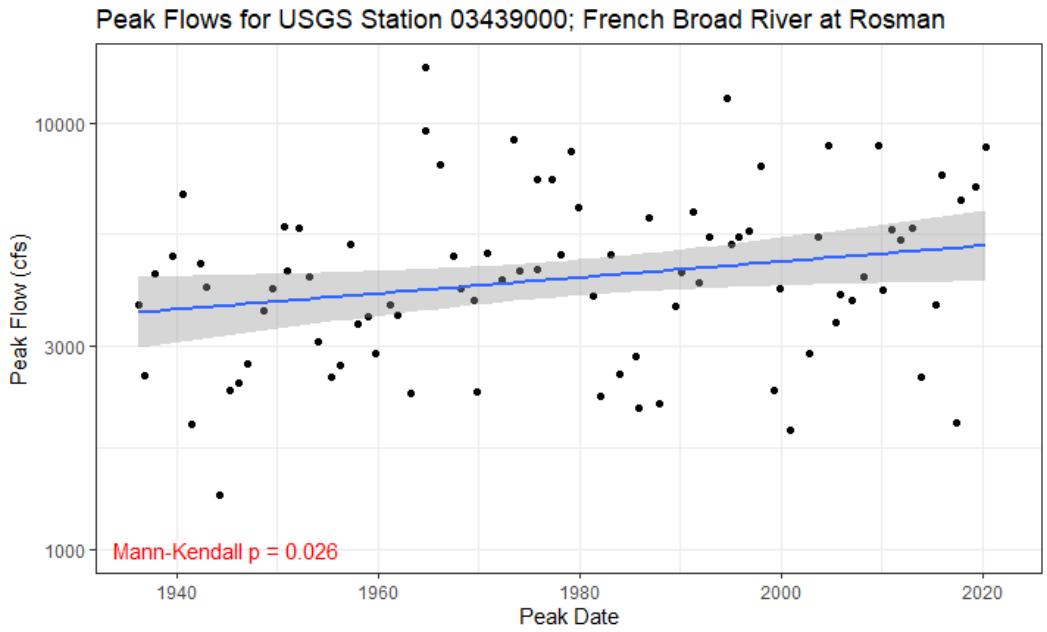


Figure B4. Peak flow record for the French Broad River at Rosman.

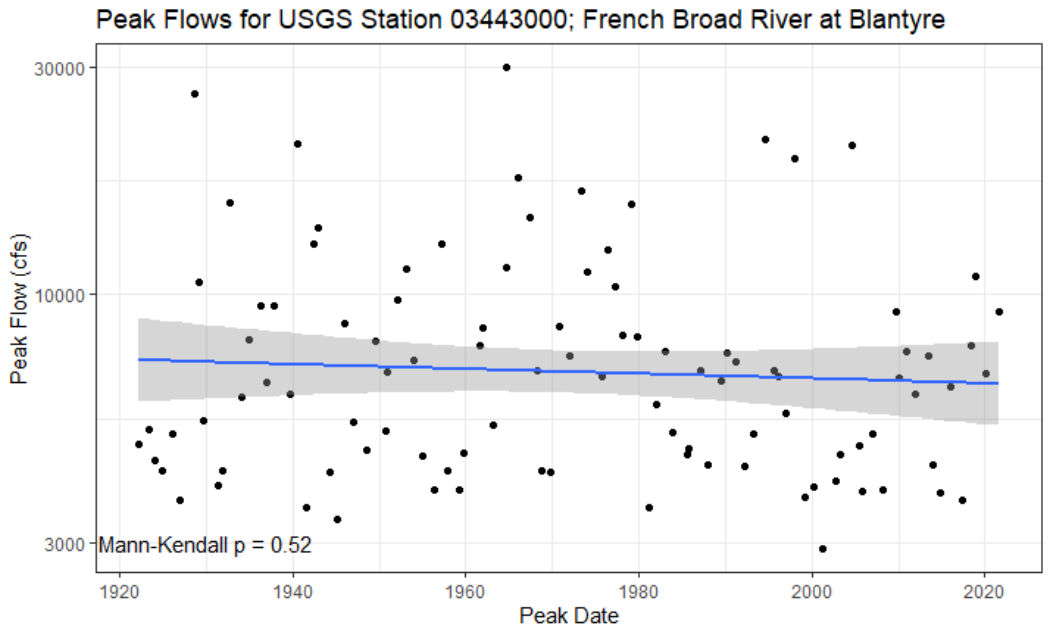


Figure B5. Peak flow record for the French Broad River at Blantyre.

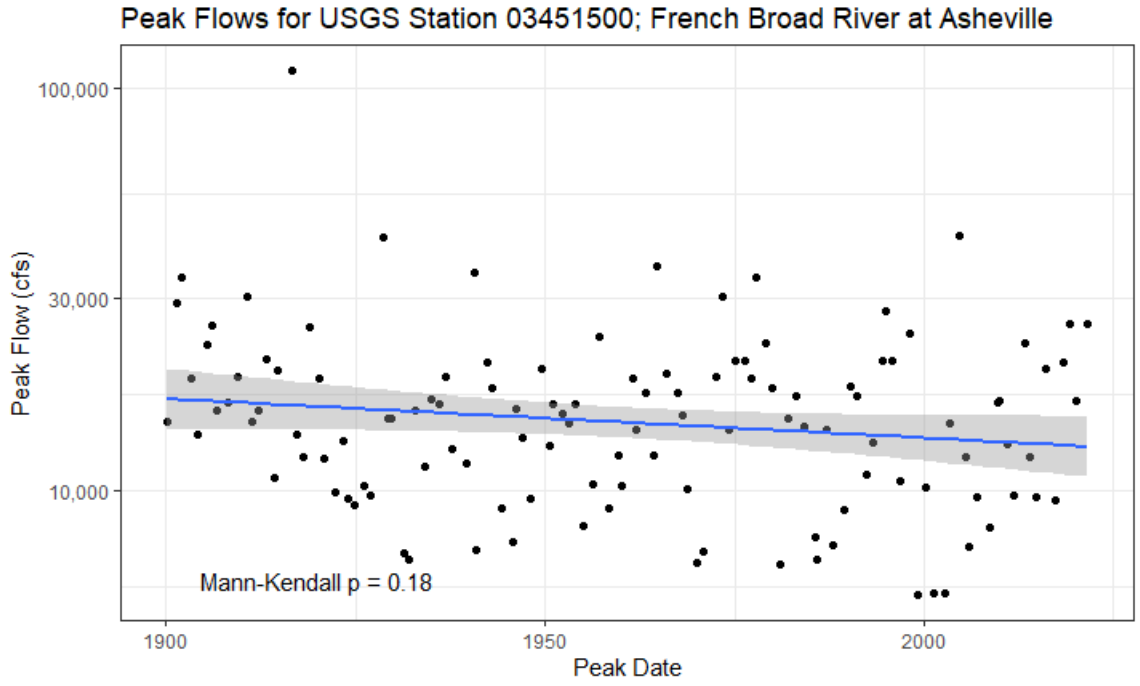


Figure B6. Peak flow record for the French Broad River at Asheville.

Frequency of Lower Return Period Events

Methodology: Daily mean discharge data from the US Geological Survey (USGS) were downloaded for French Broad River at Blantyre and Asheville gages. The discharge values were compared to $Q_{50\%}$ (2-yr) discharge calculated from the flood frequency analysis. The daily mean discharge was disaggregated into events that exceeded the $Q_{50\%}$ discharge. A period of two days with a discharge below the $Q_{50\%}$ discharge threshold was used to define individual events. The number of events were then summarized by decade and plotted. The daily mean discharge was used for this analysis because daily maximum and continuous discharge (15 minutes) records were only available for approximately the last two decades, while daily mean values were available for the entire period of record. The Mann-Kendall test was used to test for trends in the numbers of events per decade.

Summary of Findings: At the Blantyre gage location, the number of events with mean daily discharge above the $Q_{50\%}$ ranged from 2 to 11 per decade from 1920 to 2020 (Figure B7). There was no significant trend at this location ($p = 0.52$). At the Asheville gage, the number of events greater than $Q_{50\%}$ ranged from 2 to 10 per decade (Figure B8), with eight or more events per decade in the 1970s, 1990s, and 2010s. However, no $Q_{50\%}$ events were recorded in the 1980s and only three in the 2000s. There was also not a significant trend at this location ($p = 0.28$).

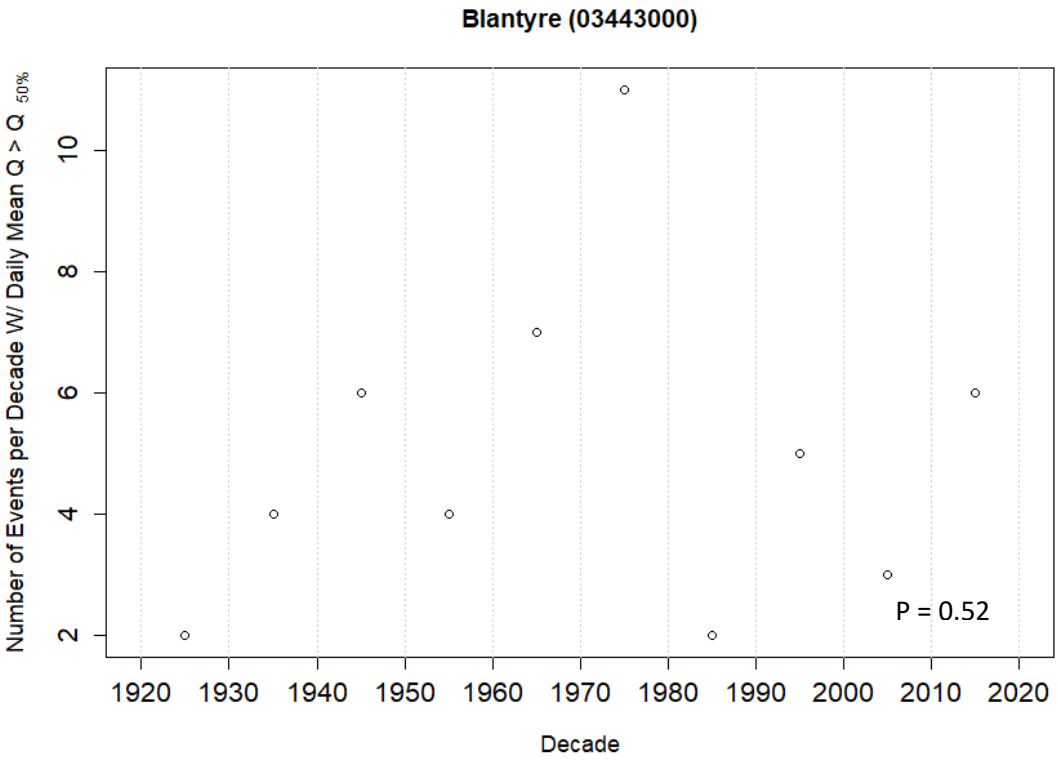


Figure B7. Mean daily flow events greater than $Q_{50\%}$ at the French Broad River at Blantyre gage.

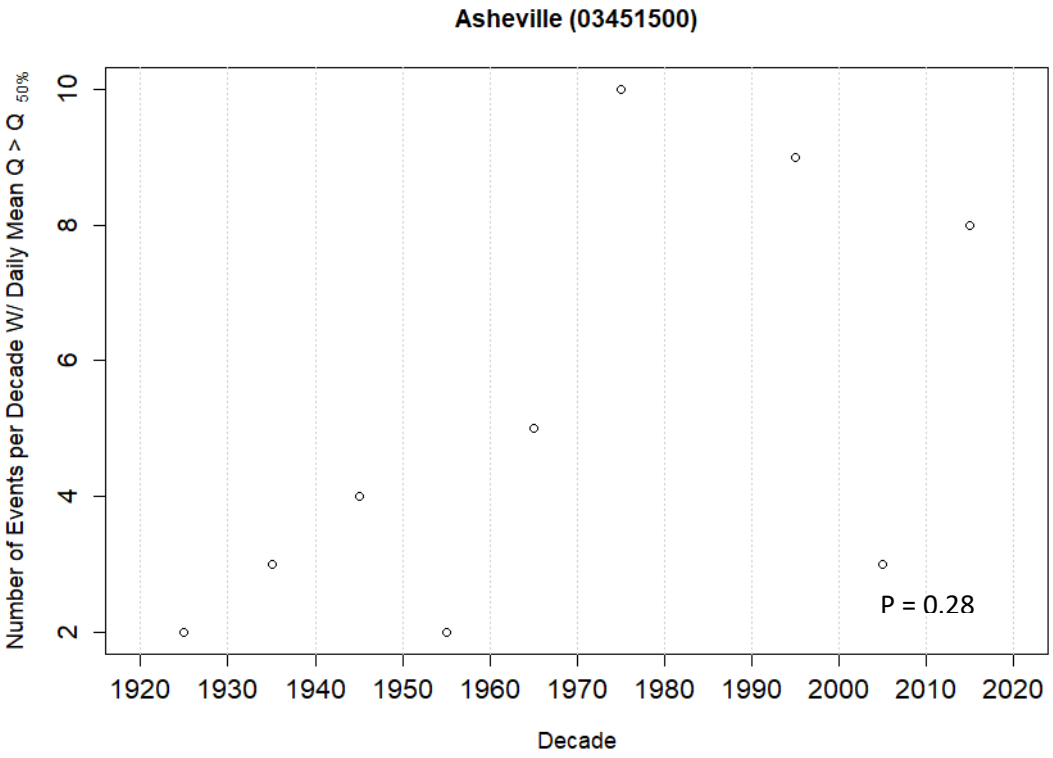


Figure B8. Mean daily flow events greater than $Q_{50\%}$ at the French Broad River at Asheville gage.

HEC-RAS Modeling

Methodology:

Blantyre – Etowah Area: A HEC-RAS model was developed from river stations 943272 to 974160 on the French Broad River. The model cross section locations were based on the cross sections shown on the FEMA effective maps. Additional cross sections were added following standard engineering practice and best professional judgment. The Manning's roughness values were based on values used in the effective model, but were simplified to aggregate values for the channel and floodplain. Cross section elevations were cut from the most recent QL1 LiDAR based DEMs from NC Emergency Management (NCEM). The river bed was lowered by 2.5 feet in each cross section by burning a deeper channel into the DEM to account for the LiDAR elevation data which only measures to water surface. Bridges were entered into the model based on the elevations cut from the LiDAR topographic surface.

Brevard Area: The effective model for Transylvania County was obtained in HEC-2 electronic format from NCEM. The model was imported into HEC-RAS and the cross sections were georeferenced to the locations shown on the effective flood maps. Additional cross sections were added per best professional judgment. The Manning's roughness values were based on values used in the effective model. The cross section and bridge geometry were updated using the QL1 LiDAR data. The channel bed elevations were lowered to match the bed elevations in the effective model cross sections.

Discharge Scenarios: The models were run for a range of return period events (2-yr to 500-yr). The discharge values for the 50-yr to 500-yr events were obtained from the effective models. For the 2-yr to 25-yr events, discharges values were obtained from StreamStats and scaled based on the drainage areas. Downstream boundary conditions were set to the elevations from the effective model for the 10-yr to 500-yr discharges and at normal depth for the 2-yr and 5-yr discharges. The floodplain inundation limits and water depths were then exported as GeoTIFF files.

Summary of Findings: Two example cross sections are provided in Figures B9 and B10. Only relatively minor changes in the extent of flooding across the range of return periods simulated were noted – the floodplain is wide and flat and water spreads out to near the valley edges – even for the 2-yr and 5-yr events. The primary impacts of flooding for larger events is the difference in the depth of flooding.

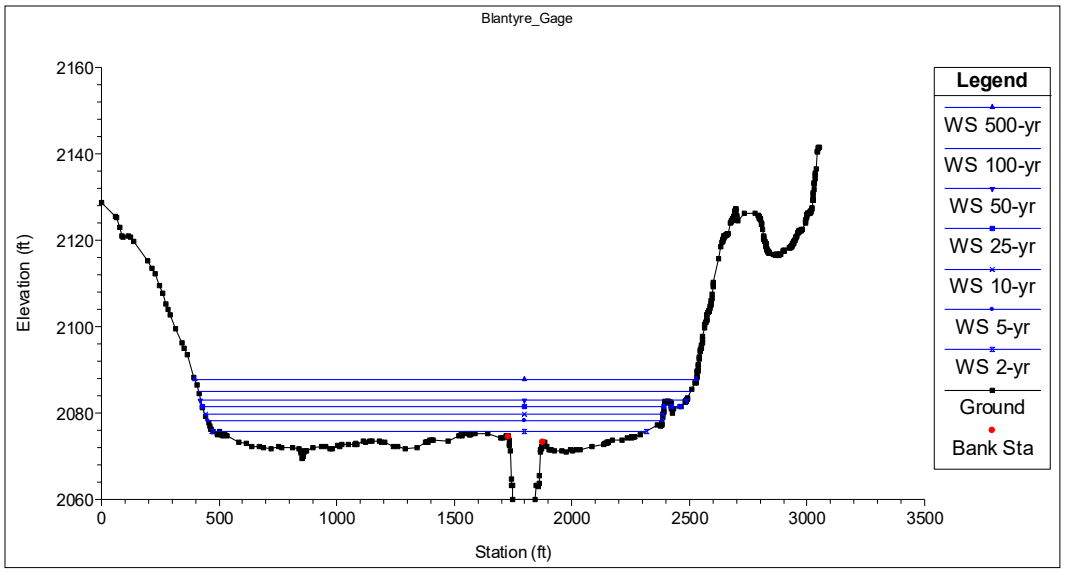


Figure B9. Blantyre area model example Cross-section.

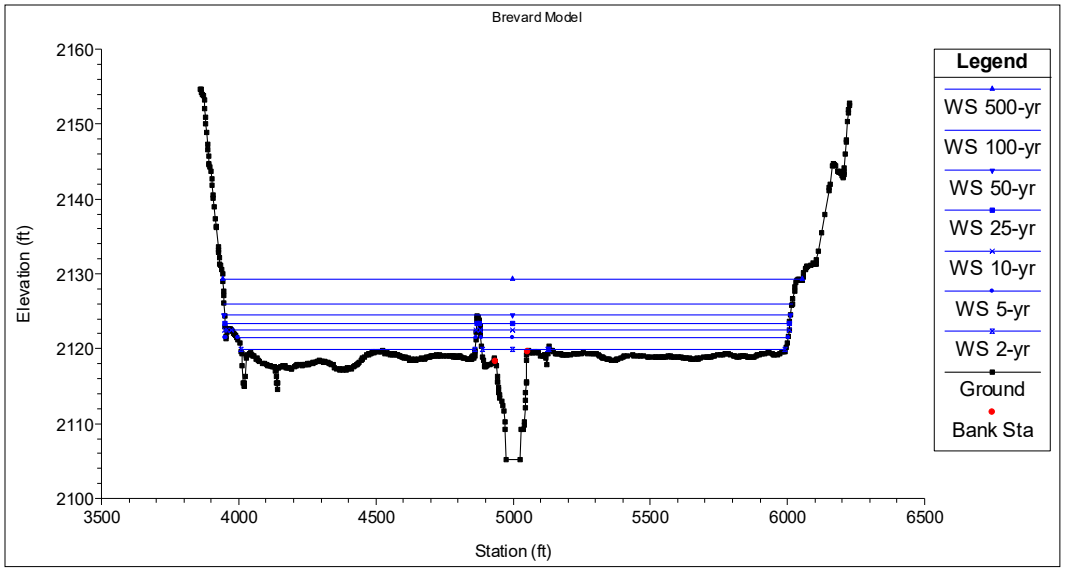


Figure B10. Brevard area model example Cross-section.

N

S E

Legend

- French Broad River
- Selected Parcel Boundary
- Flood Extent, 500 Year Return Interval
- Flood Extent, 100 Year Return Interval
- Flood Extent, 10 Year Return Interval
- Flood Extent, 2 Year Return Interval

Note: Flood modeling results shown here are for informational purposes only. These results are not equivalent to FEMA Flood Hazard Areas, and should not be used as such.

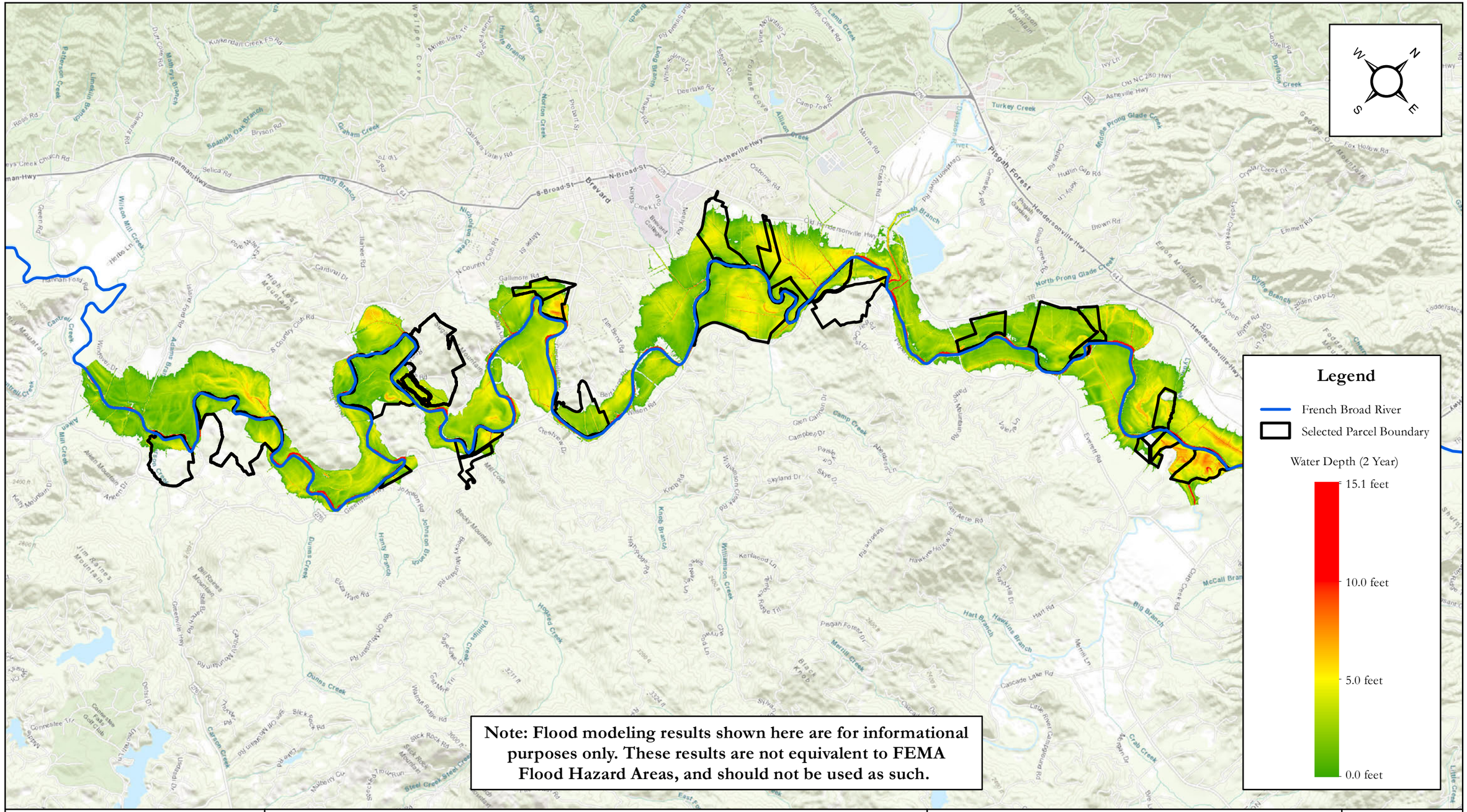
Jennings Environmental

Modeled Flood Extents - Brevard Area

0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B1



Jennings Environmental

Modeled Flood Depths (2 Year) - Brevard Area

0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B2

Legend

French Broad River

Selected Parcel Boundary

Water Depth (100 Year)

25.0 feet

20.0 feet

15.0 feet

10.0 feet

5.0 feet

0.0 feet

Note: Flood modeling results shown here are for informational purposes only. These results are not equivalent to FEMA Flood Hazard Areas, and should not be used as such.

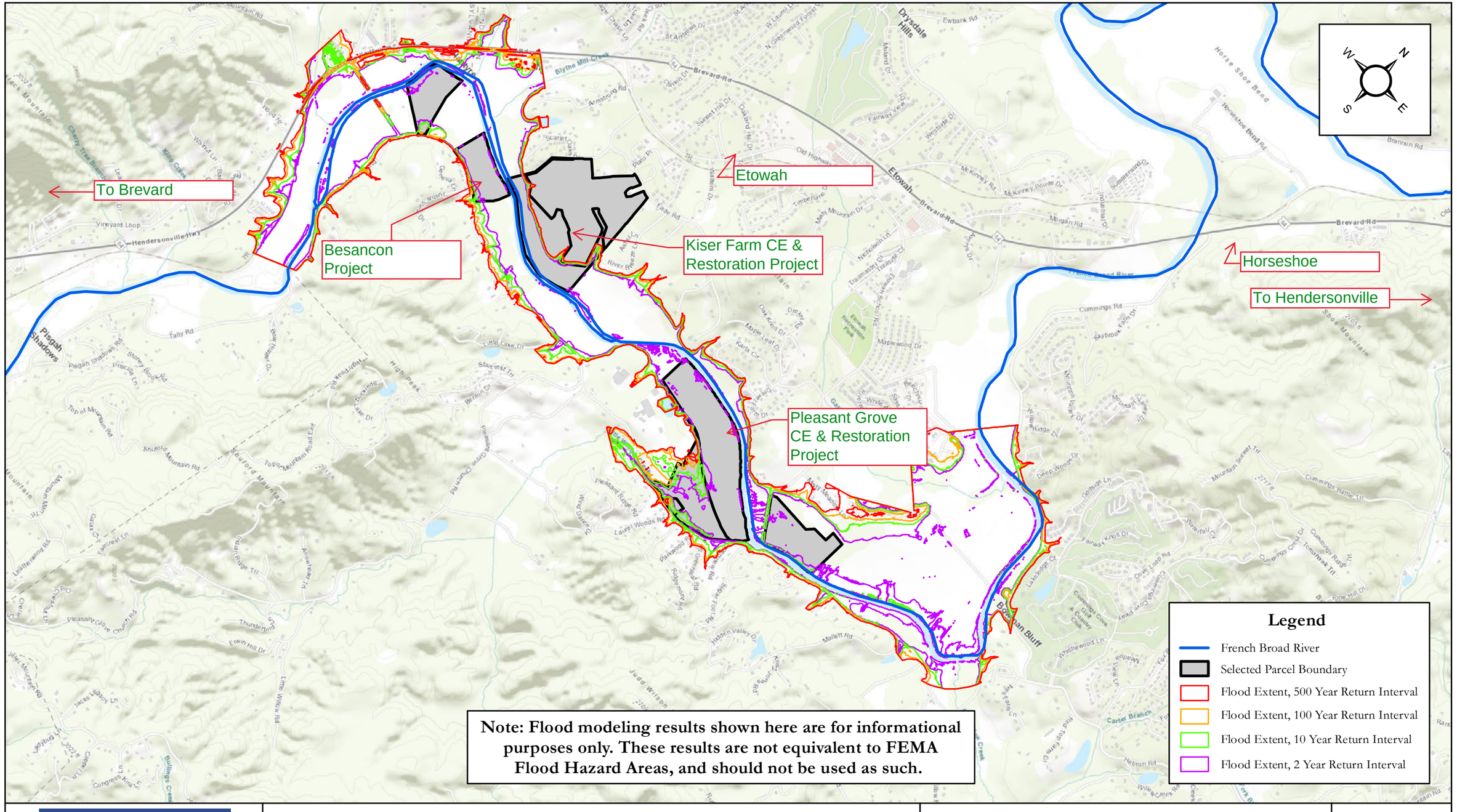
Jennings Environmental

Modeled Flood Depths (100 Year) - Brevard Area

0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B3



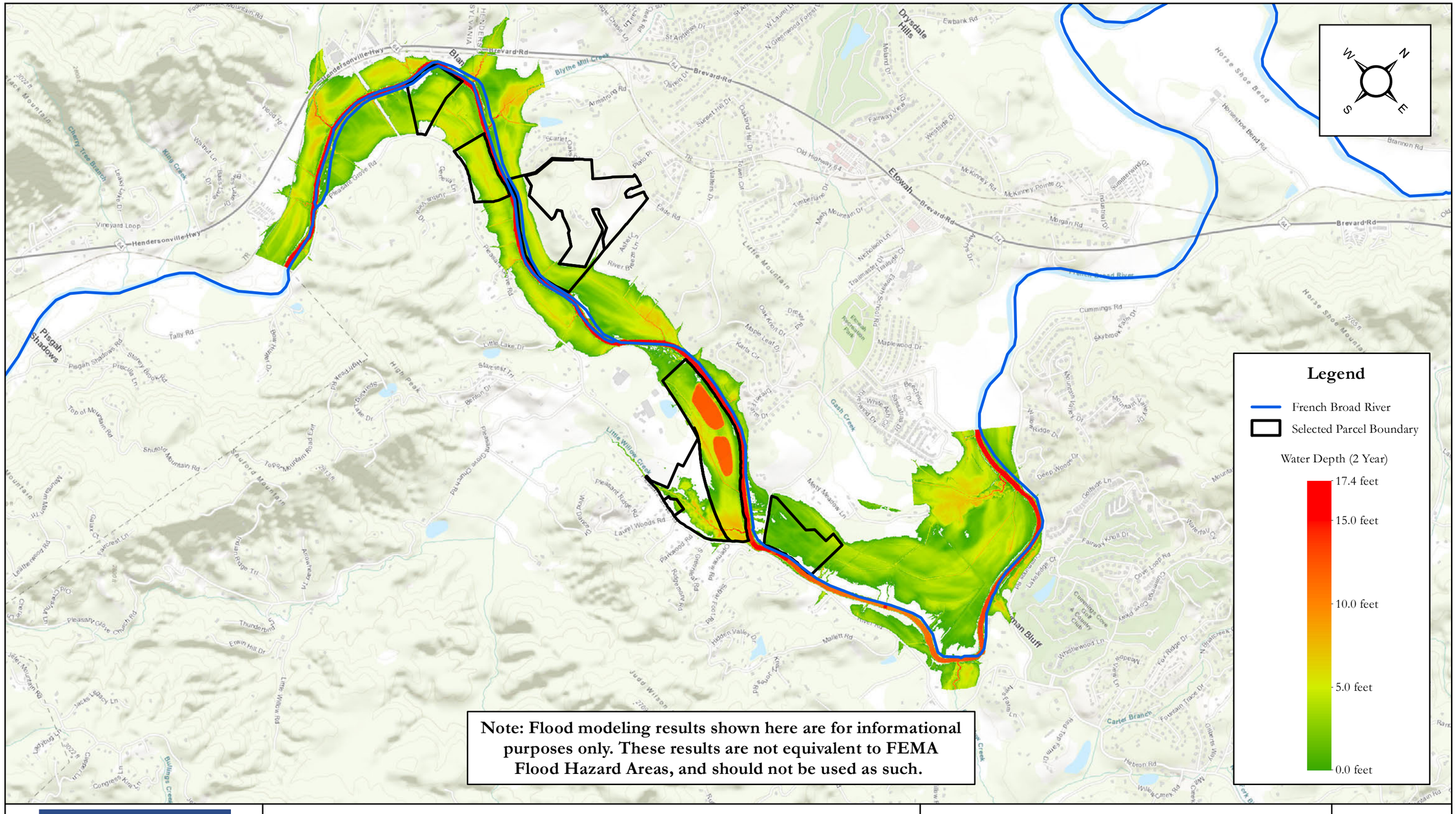
Jennings Environmental

Modeled Flood Extents - Blantyre Area

0 1,000 2,000 4,000 6,000 8,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B4



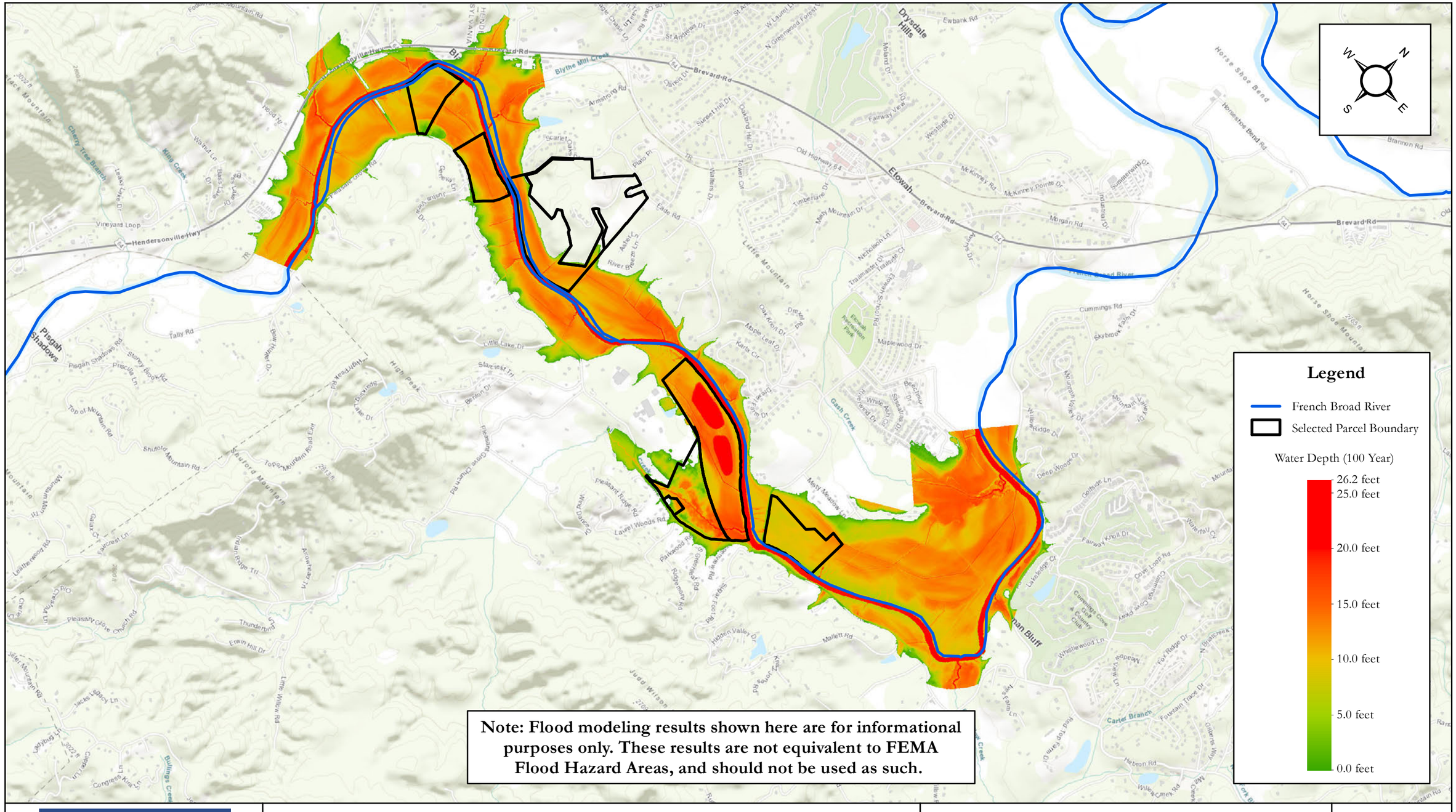
Jennings Environmental

Modeled Flood Depths (2 Year) - Blantyre Area

0 1,000 2,000 4,000 6,000 8,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B5



Jennings Environmental

Modeled Flood Depths (100 Year) - Blantyre Area

0 1,000 2,000 4,000 6,000 8,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet B6

APPENDIX C

POTENTIAL WATERSHED RESTORATION PROJECTS

Table C1
Upper French Broad River Watershed Restoration Plan
Potential Watershed Restoration Projects

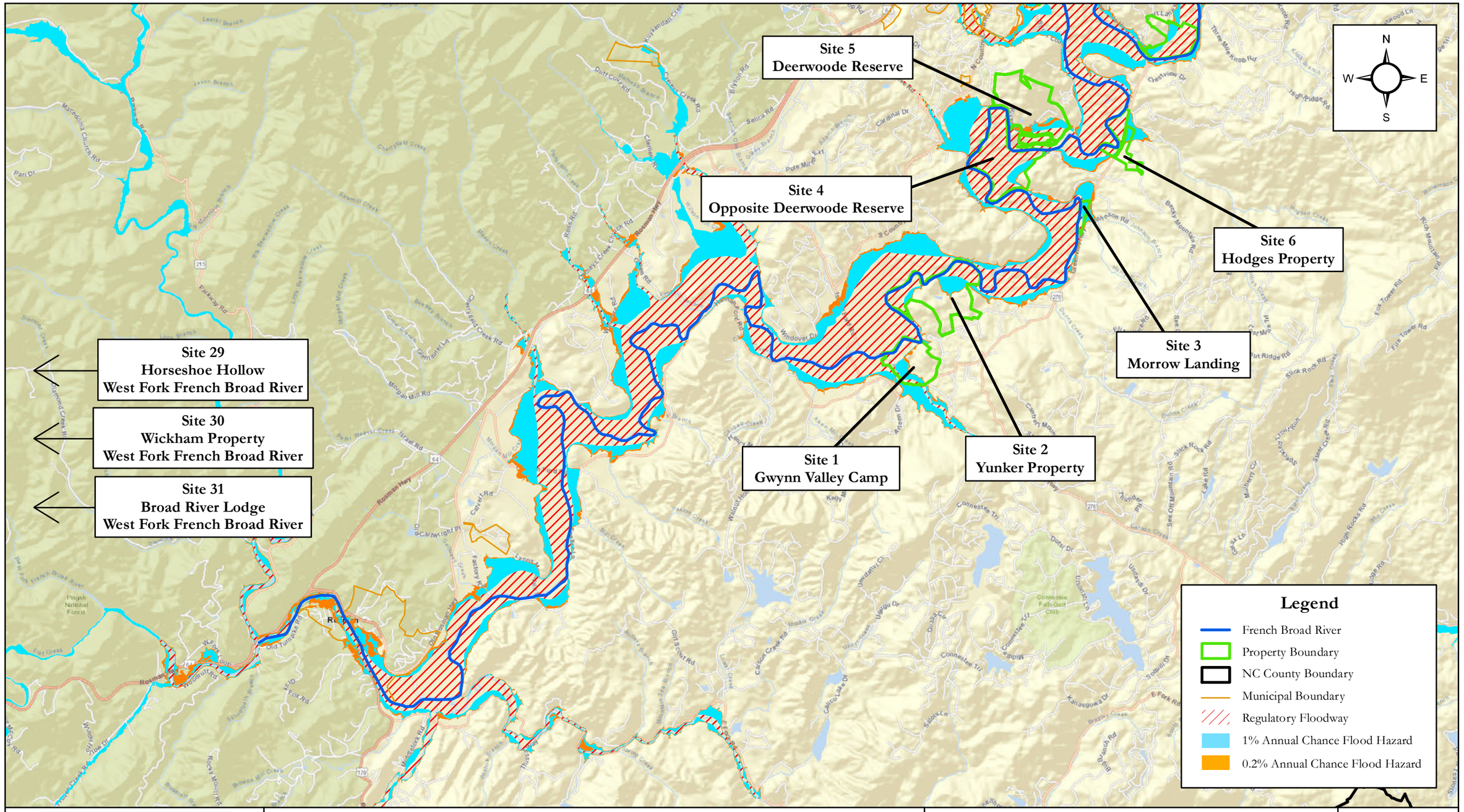
Site No.	Name	Owner	County	Latitude	Longitude	Parcel Size (acres)	PIN	Potential Restoration Approaches
1	Gwynn Valley Camp	Erwin	Transylvania	35.177462	-82.746256	74.17	8584-00-8673	Stream restoration (Carson Creek), Bank stabilization
2	Yunker Property	Yunker	Transylvania	35.184898	-82.741521	151.50	8584-13-7310	Wetland restoration, Stream restoration (UT French Broad River), Fish habitat
3	Morrow Landing	Morrow	Transylvania	35.194417	-82.722417	8.48	8584-86-2623	Wetland restoration, Stream restoration (Johnson Branch), Fish habitat
4	Opposite Deerwoode Reserve	The Sons LLC	Transylvania	35.200725	-82.730506	127.46	8584-48-4752	Bank stabilization
5	Deerwoode Reserve	Hodgson	Transylvania	35.203090	-82.728619	166.44	8585-60-4875	Wetland enhancement, Bank stabilization, Riparian buffer enhancement, Fish habitat
6	Hodges Property	Hodges	Transylvania	35.203401	-82.716644	40.17	8594-08-3622	Wetland restoration, Stream restoration (Hogsed Creek), Fish habitat
7	Brevard Community Park	City of Brevard	Transylvania	35.222530	-82.727170	28.81, 21.86	8585-76-0653, 8585-86-0476	Stream restoration (UT French Broad River), Wetland restoration, Riparian buffer enhancement, Trails
8	Witherspoon Property	Witherspoon	Transylvania	35.214768	-82.709014	61.15	8595-24-0085	Stream restoration (UT French Broad River), Wetland enhancement, Riparian buffer enhancement, Fish habitat
9	Turf Mountain Sod	Turf Mountain Sod	Transylvania	35.238277	-82.706081	205.42	8596-41-0889	Stream restoration (Williamson Creek), Bank stabilization
10	Lambo Creek	Snipes	Transylvania	35.240717	-82.713735	64.00	8596-03-9390	Stream restoration (Lambo Creek)
11	Scott Properties	Scott	Transylvania	35.241002	-82.699816	26.14, 24.57	8596-44-7045, 8596-34-9250	Bank stabilization, Fish habitat
12	Lingerlong Property	Lingerlong	Transylvania	35.247472	-82.698617	100.58	8596-75-0900	Wetland restoration, Stream restoration (UT French Broad River), Fish habitat
13	Pisgah Laboratories	Pisgah Laboratories	Transylvania	35.253096	-82.679363	38.28	9506-18-9621	Bank stabilization
14	Merrill & Cantrell Property	Merrill and Cantrell	Transylvania	35.261659	-82.671314	124.72	9507-40-2521	Stream restoration (Glade Creek), Wetland enhancement, Bank stabilization, Fish habitat
15	Bridges Property	Bridges	Transylvania	35.262972	-82.667444	17.43	9507-42-7033	Stream restoration (Glade Creek), Riparian buffer enhancement
16	Platt Properties	Platt	Transylvania	35.262639	-82.649806	23.85, 9.38, 3.51	9516-09-5388, 9517-00-4126, 9516-19-1610	Wetland enhancement, Riparian buffer enhancement, Fish habitat
17	Lyday Creek	Broadbent	Transylvania	35.264161	-82.652540	24.93	9507-91-8042	Stream restoration (Lyday Creek)
18	Hooper Property	Hooper	Transylvania	35.264090	-82.643290	38.96	9517-20-4236	Bank stabilization

Table C1
Upper French Broad River Watershed Restoration Plan
Potential Watershed Restoration Projects

Site No.	Name	Owner	County	Latitude	Longitude	Parcel Size (acres)	PIN	Potential Restoration Approaches
19	James Property	James	Henderson	35.302332	-82.620655	21.15	9518-94-9306	Riparian buffer enhancement
20	Besancon Property	Besancon	Henderson	35.300689	-82.614416	20.41	9528-13-9941	Wetland enhancement, Riparian buffer enhancement, Fish habitat
21	Kiser Property	Kiser	Henderson	35.301349	-82.607990	44.92, 72.21	9528-33-9943, 9528-34-9979	Stream stabilization, Riparian buffer enhancement
22	Freer Properties	Freer	Henderson	35.300693	-82.599223	21.37, 9.84, 2.72	9528-64-6321, 9528-74-6617, 9528-74-9211	Stream restoration (UT French Broad River), Wetland enhancement, Riparian buffer enhancement
23	Pleasant Grove	Conserving Carolina	Henderson	35.298121	-82.586181	66.49	9528-93-5163	Wetland restoration, Stream restoration (Little Willow Creek), Fish habitat
24	Ceron Brothers Farms	Ceron Brothers Farms	Henderson	35.298285	-82.579315	28.94	9538-22-2946	Bank stabilization
25	Muddy Bottom Hunt Club	Muddy Bottom Hunt Club	Henderson	35.365483	-82.545877	40.18	9640-26-7269	Stream restoration (UT French Broad River), Fish habitat
26	King's Bridge Property	State of North Carolina	Henderson	35.375538	-82.532329	85.27	9640-69-8997	Stream restoration (UT French Broad River), Wetland restoration, Riparian buffer enhancement, Fish habitat
27	Asheville Water Plant	City of Asheville	Henderson	35.386997	-82.535902	330.47	9641-53-7269	Wetland restoration, Stream restoration (Mills River), Riparian buffer enhancement
28	Broadmoor Golf Links	Asheville Airport Authority, Big J Small J Partnership	Henderson	35.415512	-82.532044	189.21, 94.14	9642-75-2558, 9642-84-4544	Stream restoration (Cane Creek), Riparian buffer enhancement
29	Horseshoe Hollow	Horseshoe Hollow	Transylvania	35.179299	-82.904263	15.00	8534-32-7703	Stream restoration (West Fork French Broad River)
30	Wickham Property	Wickham	Transylvania	35.176252	-82.902515	75.50	8534-41-1457	Bank stabilization, Riparian buffer enhancement
31	Broad River Lodge	Broad River Lodge	Transylvania	35.177107	-82.897360	9.60	8534-51-5927	Bank stabilization, Riparian buffer enhancement
32	Sherwood Forest	Sherwood Forest	Transylvania	35.147473	-82.684353	multiple parcels		Bank stabilization, Riparian buffer enhancement

Table C2
Upper French Broad River Watershed Restoration Plan
Multi-Criteria Decision Analysis Calculator

Project Ranking Based on Potential for Achieving Objectives and Cost-Effectiveness	Project Objectives												For each objective, enter its weighting factor from 0 to 3, representing the importance of the objective for project ranking. For each project, enter its score from 0 to 5 for each objective, representing its potential to achieve the objective.		
	Risk Management			Ecosystem Health						Community Values					
	Public Safety	Infrastructure Protection	Flooding Reduction	Habitat Enhancement	Water Quality Improvement	Floodplain Functions	Buffer Enhancement	Streambank Stability	Geomorphic Equilibrium	Public Access & Education	Aesthetics	Recreation			
Objective Weighting Factor	3	3	3	2	3	2	2	3	3	2	1	1	MCDA Score (points)	Points per Unit Cost	Project Rank Based on Points per Unit Cost
Deerwoode Reserve	4	4	2	4	4	4	4	4	3	3	3	3	99	0.63	3
Brevard Community Park	5	5	4	5	5	5	5	5	5	5	5	5	137	0.38	6
Witherspoon Property	3	3	2	5	5	5	5	4	4	1	4	3	102	0.63	4
Scott Properties	3	2	2	3	3	3	3	3	3	1	2	3	73	0.37	7
Merrill & Cantrell and Bridges Properties	3	3	2	4	4	4	5	4	4	1	3	4	95	0.28	9
Platt Properties	3	3	2	4	4	4	5	4	4	1	3	4	95	0.19	10
Besancon Property	3	3	2	4	4	4	5	4	4	1	3	4	95	0.33	8
Kiser Property	4	4	4	5	5	5	5	4	4	2	4	4	117	1.81	1
Freer Properties	3	3	2	4	5	5	5	4	4	1	3	3	99	0.10	11
King's Bridge Property	5	5	3	5	5	5	5	5	5	5	5	5	134	0.91	2
Broadmoor Golf Links	5	5	2	5	5	5	5	5	5	5	5	5	131	0.58	5



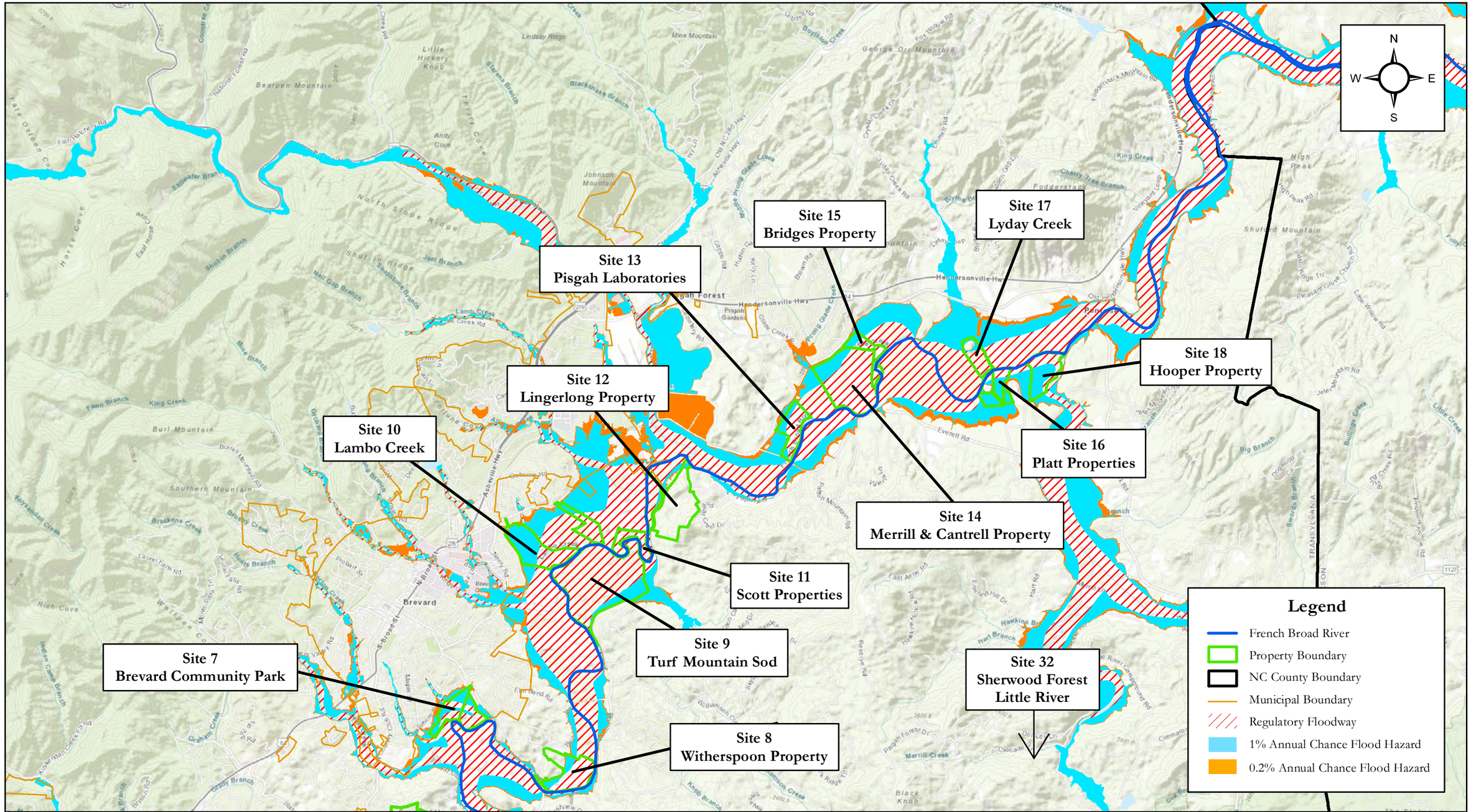
Jennings Environmental

Transylvania County - South

0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C1



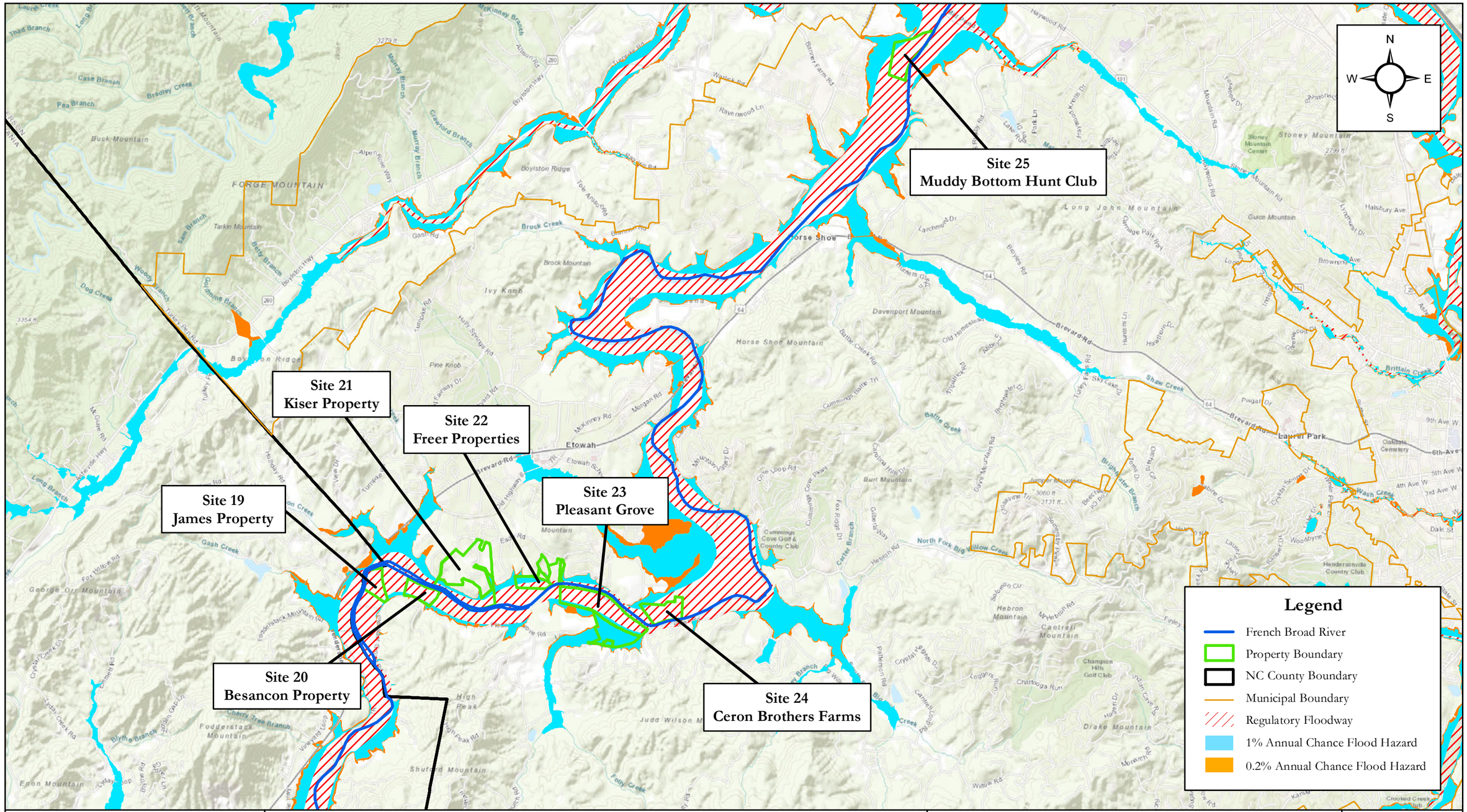
Jennings Environmental

Transylvania County - North

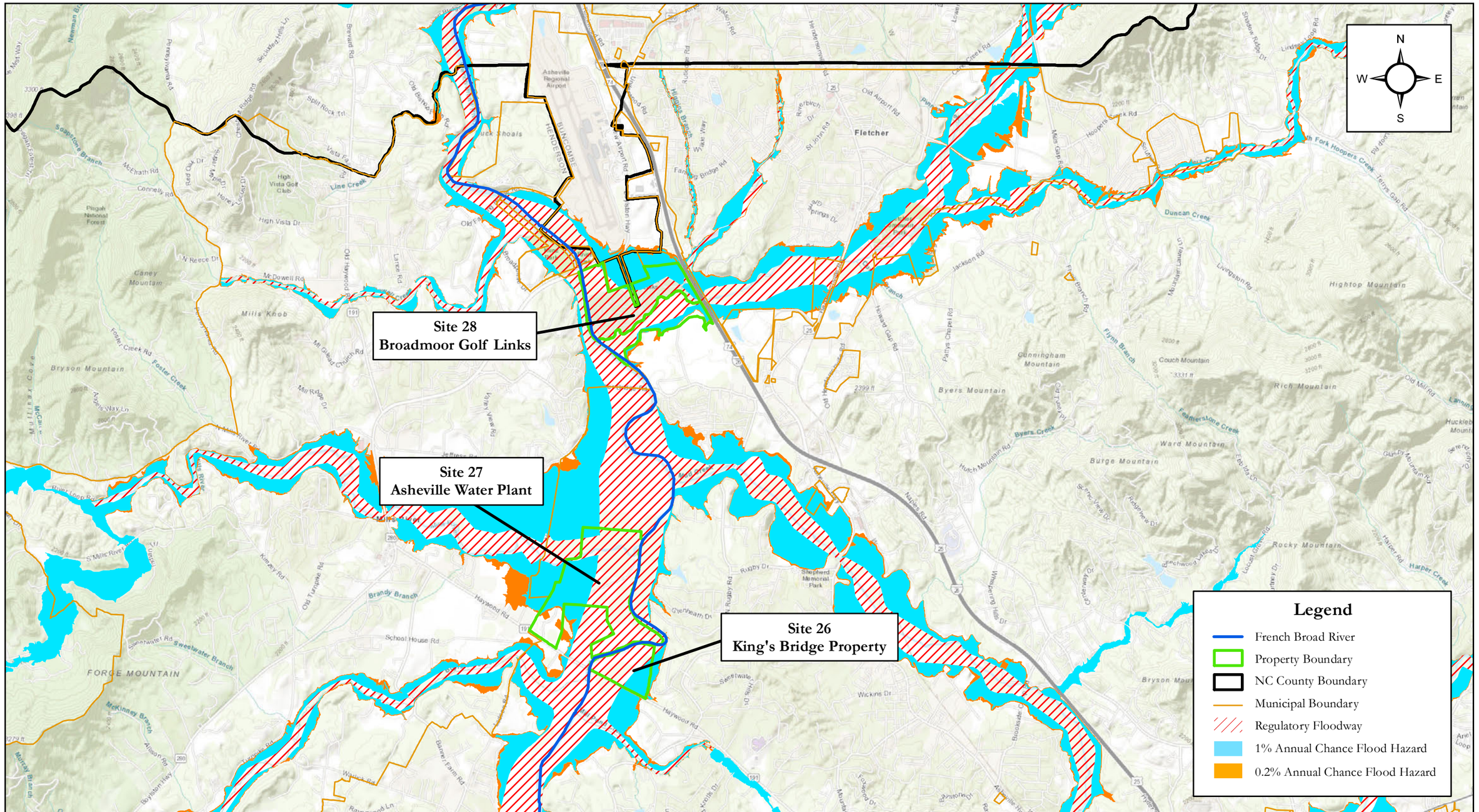
0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C2



Jennings Environmental	**Henderson County - South** 0 2,000 4,000 8,000 12,000 16,000 Feet	**Upper French Broad River Watershed Restoration Plan**	**Sheet C3**



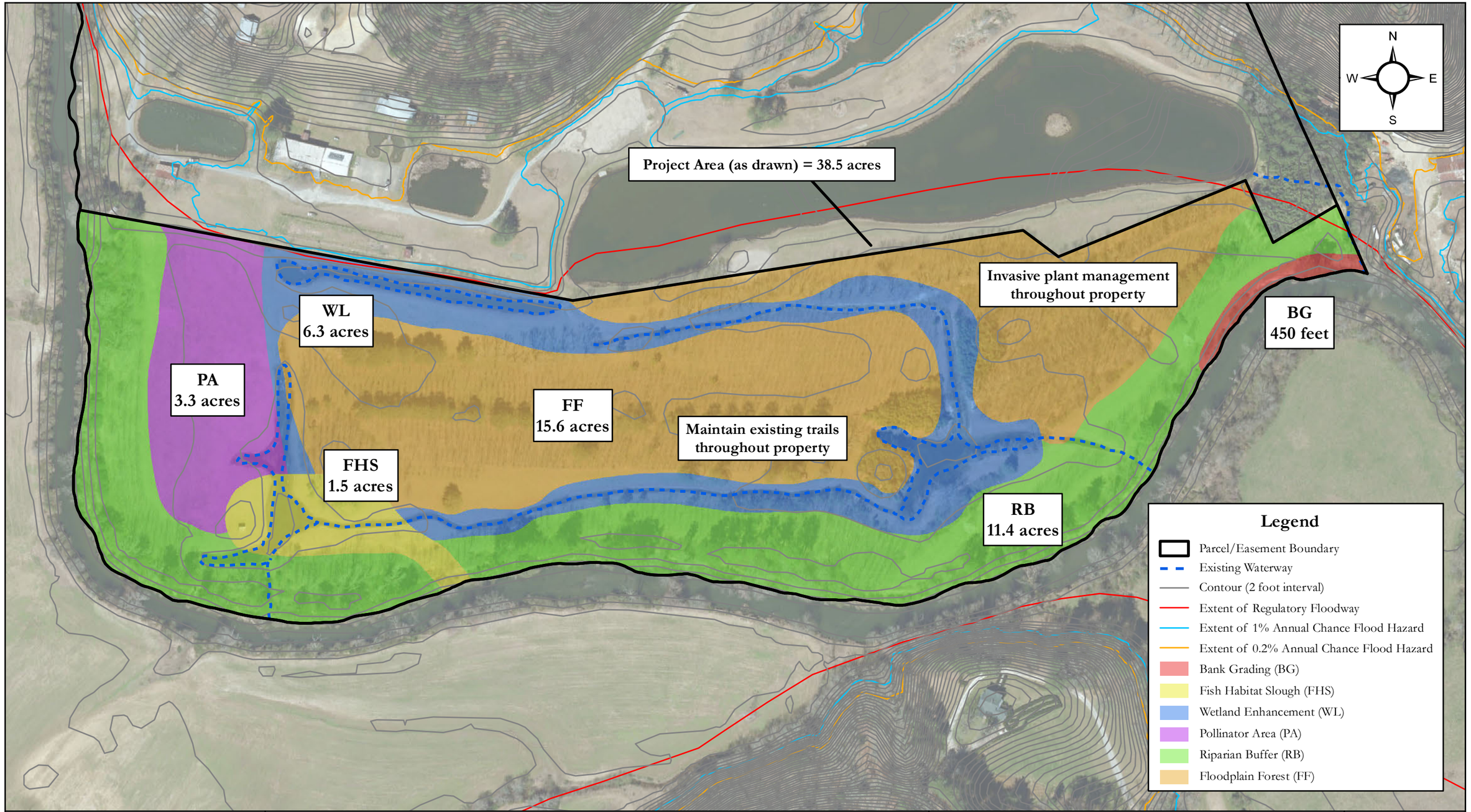
Jennings Environmental

Henderson County - North

0 2,000 4,000 8,000 12,000 16,000 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C4



Jennings Environmental

Conceptual Design: Deerwoode Reserve

0 100 200 400 600 800 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C5

Trail length (as drawn) = 5,400 feet

Manage invasive plants throughout the property

WL
3.4 acres

SR
10.9 acres

FF
7.9 acres

PA
21.5 acres

RB
10.0 acres

As needed within the riparian buffer, stabilize eroding banks by grading to a stable slope

N
W
E
S

Legend

- Property Boundary
- Stream
- Trail
- Contour (2 foot interval)
- Extent of Regulatory Floodway
- Extent of 1% Annual Chance Flood Hazard
- Extent of 0.2% Annual Chance Flood Hazard
- Stream Restoration (SR)
- Wetland Enhancement (WL)
- Pollinator Area (PA)
- Riparian Buffer (RB)
- Floodplain Forest (FF)

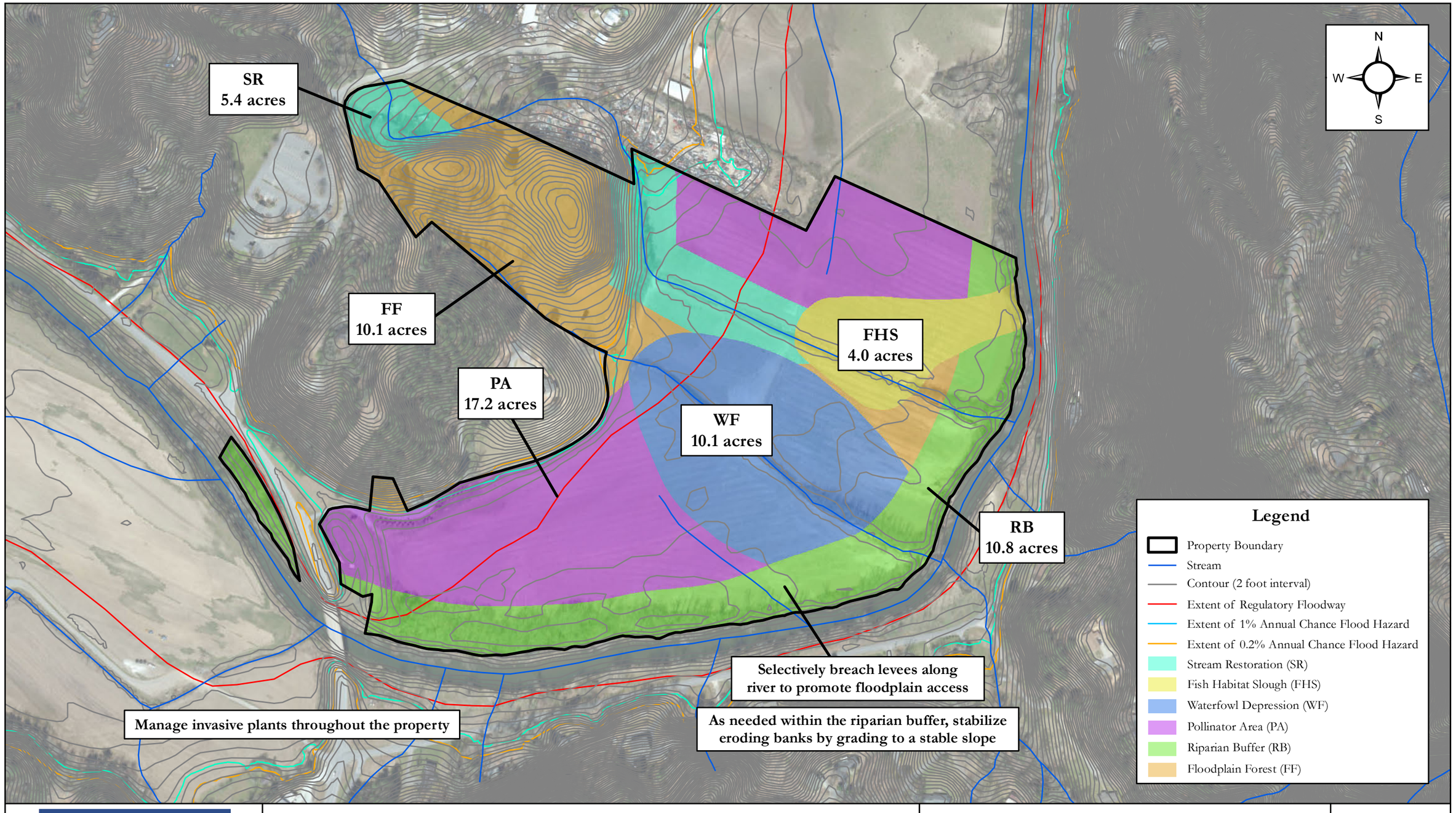
Jennings Environmental

Conceptual Design: Brevard Community Park

0 150 300 600 900 1,200 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C6



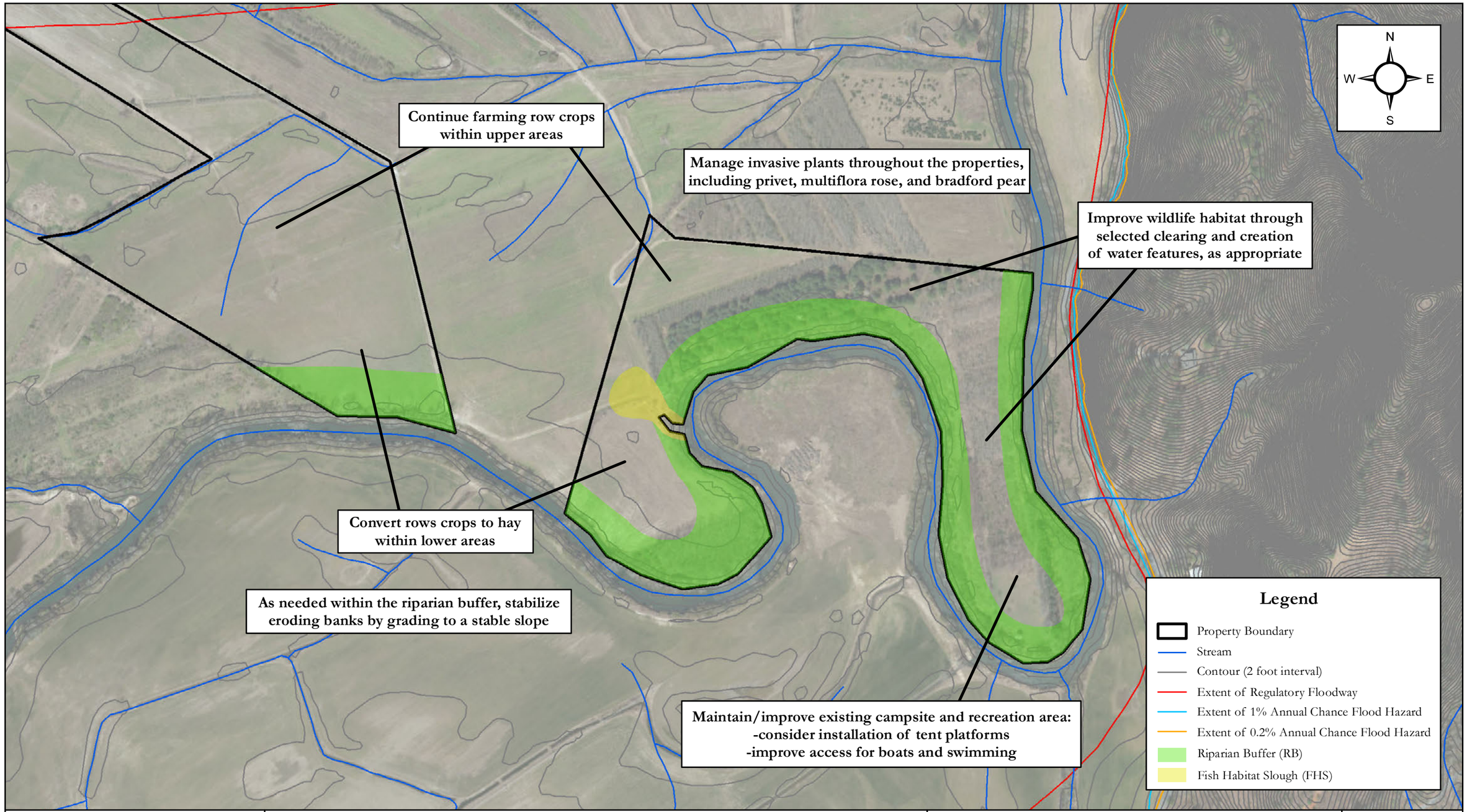
Jennings Environmental

Conceptual Design: Witherspoon Property

0 150 300 600 900 1,200 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C7



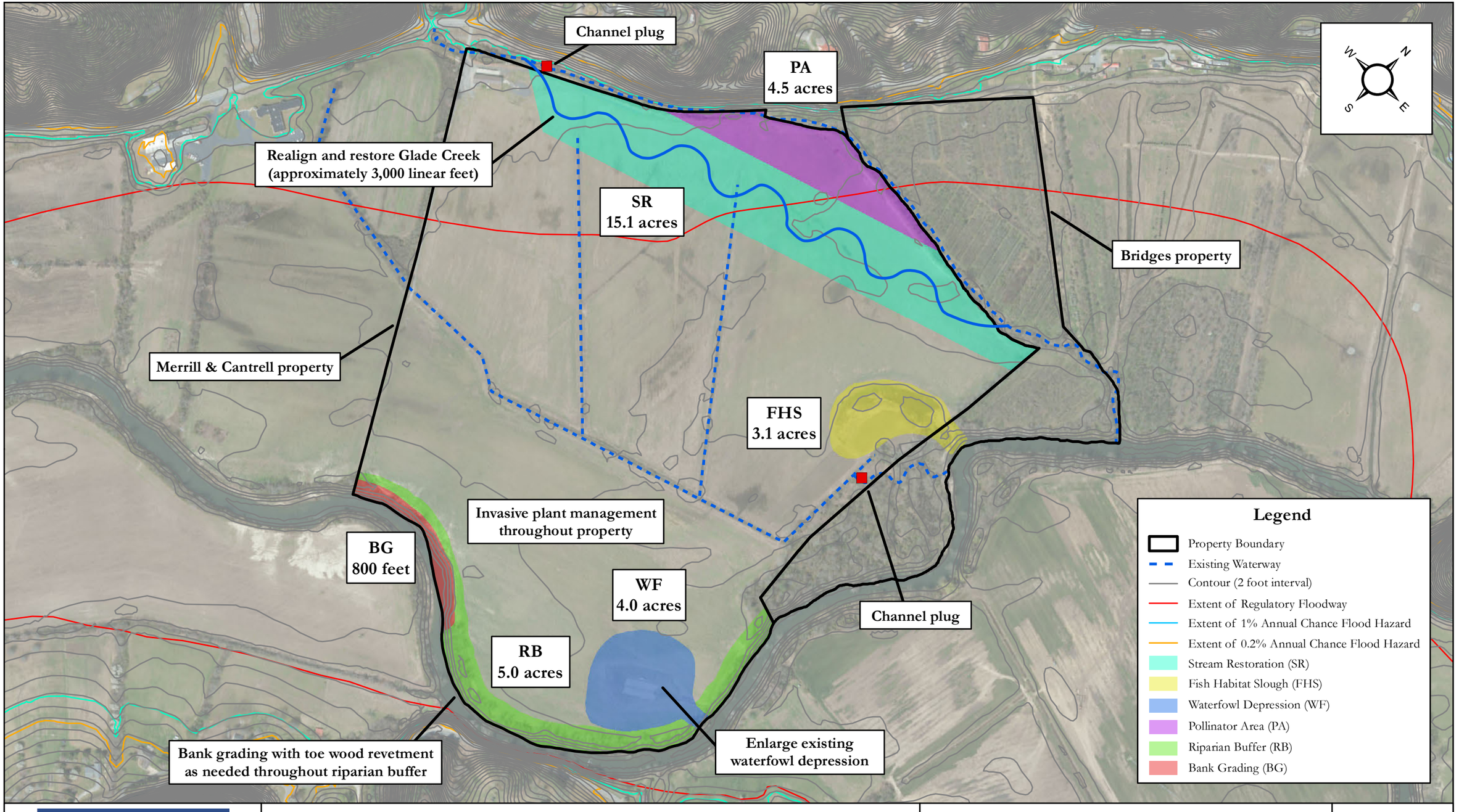
Jennings Environmental

Conceptual Design: Scott Properties

0 150 300 600 900 1,200 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C8



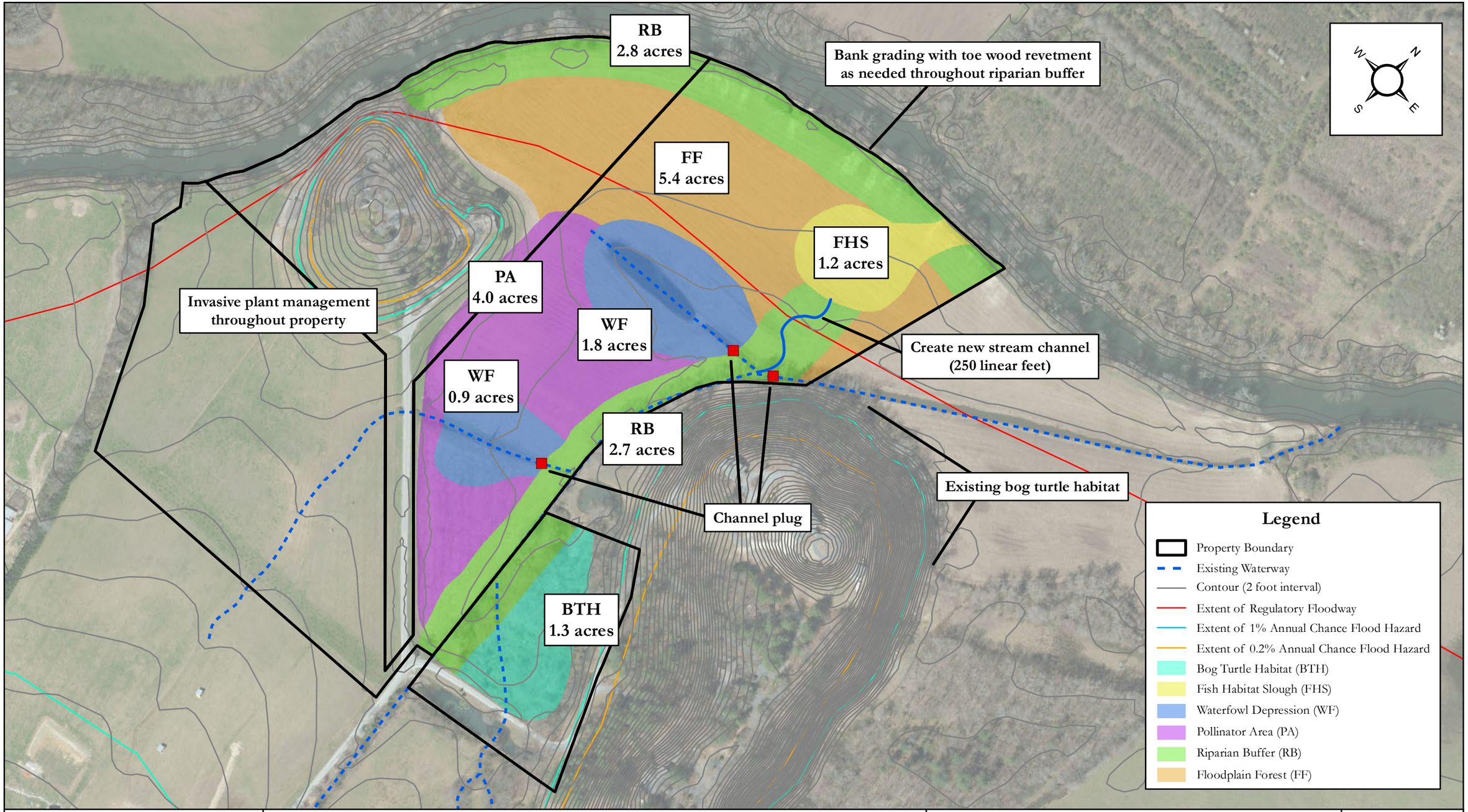
Jennings Environmental

Conceptual Design: Merrill & Cantrell and Bridges Properties

0 200 400 800 1,200 1,600 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C9



Jennings Environmental

Conceptual Design: Platt Properties

0 100 200 400 600 800 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C10

Selectively breach levees along river to promote floodplain access.

As needed within the riparian buffer, stabilize eroding banks by grading to a stable slope.

Buffer width should be a minimum of 100 feet along the French Broad River and 25 feet per side along tributaries.

Manage invasive plants within all riparian buffers.

RB
6.0 acres

FF
5.5 acres

FHS
0.4 acres

PA
2.5 acres

WF
3.5 acres

Stabilize existing head cut using grading, in-stream boulder structures, and vegetation.

Preserve for future use
2.5 acres

N
W
E
S

Legend

- Property Boundary
- Stream
- Contour (2 foot interval)
- Extent of Regulatory Floodway
- Extent of 1% Annual Chance Flood Hazard
- Extent of 0.2% Annual Chance Flood Hazard
- Floodplain Forest (FF)
- Fish Habitat Slough (FHS)
- Waterfowl Depression (WF)
- Pollinator Area (PA)
- Riparian Buffer (RB)

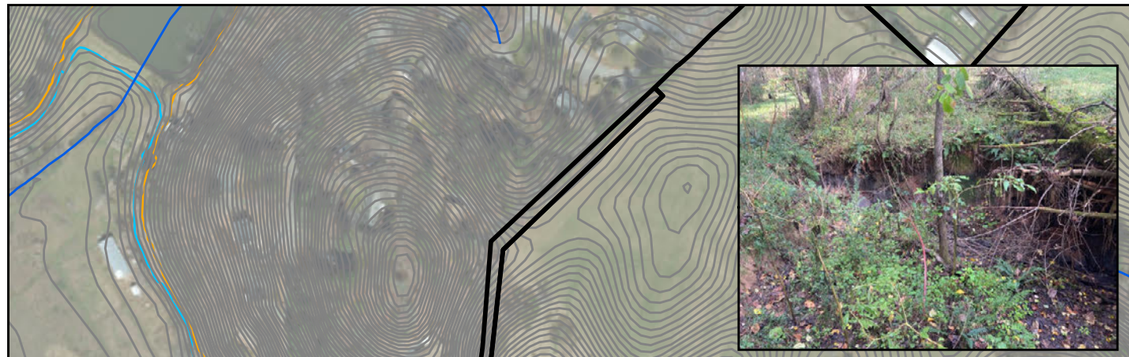
Jennings Environmental

Conceptual Design: Besancon Property

0 100 200 400 600 800 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C11



Stabilize existing head cut using grading, in-stream boulder structures, and vegetation.

Stabilize existing minor bank erosion using grading and vegetation.

Buffer width should be a minimum of 100 feet along the French Broad River and 25 feet per side along tributaries.

Manage invasive plants within all wooded buffers.

Maintain and enhance existing wooded buffer along French Broad River (approximately 3,000 linear feet).

N

W E

S

Legend

- Property Boundary
- Stream
- Contour (2 foot interval)
- Extent of Regulatory Floodway
- Extent of 1% Annual Chance Flood Hazard
- Extent of 0.2% Annual Chance Flood Hazard
- Riparian Buffer (RB)

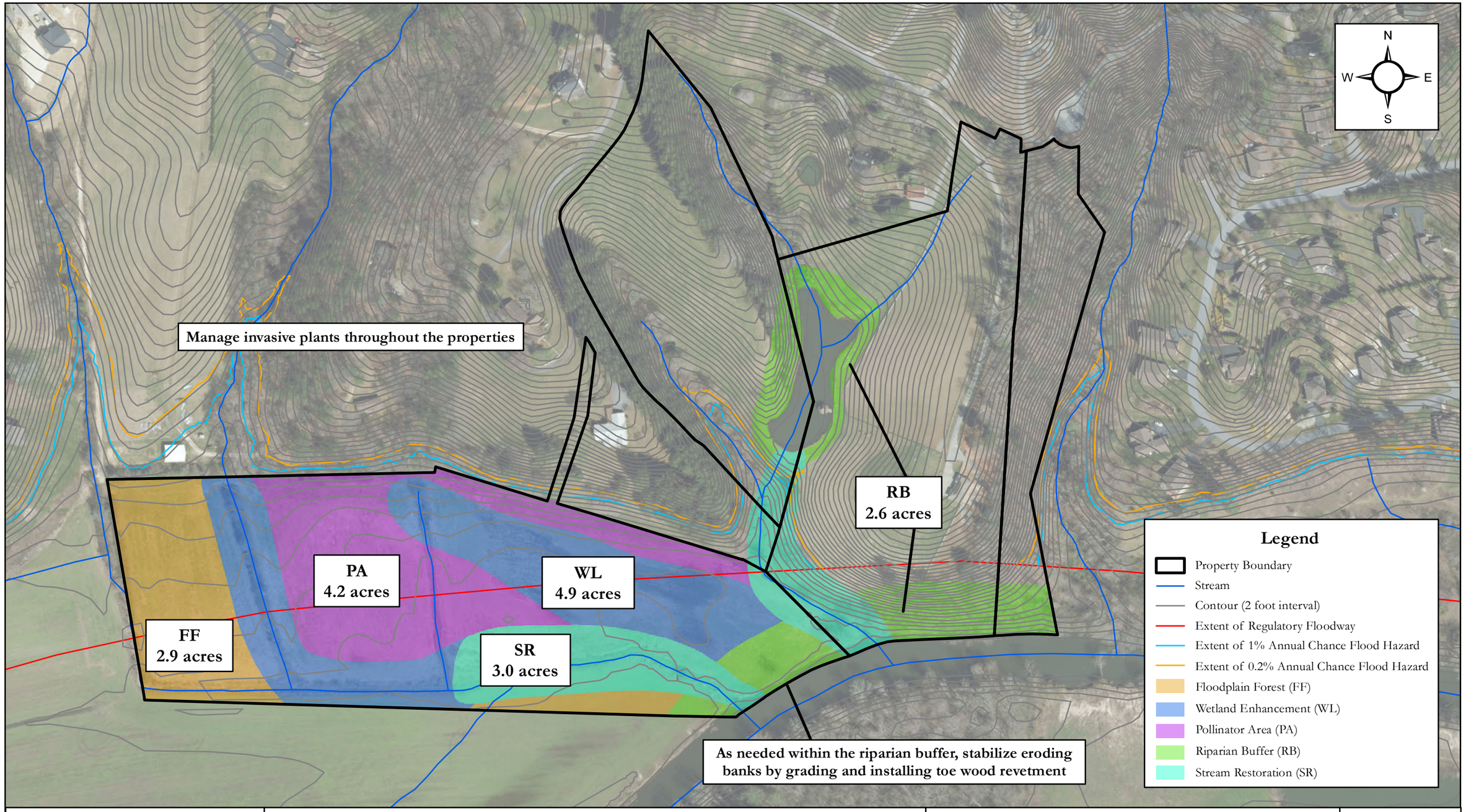
Jennings Environmental

Conceptual Design: Kiser Property

0 150 300 600 900 1,200 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C12



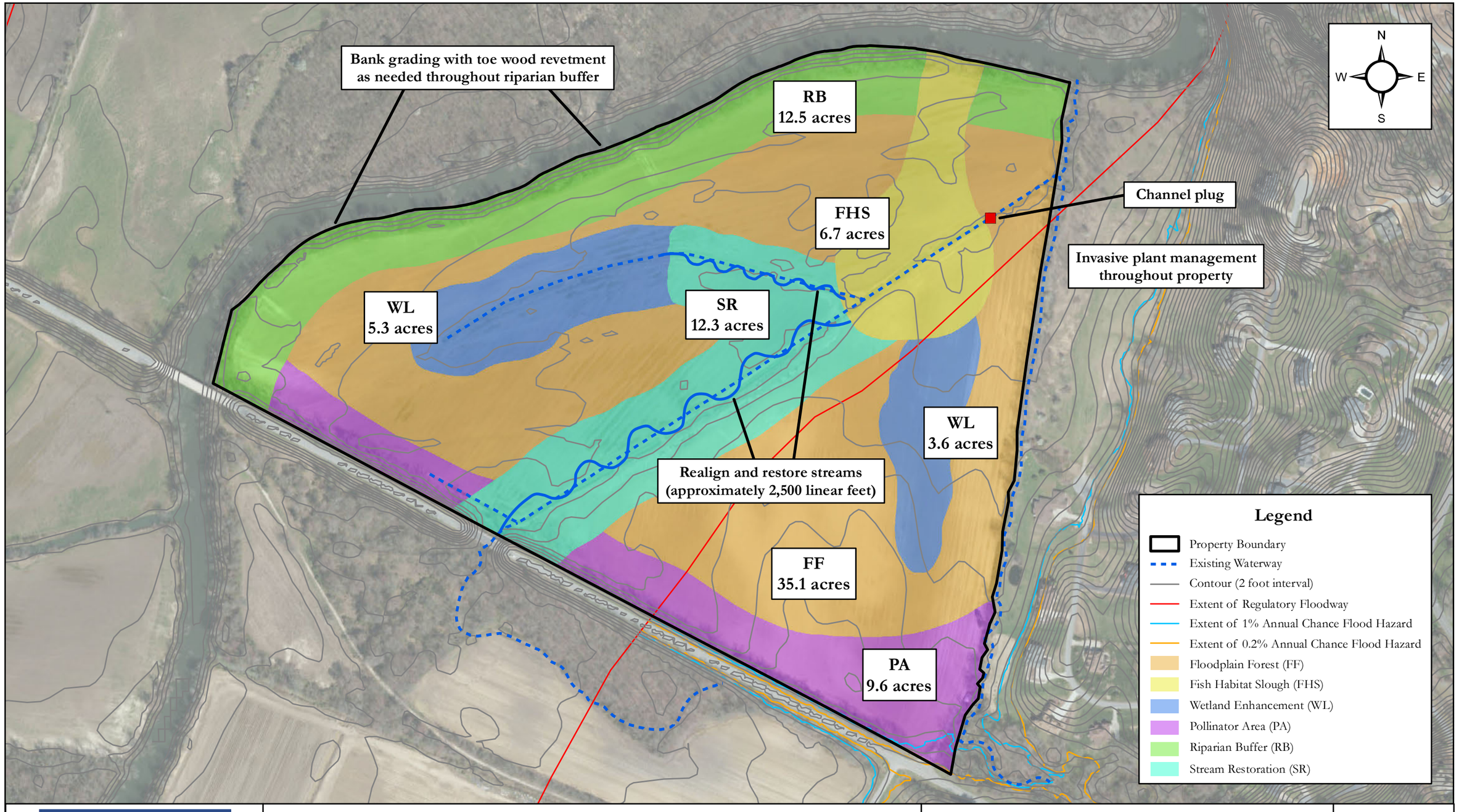
Jennings Environmental

Conceptual Design: Freer Properties

0 100 200 400 600 800 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C13



Jennings Environmental

Conceptual Design: King's Bridge Property

0 150 300 600 900 1,200 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C14

Maintain existing wooded buffer along French Broad River (approximately 3,100 linear feet). Manage invasive plants within the buffer.

Along both sides of Cane Creek, plant and/or enhance a native riparian shrub/forest buffer, at least 50 feet in width. Manage invasive plants within the buffer.

Cane Creek buffer length = approximately 5,900 feet
Cane Creek buffer area = approximately 13.5 acres

For reaches of Cane Creek without stream realignment (approximately 4,300 feet):
-as needed, stabilize eroding streambanks by grading to a stable slope and/or installing toe wood revetment
-install in-stream boulder and log structures for bank protection, grade control, and bedform diversity

For reaches of Cane Creek with stream realignment (approximately 1,600 feet):
-realign channel into a stable planform location, with design bankfull width of approximately 80 feet
-fill remnant channel to design floodplain elevation
-grade streambanks to stable slope (3:1 or flatter)
-install in-stream boulder and log structures for bank protection, grade control, and bedform diversity

N
W E
S

Legend

- Property Boundary
- Stream
- Existing Top of Bank (approximate)
- Design Top of Bank (approximate)
- Contour (2 foot interval)
- Extent of Regulatory Floodway
- Extent of 1% Annual Chance Flood Hazard
- Extent of 0.2% Annual Chance Flood Hazard
- Riparian Buffer (existing and design)

Jennings Environmental

Conceptual Design: Broadmoor Golf Links

0 200 400 800 1,200 1,600 Feet

Upper French Broad River Watershed Restoration Plan

Sheet C15

Site Information and Performance Standard Stratification	
Project Name:	Deerwoode Preserve
Reach ID:	1
Restoration Potential:	Level 5 - Biology
Existing Stream Type:	F
Proposed Stream Type:	C
Region:	Mountains
Drainage Area (sqmi):	120
Proposed Bed Material:	Gravel
Existing Stream Length (ft):	4200
Proposed Stream Length (ft):	4200
Stream Slope (%):	0.3
Flow Type:	Perennial
River Basin:	French Broad
Stream Temperature:	Coldwater
Data Collection Season:	Winter/Spring
Valley Type:	Unconfined Alluvial

Notes
1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

FUNCTIONAL CHANGE SUMMARY	
Exisiting Condition Score (ECS)	0.20
Proposed Condition Score (PCS)	0.48
Change in Functional Condition (PCS - ECS)	0.28
Percent Condition Change	140%
Existing Stream Length (ft)	4200
Proposed Stream Length (ft)	4200
Additional Stream Length (ft)	0
Existing Functional Foot Score (FFS)	840
Proposed Functional Foot Score (FFS)	2016
Proposed FFS - Existing FFS	1176
Functional Change (%)	140%

BMP FUNCTIONAL CHANGE SUMMARY	
Existing BMP Functional Feet Score (FFS)	0
Proposed BMP Functional Feet Score (FFS)	0
Proposed BMP FFS - Existing BMP FFS	0
Functional Change (%)	

FUNCTIONAL FEET (FF) SUMMARY	
Existing Stream FFS + Existing BMP FFS	840
Proposed Stream FFS + Proposed BMP FFS	2016
Total Proposed FFS - Total Existing FFS	1176
Functional Change (%)	140%

FUNCTION BASED PARAMETERS SUMMARY

Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.58	0.58
	Reach Runoff		
Hydraulics	Floodplain Connectivity	0.15	0.89
Geomorphology	Large Woody Debris	0.07	0.90
	Lateral Stability	0.15	1.00
	Riparian Vegetation	0.34	1.00
	Bed Material		
	Bed Form Diversity	0.56	0.83
	Plan Form		
Physicochemical	Temperature		
	Bacteria		
	Organic Matter		
	Nitrogen		
	Phosphorus		
Biology	Macros		
	Fish		

FUNCTIONAL CATEGORY REPORT CARD

Functional Category	ECS	PCS	Functional Change
Hydrology	0.58	0.58	0.00
Hydraulics	0.15	0.89	0.74
Geomorphology	0.28	0.93	0.65
Physicochemical			
Biology			

EXISTING CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	**Function-Based Parameters**	**Measurement Method**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**	**Overall**	**Overall**
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.20	Not Functioning
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	2 2	0 0.3	0.15	0.15	Not Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	5	0.07	0.07	0.28	Not Functioning		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	VH/M 50	0.3 0	0.15				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	40 25	0.47 0.2	0.34				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	6 1.5 20	1 0.69 0	0.56				
	Plan Form	Sinuosity							
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

PROPOSED CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	**Function-Based Parameters**	**Measurement Method**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**	**Overall**	**Overall**
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.48	Functioning At Risk
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	1 3	1 0.77	0.89	0.89	Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	25	0.9	0.90	0.93	Functioning		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	L/L 5	1 1	1.00				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	100 200	1 1	1.00				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	2 50	1 0.65	0.83				
	Plan Form	Sinuosity							
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

BMP Routine

Site Information		BMP 1	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 2	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 3	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information and Performance Standard Stratification	
Project Name:	Brevard Community Park
Reach ID:	1
Restoration Potential:	Level 5 - Biology
Existing Stream Type:	F
Proposed Stream Type:	Bc
Region:	Mountains
Drainage Area (sqmi):	20
Proposed Bed Material:	Gravel
Existing Stream Length (ft):	2200
Proposed Stream Length (ft):	2200
Stream Slope (%):	0.5
Flow Type:	Perennial
River Basin:	French Broad
Stream Temperature:	Coldwater
Data Collection Season:	Winter/Spring
Valley Type:	Unconfined Alluvial

Notes
1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

FUNCTIONAL CHANGE SUMMARY	
Exisiting Condition Score (ECS)	0.24
Proposed Condition Score (PCS)	0.51
Change in Functional Condition (PCS - ECS)	0.27
Percent Condition Change	113%
Existing Stream Length (ft)	2200
Proposed Stream Length (ft)	2200
Additional Stream Length (ft)	0
Existing Functional Foot Score (FFS)	528
Proposed Functional Foot Score (FFS)	1122
Proposed FFS - Existing FFS	594
Functional Change (%)	113%

BMP FUNCTIONAL CHANGE SUMMARY	
Existing BMP Functional Feet Score (FFS)	0
Proposed BMP Functional Feet Score (FFS)	0
Proposed BMP FFS - Existing BMP FFS	0
Functional Change (%)	

FUNCTIONAL FEET (FF) SUMMARY	
Existing Stream FFS + Existing BMP FFS	528
Proposed Stream FFS + Proposed BMP FFS	1122
Total Proposed FFS - Total Existing FFS	594
Functional Change (%)	113%

FUNCTION BASED PARAMETERS SUMMARY

Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.58	0.58
	Reach Runoff		
Hydraulics	Floodplain Connectivity	0.15	1.00
Geomorphology	Large Woody Debris	0.69	1.00
	Lateral Stability	0.15	0.85
	Riparian Vegetation	0.35	1.00
	Bed Material		
	Bed Form Diversity	0.23	0.97
	Plan Form	1.00	1.00
Physicochemical	Temperature		
	Bacteria		
	Organic Matter		
	Nitrogen		
	Phosphorus		
Biology	Macros		
	Fish		

FUNCTIONAL CATEGORY REPORT CARD

Functional Category	ECS	PCS	Functional Change
Hydrology	0.58	0.58	0.00
Hydraulics	0.15	1.00	0.85
Geomorphology	0.48	0.96	0.48
Physicochemical			
Biology			

EXISTING CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	**Function-Based Parameters**	**Measurement Method**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**	**Overall**	**Overall**
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.24	Not Functioning
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	2 1.2	0 0.3	0.15	0.15	Not Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	 15	 0.69	0.69	0.48	Functioning At Risk		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	1 H/M 50	0 0.3 0	0.15				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	40 40 10 10	0.47 0.47 0.23 0.23	0.35				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	6 1.2 30	0.4 0.3 0	0.23				
	Plan Form	Sinuosity	1.2	1	1.00				
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

PROPOSED CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	**Function-Based Parameters**	**Measurement Method**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**	**Overall**	**Overall**
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.51	Functioning At Risk
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	1 5	1 1	1.00	1.00	Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	30	1	1.00	0.96	Functioning		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	0.1 L/M 5	1 0.7 1	0.85				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	100 100 200 200	1 1 1 1	1.00				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	2 2 60	0.91 1 1	0.97				
	Plan Form	Sinuosity	1.2	1	1.00				
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

BMP Routine

Site Information		BMP 1	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 2	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 3	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information and Performance Standard Stratification	
Project Name:	Cane Creek
Reach ID:	1
Restoration Potential:	Level 3 - Geomorphology
Existing Stream Type:	F
Proposed Stream Type:	C
Region:	Mountains
Drainage Area (sqmi):	87
Proposed Bed Material:	Gravel
Existing Stream Length (ft):	3200
Proposed Stream Length (ft):	3200
Stream Slope (%):	0.007
Flow Type:	Perennial
River Basin:	French Broad
Stream Temperature:	Coldwater
Data Collection Season:	Winter/Spring
Valley Type:	Unconfined Alluvial

Notes
1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

FUNCTIONAL CHANGE SUMMARY	
Exisiting Condition Score (ECS)	0.20
Proposed Condition Score (PCS)	0.48
Change in Functional Condition (PCS - ECS)	0.28
Percent Condition Change	140%
Existing Stream Length (ft)	3200
Proposed Stream Length (ft)	3200
Additional Stream Length (ft)	0
Existing Functional Foot Score (FFS)	640
Proposed Functional Foot Score (FFS)	1536
Proposed FFS - Existing FFS	896
Functional Change (%)	140%

BMP FUNCTIONAL CHANGE SUMMARY	
Existing BMP Functional Feet Score (FFS)	0
Proposed BMP Functional Feet Score (FFS)	0
Proposed BMP FFS - Existing BMP FFS	0
Functional Change (%)	

FUNCTIONAL FEET (FF) SUMMARY	
Existing Stream FFS + Existing BMP FFS	640
Proposed Stream FFS + Proposed BMP FFS	1536
Total Proposed FFS - Total Existing FFS	896
Functional Change (%)	140%

FUNCTION BASED PARAMETERS SUMMARY

Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.58	0.58
	Reach Runoff		
Hydraulics	Floodplain Connectivity	0.00	0.89
Geomorphology	Large Woody Debris	0.19	1.00
	Lateral Stability	0.19	0.85
	Riparian Vegetation	0.22	0.86
	Bed Material		
	Bed Form Diversity	0.43	1.00
	Plan Form	1.00	1.00
Physicochemical	Temperature		
	Bacteria		
	Organic Matter		
	Nitrogen		
	Phosphorus		
Biology	Macros		
	Fish		

FUNCTIONAL CATEGORY REPORT CARD

Functional Category	ECS	PCS	Functional Change
Hydrology	0.58	0.58	0.00
Hydraulics	0.00	0.89	0.89
Geomorphology	0.40	0.94	0.54
Physicochemical			
Biology			

EXISTING CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	**Function-Based Parameters**	**Measurement Method**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**	**Overall**	**Overall**
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.20	Not Functioning
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	2 1.5	0 0	0.00	0.00	Not Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	8	0.19	0.19	0.40	Functioning At Risk		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	VH/VH 30	0.1 0.27	0.19				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	30 30 15 15	0.36 0.36 0.07 0.07	0.22				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	1.4 40	0.56 0.3	0.43				
	Plan Form	Sinuosity	1.2	1	1.00				
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

PROPOSED CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	Function-Based Parameters	Measurement Method	Field Value	Index Value	Parameter	Category	Category	Overall	Overall
Hydrology	Catchment Hydrology	Curve Number	60	0.58	0.58	0.58	Functioning At Risk	0.48	Functioning At Risk
	Reach Runoff	Curve Number Concentrated Flow Points Soil Compaction							
Hydraulics	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio	1 3	1 0.77	0.89	0.89	Functioning		
Geomorphology	Large Woody Debris	LWD Index # Pieces	30	1	1.00	0.94	Functioning		
	Lateral Stability	Erosion Rate (ft/yr) Dominant BEHI/NBS Percent Streambank Erosion (%)	L/M 5	0.7 1	0.85				
	Riparian Vegetation	Left Canopy Coverage (%) Right Canopy Coverage (%) Left Buffer Width (ft) Right Buffer Width (ft) Left Basal Area (sq.ft/acre) Right Basal Area (sq.ft/acre) Left Stem Density (stems/acre) Right Stem Density (stems/acre)	100 100 50 50	1 1 0.72 0.72	0.86				
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle Aggradation Ratio	6 2 60	1 1 1	1.00				
	Plan Form	Sinuosity	1.2	1	1.00				
Physicochemical	Temperature	Summer Daily Maximum (°F)							
	Bacteria	Fecal Coliform (Cfu/100 ml)							
	Organic Carbon	Leaf Litter Processing Rate Percent Shredders							
	Nitrogen	Total Nitrogen (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macros	Biotic Index EPT Taxa Present							
	Fish	North Carolina Index of Biotic Integrity							

BMP Routine

Site Information		BMP 1	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 2	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

Site Information		BMP 3	
BMP ID			
Basin Area treated by BMP (Ac)			
Effective Stream Length (ft)			
Existing Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Proposed Condition Assessment			
Function-Based Parameters	**Measurement Method**	**Field Value**	**Index Value**
Runoff	Impervious Cover (%)		
Temperature	Summer Daily Maximum (°F)		
Specific Conductivity	Specific Conductivity (uS/cm at 25°C)		
Nitrogen	JFSLAT (mg/L)		
Phosphorus	JFSLAT (mg/L)		
Results			
BMP Existing Score			
BMP Proposed Score			
Existing BMP Functional Foot Score			
Proposed BMP Functional Foot Score			
Proposed FFS - Existing FFS			

APPENDIX D

STREAM RESTORATION ASSESSMENT REPORT
WEST FORK FRENCH BROAD RIVER

Jennings Environmental

7 Samuel Ashe Drive, Asheville, NC 28805 | 919-600-4790 | greg@jenningsenv@gmail.com

Stream Restoration Assessment Report
West Fork French Broad River

Submitted to: Andrew Dalrymple, Mark Boyce, Blake Coffey

February 19, 2021

The report documents results of a stream restoration assessment on 2,000 linear feet of the West Fork French Broad River on private property in Transylvania County, NC, as shown on the aerial photo below:

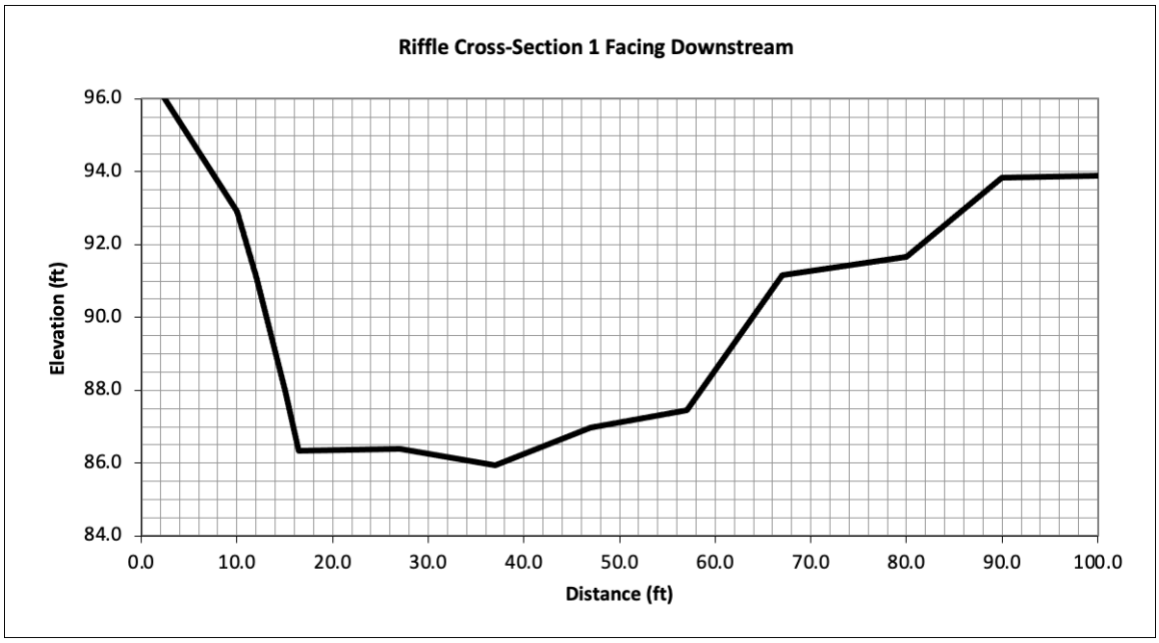
Parcel ID:	Transylvania County PIN 8534-32-7703-000
Coordinates:	35.17932, -82.90427
Drainage Area:	13.6 square miles with 90% forested land
Annual Precipitation:	77 inches average
NCDEQ Classification:	B;Tr (Primary Recreation, Fresh Water; Trout Waters)

The stream enters the West side of the property flowing North through a forested area for 400 feet before entering the open field where the right descending bank and floodplain are mostly unforested. The stream flows around a horseshoe bend to the right for 900 feet before flowing under the driveway bridge. The stream continues flowing South along the East side of the property for 700 feet before leaving the property. The open field is prone to flooding during high flows, as evidenced by sandy deposition and woody debris remnants.

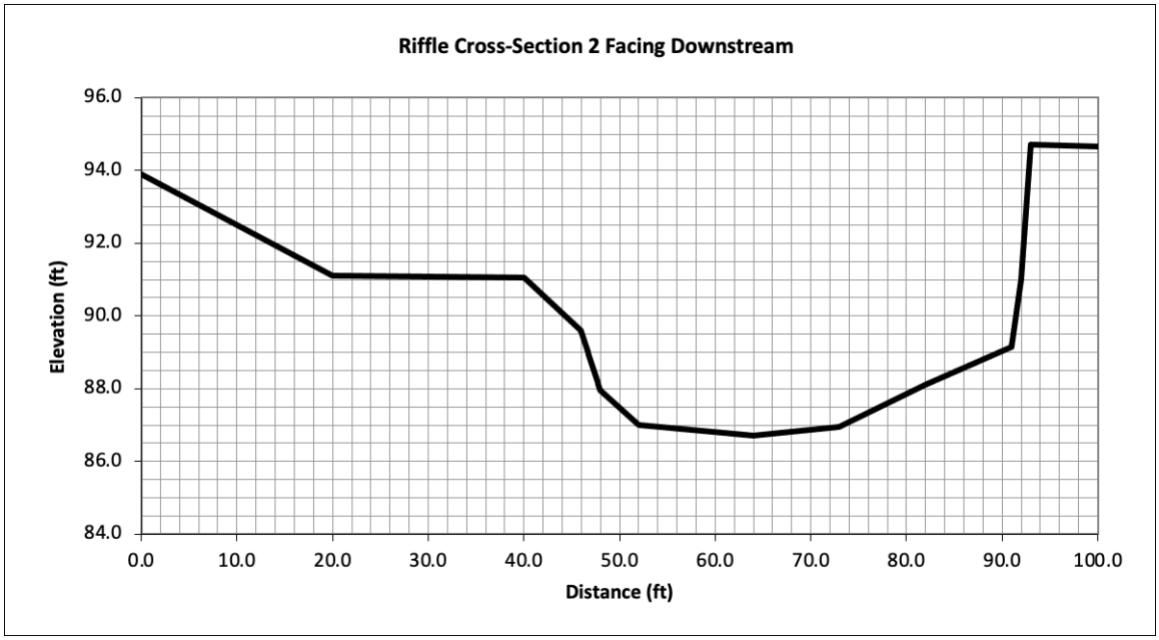
The existing stream stability and habitat condition range from excellent to poor based on streambank erosion, riparian buffer, and bedform diversity. Several areas of the right bank are eroding due to incision, lack of deep-rooted vegetation, and excessive near-bank shear stress as shown in photos below taken in January, 2021. The streambank immediately upstream of the driveway bridge is severely unstable as shown in the photo on the right taken from the bridge facing upstream.

Two stream channel cross-sections were measured in January, 2021, to determine geomorphic and hydraulic conditions as shown in the figures and table below. At each cross-section location, the elevation of the "bankfull" stage was identified as the sandy depositional surface along the channel where high flows fill the active channel and start to spread on the adjacent floodplain to dissipate hydraulic energy. This represents the natural stream process of maintaining equilibrium between erosion and deposition processes that continually cause minor adjustments to stream form. Where the floodplain is restricted by one or both tall banks, the channel is considered incised and susceptible to erosion during high flows.

Cross-section 1 was measured at a stable stream location 140 downstream from the picnic pavilion. The diagram below shows the relative elevation of the ground above an arbitrary datum moving from left to right across the streambed. The deepest point on the cross-section, termed the "thalweg," located at a distance of 37 feet from the left bank at an arbitrary elevation of 86 feet. At this cross-section, the left bank is solid rock and very stable. The right bank is mostly covered in trees and shrubs with some evidence of sandy deposition at the "bankfull" elevation of 91 feet. The measured area, width, and depth of the bankfull channel below this elevation are listed in Table 1 and used to calculate several morphology and hydraulic parameters.



Cross-section 2 was measured at an unstable stream location 410 downstream from the picnic pavilion. The diagram below shows the flat sandy bankfull depositional bench on the left side and the eroding vertical bank on the right side. The bankfull stage is about 4 feet above the thalweg at this location, while the bank height on the right side is about 8 feet high, meaning that large flows will cause erosion due to high velocity, shear stress, and stream power which are all related to flow depth.



The bankfull geomorphic and hydraulic parameters listed in Table 1 were calculated for the two cross-sections to document existing conditions and for comparison to naturally stable reference streams with the same drainage area in the same ecoregion. The measured bankfull cross-sectional areas are somewhat larger that reference streams, primarily because the channel is deeper with no access to a

wide floodplain when flowing at the bankfull stage. This condition of vertical incision is indicated by the "bank height ratio" being greater the 1.0. The remedy for this condition is often excavation of a bankfull bench to allow streamflow exceeding bankfull stage to spread out and dissipate energy on a forested floodplain. The calculated hydraulic parameters of velocity, shear stress, and stream power are all substantially greater in the measured cross-sections than found in stable reference streams, meaning that the streambanks are regularly exposed to erosive forces.

Table 1. Morphology and Hydraulic Parameters at Two Cross-sections and Reference Streams.

Parameter	XS 1	XS 1	Reference
Bankfull cross-section area, A_{bkf} (sq ft)	194.7	165.9	122.1
Bankfull width, W_{bkf} (ft)	55.0	52.0	50.0
Bankfull mean riffle depth, d_{bkf} (ft)	3.5	3.2	2.4
Width-to-depth ratio, [W_{bkf}/d_{bkf}]	15.5	16.3	20.5
Max riffle depth, d_{mbkf} (ft)	5.1	4.3	3.2
Max riffle depth ratio, [d_{mbkf}/d_{bkf}]	1.5	1.4	1.3
Low bank height, LBH (ft)	7.9	8.1	3.2
Low bank height ratio, BHR [LBH/d_{mbkf}]	1.5	1.9	1.0
Width of flood-prone area, W_{fpa} (ft)	80	120	250
Entrenchment ratio, ER [W_{fpa}/W_{bkf}]	1.5	2.3	5.0
Bankfull wetted perimeter, P (ft)	62.1	58.4	54.9
Bankfull hydraulic radius, R (ft)	3.1	2.8	2.2
Average water surface slope, S (ft/ft)	0.010	0.010	0.010
Bankfull Mannings roughness, n	0.045	0.045	0.045
Bankfull average velocity, V_{bkf} (ft/s)	7.1	6.6	5.8
Bankfull discharge, Q_{bkf} (cfs)	1382	1103	709
Bankfull shear stress, t (lb/ft^2)	2.0	1.8	1.4
Bankfull stream power, w (lb/ft/s)	13.9	11.8	8.1

The fact that cross-section 1 is quite stable indicates that the presence of deep-rooted native trees and shrubs along the streambanks can provide substantial resistance to erosion. To evaluate overall bank erodibility, the Bank Erosion Hazard Index (BEHI) method was applied by walking the entire stream length and categorizing the bank conditions based on these parameters:

- Bank height ratio
- Root depth and density
- Bank angle
- Soil protection from erosive forces
- Soil composition

The BEHI assessment results documented that 1,240 linear feet of streambank has low erodibility, 2,280 linear feet has high erodibility, and 480 linear feet has very high erodibility. Combining these results with assessments of relative near-bank shear stress, the estimated average streambank erosion rate for the entire property was estimated to be 200 to 250 cubic yards per year. Most of this sediment is sand and silt which ends up clogging bed gravels downstream.

Considering the existing stream conditions, the recommended tactics for enhancing stream resilience and habitat quality are:

- Reduce hydraulic forces during high flows by excavating a bankfull bench to provide for floodplain energy dissipation.
- Add in-stream log and/or rock vane structures to direct erosive flows away from banks and maintain scour pools.
- Plant native trees, shrubs, and grasses along banks and on the floodplain to strengthen soil resistance to erosion and provide shade and food for aquatic animals.

The concept plan sheets attached show the recommended restoration plan to achieve optimal stream stability and habitat quality for this property. The exact size, location, and orientation of each feature may be adjusted during the design and permitting process to fit budget and regulatory constraints. Some of the in-stream structures at the upstream and downstream ends of the river on this property are not as critical as those located where erosion is more severe. Preliminary cost estimates for construction and planting of the complete project range from $80,000 to $100,000 in addition to engineering and permitting costs of about $20,000. Exact costs of implementation may be determined after detailed design development.

Stream restoration projects require permitting at the federal, state, and local levels for environmental and floodplain impacts. Environmental permitting is coordinated by the NC Division of Water Resources and US Army Corps of Engineers using the web-based Pre-Construction Notification (PCN) Form for Nationwide Permits along with corresponding Water Quality Certifications:

https://edocs.deq.nc.gov/Forms/Pre-Construction_Notification_Form

Once the application is complete, the Army Corps will process it within 45 days for a Nationwide or General Permit, and the NC DWR will process the 401 Certification within 60 days. Other permit approvals may be required by NC DEMLR, NC Wildlife Resources Commission, US Fish & Wildlife Service, and the State Historic Preservation Office.

This property is not currently mapped as a regulated floodplain in the FEMA National Flood Insurance Program, meaning that the restoration project does not require a Floodplain Development Permit:

https://fris.nc.gov/fris/Index.aspx?FIPS=045&ST=NC&user=General%20Public

Grant funding to partially cover project costs may be obtained from the following sources by working in collaboration with a non-profit organization or government agency:

NC DEQ Water Resources Development Grant Program
https://deq.nc.gov/about/divisions/water-resources/water-resources-grants/financial-assistance

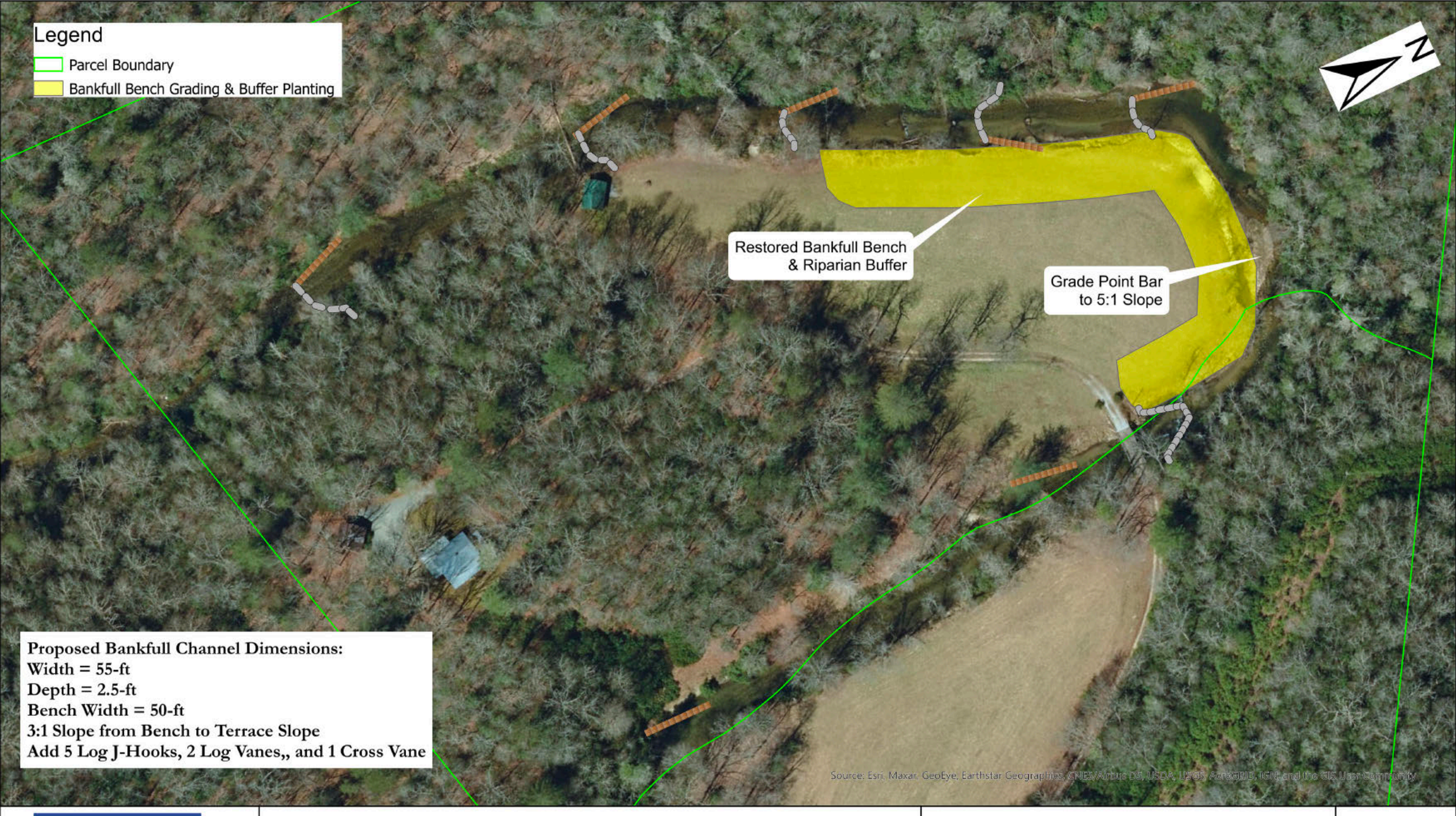
North Carolina Land and Water Fund
https://nclwf.nc.gov/

US Fish & Wildlife Service Partners for Fish and Wildlife Program
https://www.fws.gov/partners/

Other grants available for watershed restoration are described on the NC DEQ web site:
https://deq.nc.gov/about/divisions/water-resources/planning/basin-planning/use-restoration-watershed-programs/funding

Because this stream is located in a priority area for nature-based recreation and habitat protection, a restoration project will likely be considered favorably by many regulatory and granting organizations. It is recommended that property owners consider developing a collaboration with Conserving Carolina, a local land conservancy, to evaluate common restoration and preservation interests:

https://conservingcarolina.org/



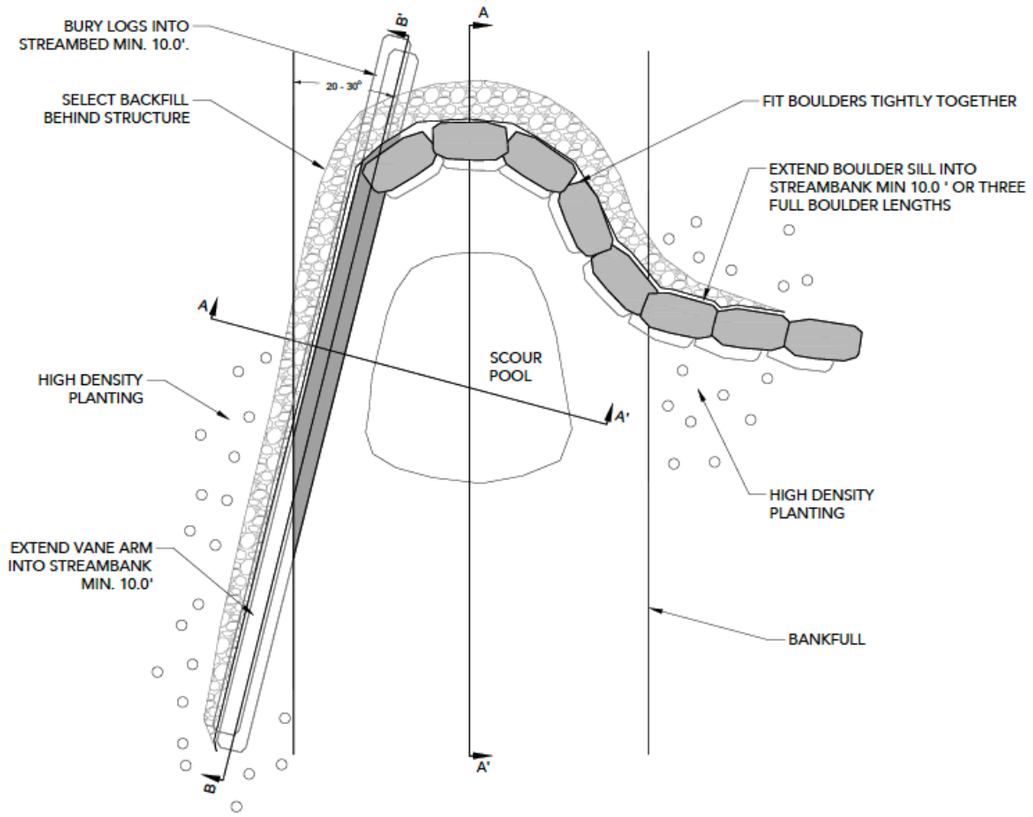
Jennings Environmental

NOT FOR CONSTRUCTION

0 40 80 160 Feet

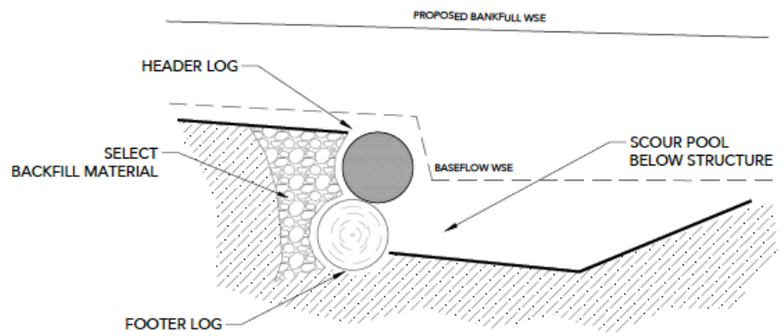
Conceptual Stabilization Plan
West Fork French Broad River
Transylvania County, North Carolina

Sheet 1 of 1



LOG VANE WITH BOULDER J-HOOK
DETAILED PLAN

NOT TO SCALE

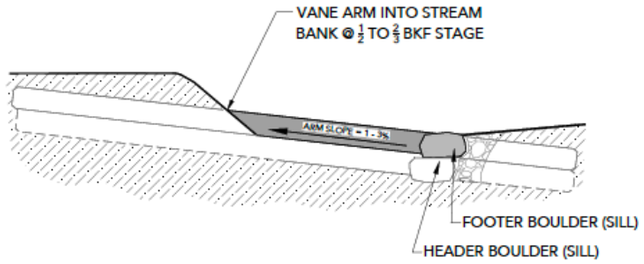


LOG VANE WITH BOULDER J-HOOK
DETAILED SECTION A - A'

NOT TO SCALE

LOG VANE WITH BOULDER J-HOOK
NOTES

1. ALL LOGS SHALL BE RELATIVELY STRAIGHT AND LIMBS AND BRANCHES SHALL BE TRIMMED FLUSH. LOGS SHALL HAVE MINIMUM DIAMETER OF 1.5'.
2. HEADER LOGS SHALL BE UNDERLAIN BY FOOTER LOGS TO PROVIDE A SILL UNLESS OTHERWISE DIRECTED BY THE ENGINEER. HEADER LOGS SHALL BE OFFSET SLIGHTLY DOWNSTREAM OF THE FOOTER LOG.
3. THE HEADER LOG OF THE VANE ARE SHALL TIE INTO THE STREAMBANK AT $\frac{1}{2}$ TO $\frac{2}{3}$ BANKFULL STAGE.
4. THE LOG VANE ARM SHALL EXTEND INTO THE OUTSIDE STREAMBANK AND STREAMBED A MINIMUM OF 10.0 FT ON EACH END.
5. ALL GAPS/VOIDS LARGER THAN 1 INCHES BETWEEN THE HEADER AND FOOTER LOGS SHALL BE CHINKED WITH LIMBS AND/OR BRUSH ON THE UPSTREAM SIDE PRIOR TO PLACEMENT OF THE GEOTEXTILE.
6. ALL BOULDERS USED FOR THE STRUCTURE SHALL BE STRUCTURAL STONE, CUBICAL OR RECTANGULAR IN SHAPE. THE ENGINEER MUST APPROVE THE USE OF BOULDERS THAT MAY BE AVAILABLE ONSITE. BOULDERS DIMENSIONS SHALL BE 2.5 FT X 4.0 FT X 1.5 FT +/- 0.5 FT.
7. CONTRACTOR WILL BE REQUIRED TO FIT BOULDERS TOGETHER TIGHTLY.
8. GAPS BETWEEN BOULDERS SHALL BE MINIMIZED BY FITTING BOULDERS TOGETHER AND PLUGGING WITH NC DOT CLASS A ROCK OR CHINKING STONE APPROVED BY ENGINEER.
9. HEADER BOULDERS SHALL BE UNDERLAIN BY FOOTER BOULDERS TO PROVIDE A FOUNDATION UNLESS OTHERWISE DIRECTED BY THE ENGINEER. HEADER BOULDERS SHALL BE OFFSET 1.0 FT UPSTREAM OF THE FOOTER.
10. SET BOULDER INVERTS AT ELEVATION SHOWN ON THE PLAN AND PROFILE SHEETS. NO ELEVATIONS OF THE BOULDERS MAY VARY FROM THE PLAN SHEETS WITHOUT DIRECTION FROM THE ENGINEER.
11. ON THE UPSTREAM SIDE OF THE STRUCTURE A LAYER OF NON-WOVEN GEOTEXTILE FABRIC SHALL BE PLACED AS SHOWN IN THE DETAIL ALONG THE ENTIRE LENGTH OF THE LOG VANE AND BOULDER J-HOOK. SECURE ALL GEOTEXTILE FABRIC ON TOP OF FOOTER LOG USING 3 INCH 10D GALVANIZED COMMON NAIL ON 12 IN SPACING ALONG LOG. NAIL NON-WOVEN GEOTEXTILE TO EDGE OF HEADER LOG AND BACKFILL.
12. DIMENSIONS AND SLOPES OF STRUCTURES DESCRIBED IN THE DETAIL MAY BE ADJUSTED BY DESIGN ENGINEER TO FIT CONDITIONS ONSITE.
13. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED.
14. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.



LOG VANE WITH BOULDER J-HOOK
CROSS-SECTION

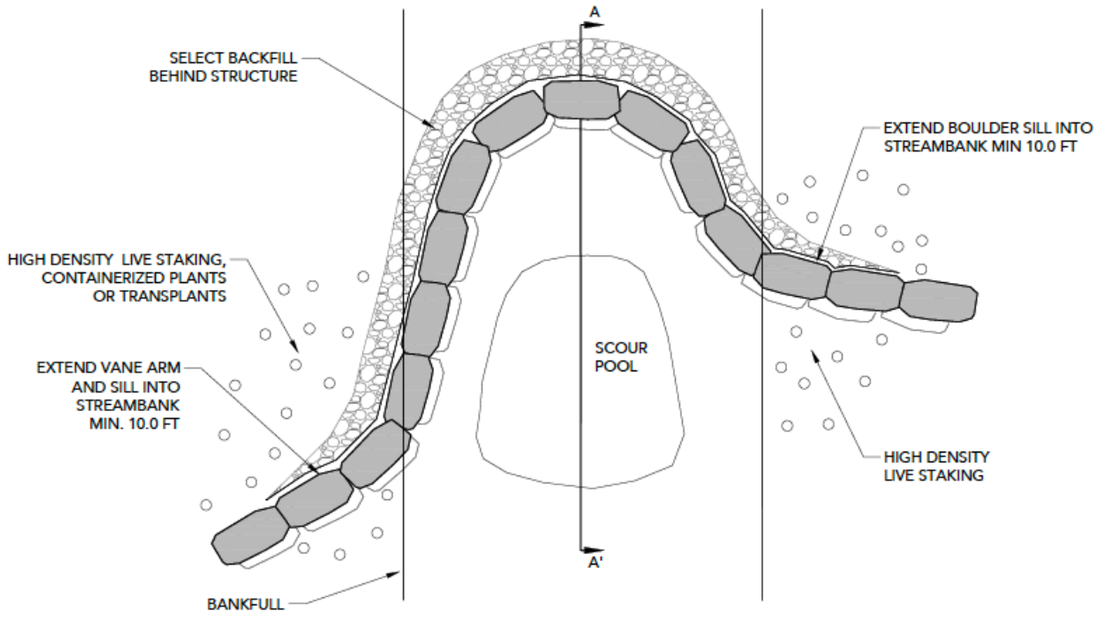
Jennings Environmental
7 SAMUEL ASHE DRIVE
ASHEVILLE, NC 28805
919.600.4790

TYPICAL DETAIL - NOT FOR CONSTRUCTION

STREAM RESTORATION: LOG VANE WITH BOULDER J-HOOK DETAIL

PRELIMINARY DESIGN

REVISIONS:
DATE: 07/08/2019
PLOT SIZE: 24" x 36"
NTS
H.D.: NAD83 (NCSP)
V.D.: NAVD88
JE PID: 4304

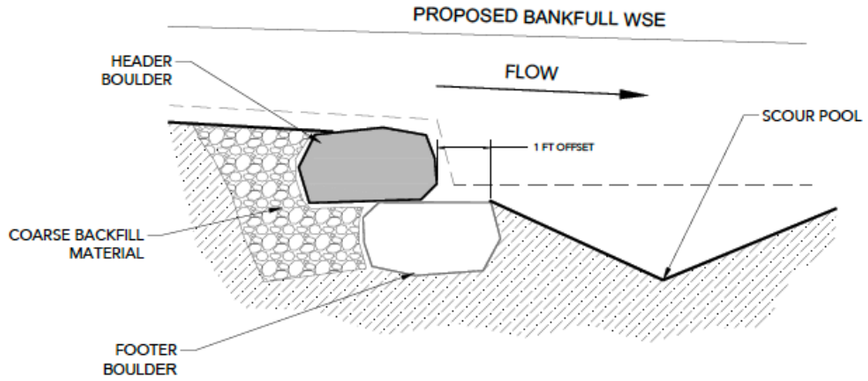


BOULDER J-HOOK VANE
DETAILED PLAN

NOT TO SCALE

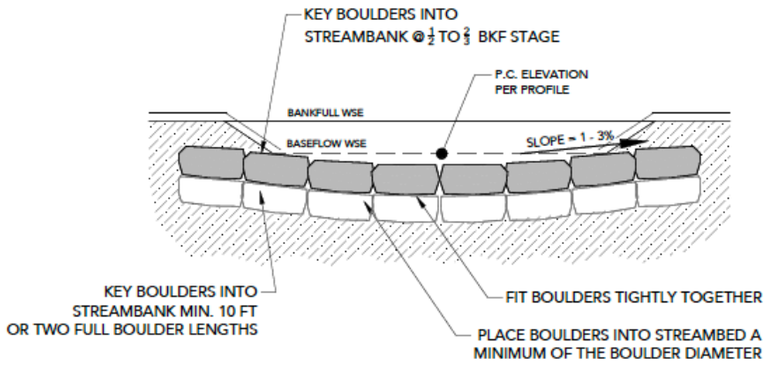
BOULDER J-HOOK VANE
NOTES

1. ALL BOULDERS USED FOR THE PROPOSED STRUCTURE SHALL BE STRUCTURAL STONE, CUBICAL OR RECTANGULAR IN SHAPE. THE ENGINEER MUST APPROVE THE USE OF BOULDERS THAT MAY BE AVAILABLE ONSITE. BOULDERS DIMENSIONS SHALL BE 2.5 FT X 4.0 FT X 1.5 FT +/- 0.5 FT.
2. DIMENSIONS AND SLOPES OF STRUCTURES DESCRIBED IN THE DETAIL MAY BE ADJUSTED BY DESIGN ENGINEER TO FIT CONDITIONS ONSITE.
3. CONTRACTOR WILL BE REQUIRED TO FIT BOULDERS TOGETHER TIGHTLY.
4. GAPS BETWEEN BOULDERS SHALL BE MINIMIZED BY FITTING BOULDERS TOGETHER AND PLUGGING WITH NC DOT CLASS A ROCK OR CHINKING STONE APPROVED BY ENGINEER.
2. HEADER BOULDERS SHALL BE UNDERLAIN BY FOOTER BOULDERS TO PROVIDE A FOUNDATION UNLESS OTHERWISE DIRECTED BY THE ENGINEER. HEADER BOULDERS SHALL BE OFFSET 1.0 FT UPSTREAM OF THE FOOTER.
3. SET BOULDER INVERTS AT ELEVATION SHOWN ON THE PLAN AND PROFILE SHEETS. NO ELEVATIONS OF THE BOULDERS MAY VARY FROM THE PLAN SHEETS WITHOUT DIRECTION FROM THE ENGINEER.
4. NON-WOVEN GEOTEXTILE SHALL BE PLACED ON THE UPSTREAM SIDE OF THE STRUCTURE TO PREVENT WASHOUT OF SEDIMENT THROUGH BOULDER GAPS. FILTER FABRIC SHALL EXTEND FROM THE BOTTOM OF THE FOOTER BOULDER TO THE FINISHED GRADE ELEVATION AND SHALL BE PLACED THE ENTIRE LENGTH OF THE STRUCTURE. SELECT BACK FILL MATERIAL SHALL BE PLACED UPSTREAM OF THE GEOTEXTILE MATERIAL.
5. SELECT BACKFILL MATERIAL SHALL BE FILL MATERIAL GENERATED ON-SITE WITH A MINIMUM D_{50} OF 60 MM OR A GRADATION SUBMITTED IN WRITING AND APPROVED BY THE ENGINEER. A WELL-GRADED BLEND OF NCDOT CLASS A RIP-RAP AND ASTM #57 ROCK MIXED WITH EARTH WILL BE AN ACCEPTABLE SUBSTITUTE. SELECT BACKFILL AND SOIL BACKFILL MATERIAL SHALL BE COMPACTED SUCH THAT FUTURE SETTLEMENT OF THE MATERIAL IS KEPT TO A MINIMUM.
6. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR INVERT ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED.
7. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.



BOULDER J-HOOK VANE
SECTION A - A'

NOT TO SCALE



BOULDER J-HOOK VANE
CROSS-SECTION

NOT TO SCALE

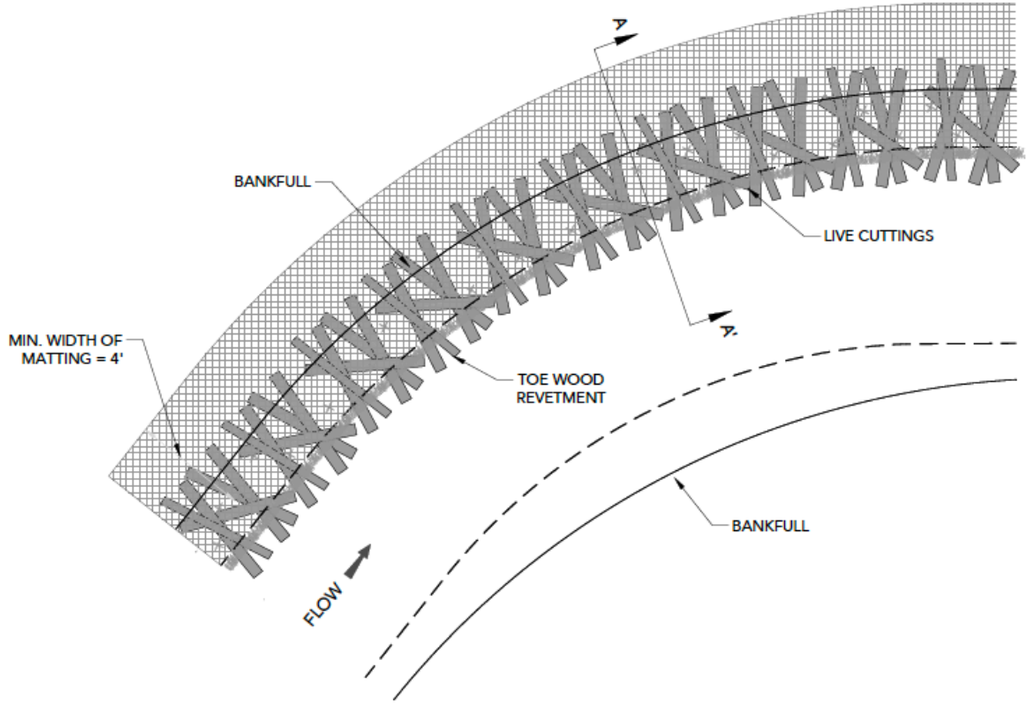
Jennings Environmental
7 SAMUEL ASHE DRIVE
ASHEVILLE, NC 28805
919.600.4790

TYPICAL DETAIL - NOT FOR CONSTRUCTION

STREAM RESTORATION: BOULDER J-HOOK VANE DETAIL

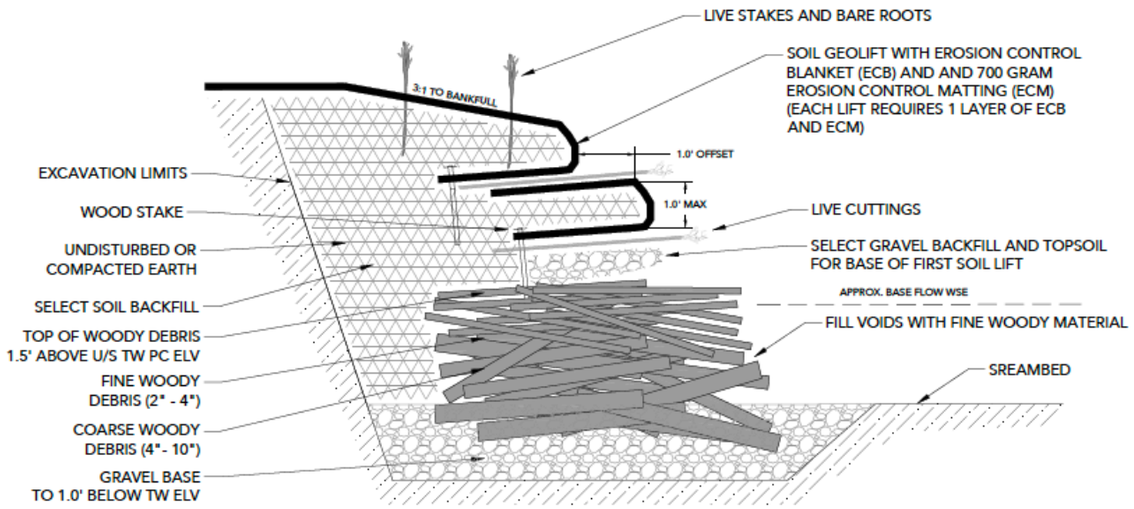
PRELIMINARY DESIGN

REVISIONS:
DATE: 07/08/2019
PLOT SIZE: 24" x 36"
NTS
H.D.: NAD83 (NCSP)
V.D.: NAVD88
JE PID: 4304



TOE WOOD REVETMENT
DETAILED PLAN

NOT TO SCALE



TOE WOOD REVETMENT
DETAILED PROFILE - SECTION A - A'

NOT TO SCALE

TOE WOOD REVETMENT
NOTES

1. ALL OUTSIDE MEANDER BENDS WITH RADIUS OF CURVATURE RATIO LESS THAN 4.0 SHALL BE PROTECTED WITH BANK REVETMENTS.
2. COARSE WOODY DEBRIS SHALL CONSIST OF LOGS, ROOTWADS, AND LARGE BRANCHES NOT SUITABLE FOR CONSTRUCTION OF LOG STRUCTURES. ALL MATERIALS ARE TO BE APPROVED BY THE ENGINEER. COARSE WOODY DEBRIS SHALL BE CONSTRUCTED WITH THE LARGEST MATERIAL PLACED FIRST. NO LOGS SHALL BE PLACED PARALLEL TO THE FLOW OF WATER, UNLESS DIRECTED BY THE ENGINEER. LOGS SHALL BE PLACED IN A CROSSING PATTERN OR WEAVE SUCH THAT EACH LOG IS ANCHORED BY ANOTHER LOG.
3. SMALL/FINE WOODY DEBRIS SHALL CONSIST OF MEDIUM TO SMALL LIMBS, BRANCHES, BUSHES, AND/OR LOGS. INVASIVE SPECIES SHALL NOT BE USED. SMALL/FINE WOODY DEBRIS SHALL BE PLACED ABOVE THE COARSE WOODY DEBRIS WITH THE LARGEST MATERIAL BEING PLACED FIRST AND THE SMALLEST MATERIAL PLACED LAST.
4. ALL WOODY DEBRIS SHALL BE COMPACTED WITH THE EXCAVATOR BUCKET TO REDUCE THE PRESENCE OF VOIDS IN THE SMALL/FINE WOODY DEBRIS LAYER.
5. GRAVEL LEVELING BASE SHALL BE INSTALLED ABOVE THE HIGHEST ELEVATION OF THE WOODY DEBRIS BEFORE THE SOIL LIFTS ARE INSTALLED.
6. THE SOIL BACKFILL USED FOR LIFTS AND TOPSOIL USED FOR LAYERING WITH THE LIVE BRANCHES SHALL BE FREE OF ANY LARGE ROOTS OR WOODY DEBRIS AND SHALL GENERALLY BE FREE FROM ANY GRAVEL OR COBBLE MATERIAL.
7. SOIL BACKFILL SHALL BE COMPACTED SUCH THAT FUTURE SETTLING WILL BE KEPT TO A MINIMUM; YET, NOT SUCH THAT THE UNDERLYING BRUSH IS DISPLACED OR DAMAGED. THE TOP OF THE BACKFILL FOR THE FIRST LIFT SHALL BE SLOPED AT APPROXIMATELY 5% AWAY FROM THE STREAM.
8. PLACE A LAYER OF TOPSOIL AND LIVE BRANCHES ON THE GRAVEL LEVELING BASE SUCH THAT APPROXIMATELY 6 INCHES TO 1 FOOT OF EACH LIVE BRANCH WILL BE EXPOSED AND THE REMAINDER (2' TO 4') OF EACH LIVE BRANCH WILL BE COVERED BY THE SOIL LIFT. LIVE BRANCHES SHALL BE OF THE SPECIES SPECIFIED FOR LIVE STAKES OR APPROVED BY THE ENGINEER.
9. PLACE A LAYER OF 6.5 FEET WIDE BIODEGRADABLE EROSION CONTROL BLANKET AND 700 GRAM EROSION CONTROL MATTING, ON TOP OF THE TOPSOIL AND LIVE BRANCHES SUCH THAT 2.5 FEET OF THE BLANKET WILL BE BURIED BELOW THE NEXT SOIL LIFT. ALLOW THE REMAINING 4.5 FEET OF BLANKET AND MATTING TO HANG OVER THE GRAVEL LEVELING BASE.
10. PLACE SOIL BACKFILL UP TO THE LIFT HEIGHT SPECIFIED OF NO GREATER THAN 1.0 FT BEING CAREFUL NOT TO PUSH/PULL OR TEAR THE FABRIC PREVIOUSLY PLACED.
11. TOP DRESS THE SOIL LIFT WITH TOPSOIL FROM THE FACE OF THE SOIL LIFT BACK INTO THE FLOODPLAIN AT LEAST 4FT.
12. THE EROSION CONTROL FABRICS SHALL BE PULLED AS TIGHT AS POSSIBLE WITHOUT TEARING OR EXCESSIVELY DISTORTING THE FABRIC. SECURE THE EROSION CONTROL AND NON-WOVEN MATTING IN PLACE BY STAKING THE END OF THE EROSION CONTROL FABRIC WITH WOODEN STAKES ON 1.5-FOOT CENTERS.
13. REPEAT STEPS 8 THROUGH 12 AS NEEDED TO BUILD SOIL LIFTS UP TO DESIGN BANKFULL ELEVATION.
14. THE SURFACE OF THIS STRUCTURE SHALL BE FINISHED TO A SMOOTH AND COMPACT SURFACE IN ACCORDANCE WITH THE LINES, GRADES, AND CROSS-SECTIONS OR ELEVATIONS SHOWN ON THE DRAWINGS. THE DEGREE OF FINISH FOR ELEVATIONS SHALL BE WITHIN 0.1 FT OF THE GRADES AND ELEVATIONS INDICATED OR APPROVED BY THE ENGINEER.
15. RE-DRESSING OF CHANNEL AND BANKFULL BENCH/FLOODPLAIN WILL LIKELY BE REQUIRED FOLLOWING INSTALLATION OF IN-STREAM STRUCTURES AND SHALL BE CONSIDERED INCIDENTAL TO CONSTRUCTION.
16. COIR LOG TOE PROTECTION MAY USED AS ALTERNATIVE BANK REVETMENT WHERE TOE WOOD IS NOT FEASIBLE DUE TO FIELD CONDITIONS.

Jennings Environmental
7 SAMUEL ASHE DRIVE
ASHEVILLE, NC 28805
919.600.4790

TYPICAL DETAIL - NOT FOR CONSTRUCTION

STREAM RESTORATION: STACKED BOULDER WALL DETAIL

PRELIMINARY DESIGN

REVISIONS:
DATE: 07/08/2019
PLOT SIZE: 24" x 36"
NTS
H.D.: NAD83 (NCSP)
V.D.: NAVD88
JE PID: 4304

APPENDIX E

PLEASANT GROVE FLOODPLAIN ECOSYSTEM RESTORATION PLAN

Pleasant Grove Floodplain Ecosystem Restoration Plan

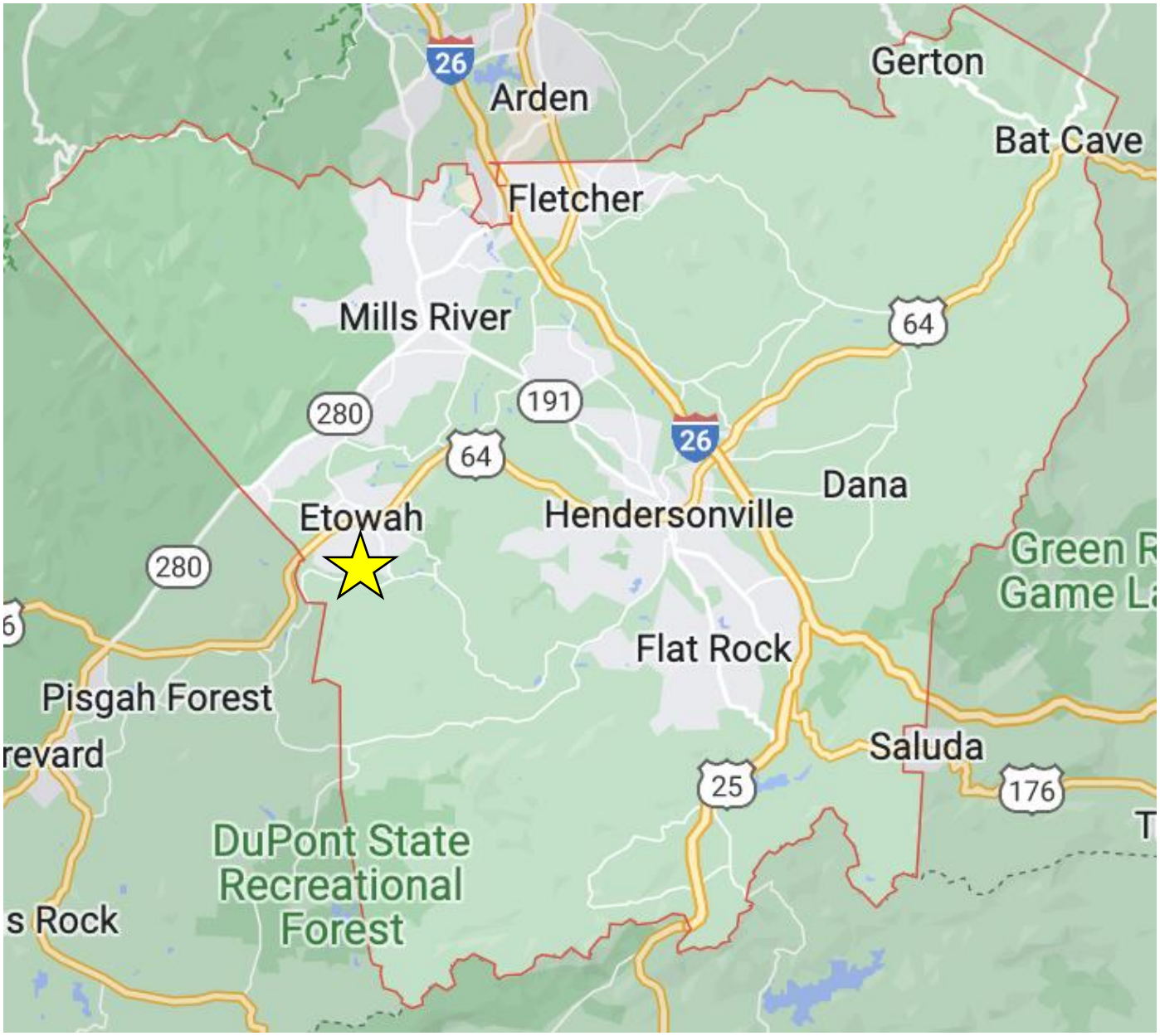
CONSERVING CAROLINA
MOUNTAINS • FOOTHILLS • RIVERS • FARMS

U.S. FISH & WILDLIFE SERVICE

NORTH CAROLINA Wildlife RESOURCES COMMISSION

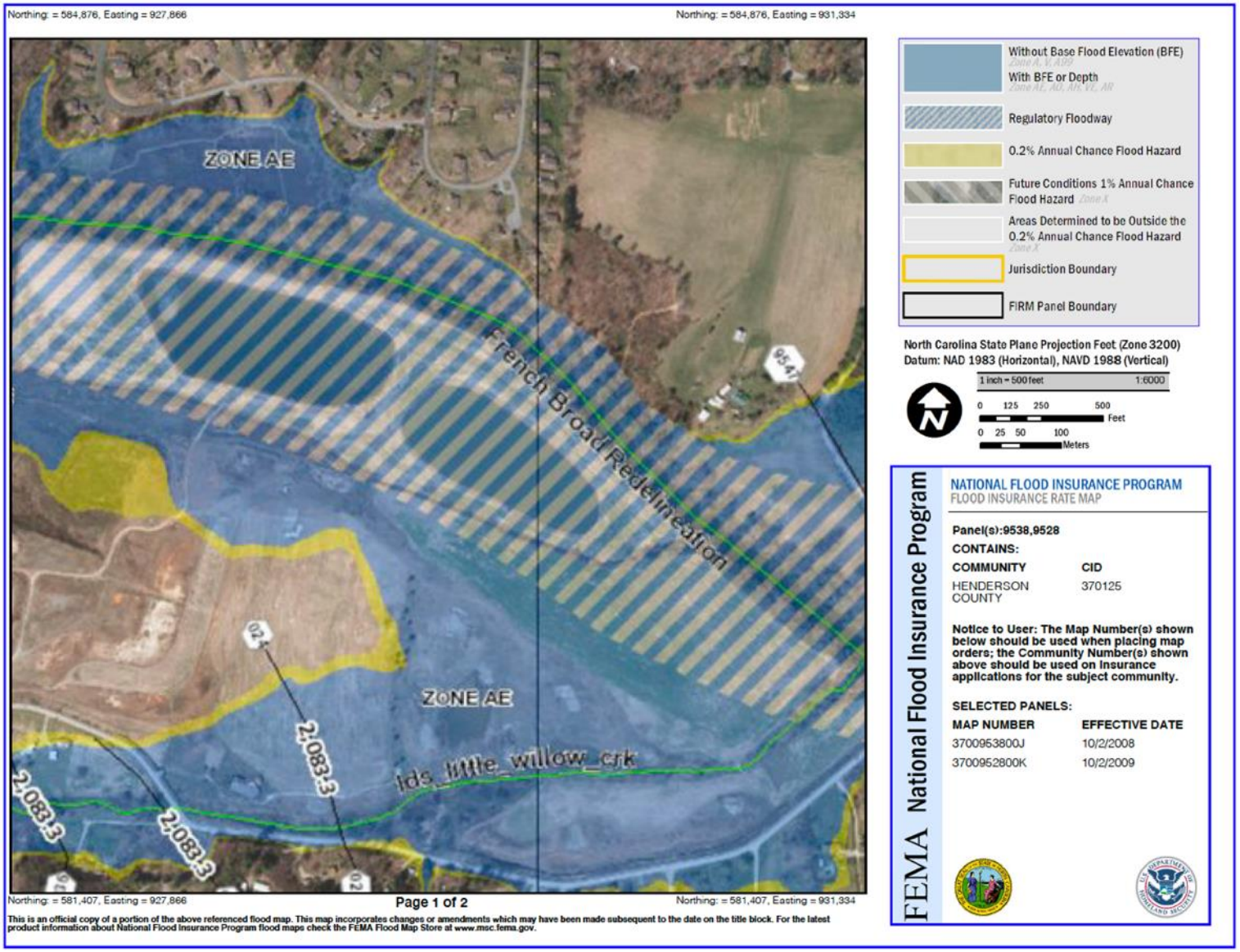
Jennings Environmental

Pleasant Grove Floodplain



Pleasant Grove Floodplain

FEMA Floodplain Map



Pleasant Grove Floodplain
1956 Aerial Photo Showing Farm Land

Pleasant Grove Floodplain
2008 Aerial Photo Showing Golf Course

Pleasant Grove Floodplain
2022 Conditions

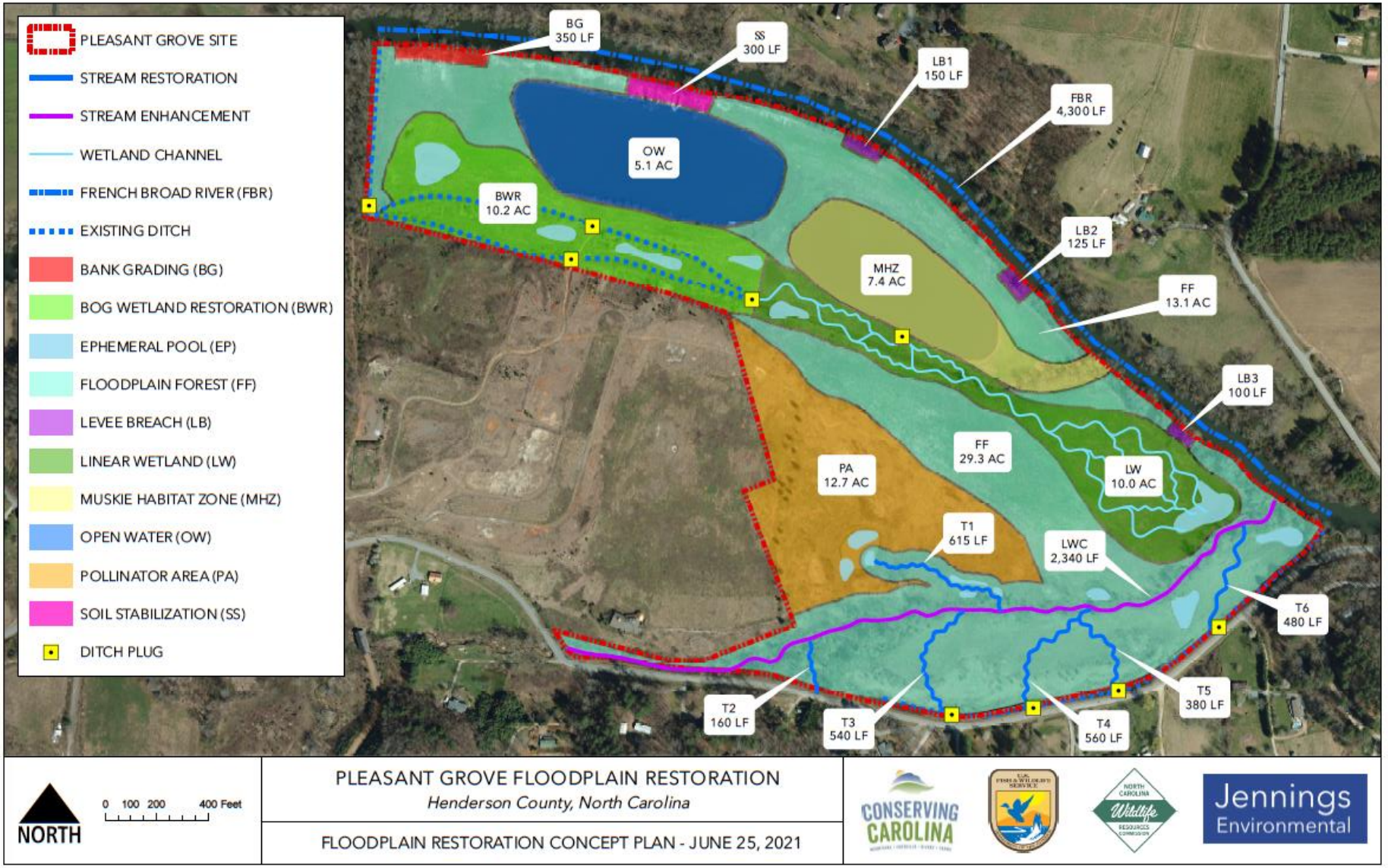
French Broad River Bank Erosion

Linear Ditch Draining Wetlands

Pond on Floodplain

Little Willow Creek with Eroding Banks

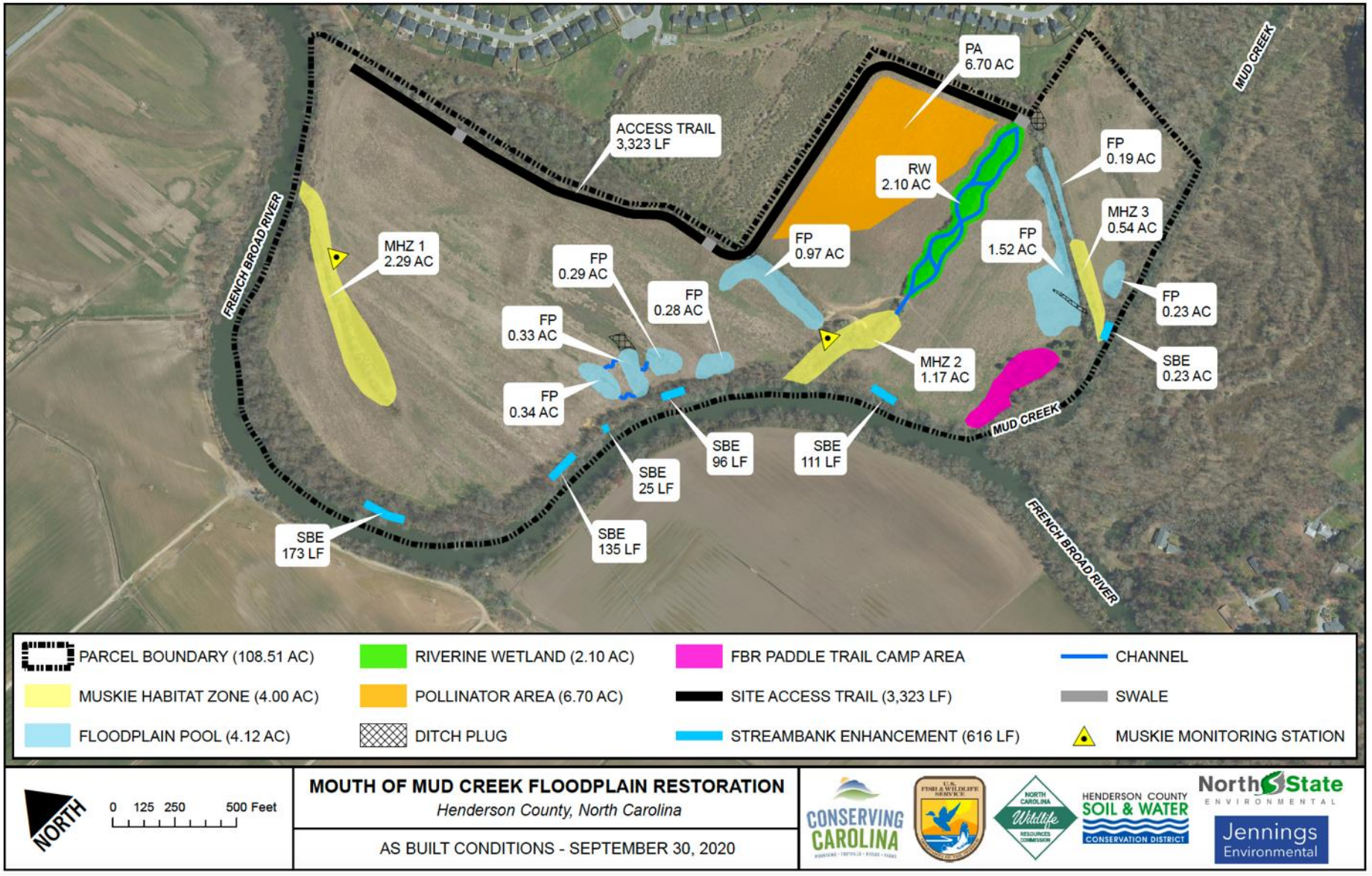
Pleasant Grove Floodplain Restoration Concept Plan: *Mosaic of Habitats*



Pleasant Grove Floodplain Restoration Concept Plan

Project Element	Amount	Planning Level Cost Range
Bank Grading on French Broad River (BG)	350 feet	$70,000 to $250,000
Bog Wetland Restoration (BWR)	10.2 acres	$40,000 to $80,000
Floodplain Forest (FF)	29.3 acres	$20,000 to $40,000
Levee Breach (LB)	375 linear feet	$30,000 to $50,000
Linear Wetland (LW)	10.0 acres	$80,000 to $120,000
Pollinator Zone (PZ)	38 acres	$50,000 to $90,000
Muskie Habitat Zone (MHZ)	7.4 acres	$60,000 to $100,000
Open Water (OW)	5.1 acres	$10,000 to $20,000
Pollinator Area (PA)	12.7 acres	$30,000 to $60,000
Soil Stabilization (SS)	300 linear feet	$40,000 to $80,000
Stream Enhancement on Little Willow Cr (LWC)	2,340 linear feet	$180,000 to $280,000
Stream Restoration on Tributaries (T)	2,735 linear feet	$200,000 to $360,000
Total		**$810,000 to $1,530,000**

Mouth of Mud Creek Floodplain
2020 Restoration Outcomes



Mouth of Mud Creek Floodplain

2020 Restoration Outcomes

French Broad River Bank Stabilization

Meandering Linear Wetland

Muskie Habitat Sloughs (3)

Wetland Depression Creation

APPENDIX F

LITTLE RIVER
RESTORATION MASTER PLAN

LITTLE RIVER RESTORATION MASTER PLAN

Submitted to: Sherwood Forest Homeowners Association

June 2022

Jennings Environmental PLLC
Greg Jennings, PhD, PE, President

Jennings Environmental

1. Introduction

This report describes a plan to improve Little River water quality and aquatic habitats, enhance natural ecosystem resilience to floods, and stabilize the surrounding landscape to protect infrastructure and land uses in the Sherwood Forest community. The study was requested by the Sherwood Forest Homeowners Association in 2022 in response to concerns about erosion and property damage following recent floods. The Jennings Environmental project team of Greg Jennings, Eric Caldwell, Zan Price, and Jason Zink worked under contract with the Sherwood Forest Homeowners Association in 2022 to assess existing river conditions and develop the master plan for addressing river restoration objectives. Information in this report will be valuable for project planning, funding acquisition, and permitting and implementation of future restoration projects.

The study area consists of the Little River corridor flowing 4,123 feet west to east along the Sherwood Forest golf course (Figure 1). At the upstream extent (Latitude 35.148560, Longitude -82.692233), the drainage area is 2.57 square miles. At the downstream extent (Latitude 35.146175, Longitude -82.679507), the drainage area is 4.53 square miles. Sheets A1 and A2 of the Appendix show delineations of these watersheds. Much of the watershed land area is forested, with some roads, open space, and low-density residential areas. Downstream of the project area, the Little River flows through several well-known landscape features of DuPont State Recreational Forest, including High Falls, Triple Falls, Hooker Falls, and Cascade Lake. Near the community of Penrose, in Transylvania County, the Little River flows into the French Broad River, which flows north toward Tennessee.

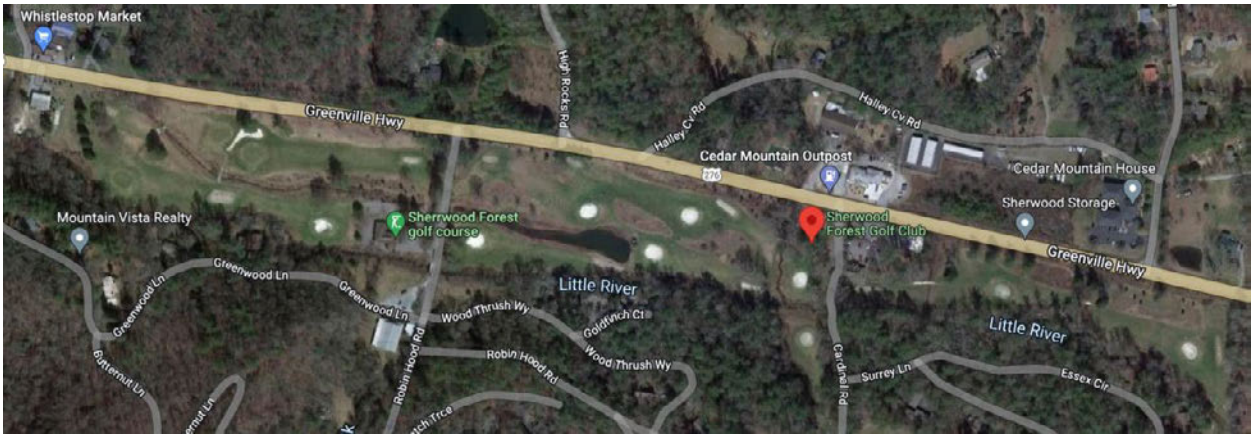


Figure 1. Map of Little River Study Area.

Previous studies of the Little River Watershed in Sherwood Forest include the following reports with findings summarized as follows:

2013: Transylvania County Extension (Eric Caldwell), Little River Site Visit Summary

- The summary document describes recommendations by Eric Caldwell, Transylvania County Extension Director, during a field visit to seven sites along the golf course with eight community members.
- Healthy native riparian buffers consist of deep-rooted grasses, shrubs, and trees to protect soil from erosion during high flows. Woody plants may be established using live stakes of some shrubs during dormant season. Removing invasive plants such as multiflora rose is required for healthy buffers.
- Streambank erosion control measures include bank grading to a stable slope and addition of rock vanes or log vanes as needed to direct flow energy away from susceptible streambanks.

2014: South Core Environmental (Joel Lenk), Assessment of Little River and Options for Restoration

- The report describes stream assessment observations and recommendations for stream restoration projects, with emphasis on fluvial geomorphology considerations.
- Observations include poor riparian buffer conditions and areas of bank erosion, mostly on the north bank (left bank facing downstream). Additional concerns noted include warm water discharge from Pilgrim Pond into Little River and utility pipe crossings that may cause debris jams and potentially leak wastewater into the river.
- The recommended river restoration plan includes grading streambanks to create stable slopes, increasing sinuosity and floodplain benches where possible, adding in-stream rock and log vanes, and riparian buffer enhancement using native vegetation.

2017: US Fish and Wildlife Service (Anita Goetz), Rapid Stream Assessment of the Little River, Restoration, and Management Recommendations

- The report includes thorough documentation of the site history and ecological conditions observed by USFWS staff biologists in addition to comprehensive restoration recommendations.
- Observations include pipes discharging into surface waters, a pipe constructed through the lower reach of the Little River; construction of buildings within the floodplain or close to the banks of the Little River; lack of adequate forested buffer; mass-wasting streambanks; concrete rubble and blocks within the active channel; proliferation of

invasive, nonnative species; and incision and channelization of the watercourses. Threats to instream aquatic habitat from these stressors include the conveyance of contaminants from development into surface waters, increased sedimentation and turbidity, increased water temperatures, increased stream power (water velocity), and changes in the timing and duration of flood flows. Sedimentation and nutrient loading can be exacerbated when riparian vegetation is not present to filter stormwater or when the streambank itself is eroding and contributing sediment to the waterbody.

- Recommendations for improving river conditions focused on enhancing the riparian buffer with deep-rooted native plants. Detailed plant lists and installation guidelines are included.
- The Cardinal Road bridge crossing consisting of a multi-barrel culvert was recommended for replacement with a free spanning bridge properly sized based on the bankfull width of the Little River for public safety and ecological benefits.

2020: Joe Pye Ecological Consulting, Sherwood Forest Aquatic Inventory Initial Survey

- The report describes an aquatic survey of four tributary streams sampled for physical, chemical, and biological parameters, including fish and aquatic macroinvertebrates. Physical and chemical sampling showed that the streams have excellent water quality with little indication of contamination. Aquatic macroinvertebrate sampling indicated a diverse community with many intolerant species present. The community's smaller creeks had more diversity and more intolerant species than the larger creeks. Fish sampling resulted in fairly low diversity, with fish present only in the two larger creeks sampled.

These studies were consistent in identifying streambank erosion and sedimentation as ongoing concerns that should be addressed by applying science-based techniques for managing hydraulic energy during high flows and enhancing natural resilience using native riparian vegetation. Little River can be enhanced and maintained as a high-quality ecosystem that adds value to the community and the watershed.

In addition to the reports listed above, a 2016 Little River Task Forest Community Forum presentation summarized recommendations including developing a "Conceptual Master Plan" for the river that:

- Provides a "blue print", or long-range plan, for addressing the priority needs of the LR, that can be executed in all or part at the discretion of the Sherwood Forest community;
- Specifies restoration options/alternatives with potential costs;

- Provides a visual rendering of the recommended remediation efforts to inform/educate the community;
- Contains a riparian buffer/landscape plan to stabilize the streambanks, remove invasive plant material and replant native alternatives;
- Highlights opportunities for community engagement in the restoration of Little River.

Following review of these documents and conversations with community leaders regarding study objectives, the project team commenced to assess existing conditions and develop a master plan focused on achieving community objectives.

2. Stream Condition Assessment

Little River was assessed to determine existing conditions regarding topography, site constraints, riparian vegetation, stream morphology, and streambank erosion. Spatial data that were reviewed included aerial photography, topographic contours, property boundaries, and FEMA flood zones. This information was used to document existing conditions, as well as opportunities and constraints that may affect potential restoration projects.

Topography and FEMA flood zones: The stream channel is relatively low-gradient for alluvial headwater mountain rivers, with an average streambed slope of 0.005 feet/foot throughout the project area. Additionally, the valley is relatively wide, with the Little River situated near the valley wall along the southern extent of the valley, as shown on Sheet A3 in the Appendix. The remainder of the valley is composed of the golf course and portions of US Highway 276. Lateral topographical constraints will allow for some realignment of the stream channel in targeted areas. The project area, and much of the river valley, is located within the FEMA AE flood zone, signifying a one percent annual chance of flooding at the extents of this zone. Areas within the interior of that zone should be expected to flood more frequently.

Site constraints: Potential constraints to restoration are numerous, and include the golf course, road crossings, utilities, and buildings. These constraints were considered in the development of the restoration approaches described in Section 3.

Riparian vegetation: Vegetation conditions along the Little River are highly variable, ranging from areas with no deep-rooted riparian vegetation to areas with mature forested buffers. The existing vegetation between the river and golf course does reflect previous efforts to establish a

healthy riparian buffer. Generally, these efforts appear to have been successful. However, several species of invasive and non-native plants were observed in portions of the riparian buffer, including multi-flora rose and privet.

Stream morphology: Observations of stream morphological parameters were made throughout the study area. These included dimensions derived from cross-section data, such as cross-section area, width, and mean depth. These dimensions were compared to reference conditions to understand to what degree this stream has departed from stable reference conditions. An area of reference quality river channel was observed within the study area, just downstream of the Robin Hood Road bridge, with a photo in Figure 2. The reference dimensions in this area are similar to what would be expected for the watershed size in the mountains of North Carolina. Reference cross-section dimensions can inform design choices for a restored stream during the engineering design process.

Figure 2. Reference-quality conditions on the Little River (within Reach 2).

For purposes of this study, the 4,123-foot stream was divided into three reaches. The extents of these reaches are shown on Sheet A4 of the Appendix, with more detail on Sheets A5 through A9. Reach 1 extends 1,431 feet from the western extent of the golf course to the crossing by Robin Hood Road. Reach 2 extends 1,315 feet to the Cardinal Road crossing. Reach 3 begins at

this crossing and continues 1,377 feet to the golf cart bridge near the eastern extent of the golf course. Photos of representative conditions within each reach are shown in Figures 3, 4, and 5.

Figure 3. Representative view of impairment within Little River, Reach 1.

Figure 4. Representative view of impairment within Little River, Reach 2.

Figure 5. Representative view of impairment within Little River, Reach 3.

Streambank erosion: Bank erosion rates and sediment loading were estimated using the BANCS approach (Rosgen, 2001). This approach applies a field estimation of bank erosion hazard based on the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) at eroding bank locations. 21 areas of bank erosion were identified throughout the study area. The length of the eroding banks totaled 820 feet in Reach 1, 320 feet in Reach 2, and 850 feet in Reach 3. Most eroding banks were located along the golf course on the left (northern) riverbank, though some erosion was present on the right (southern) riverbank, particularly within Reach 3. Tables 1, 2, 3, and A1 (in the Appendix) include the resulting estimated erosion rates for each reach. Factors included in this analysis that contribute to river bank erosion and sedimentation include the following:

- Channel incision, which prevents flood flows from accessing a floodplain for energy dissipation. Degree of incision is measured using Bank Height Ratio (BHR).
- Soil composition (cohesiveness) in the river banks, which determines the ability of the soil to resist erosion scour forces during high flows.
- Vegetation root composition (depth and density), which determines the effectiveness of plant roots in enhancing soil resistance to erosive energy.

- Bank angle, which determines the susceptibility of banks to slumping and mass wasting during high flows.
- Near bank stress (NBS), which relates to accelerated bank erosion where the depth, slope, and velocity of flow increases in channel segments with tight meander bends, deep pools, and transverse bars. NBS is evaluated using radius of curvature ratio and other geomorphic parameters that indicate potential stressful conditions.

Table 1. Estimated river bank erosion rates, Reach 1.

Site	Length (feet)	Erosion Rate (cubic feet/year)	Erosion Rate (tons/year)	Average Erosion Rate (tons/year/linear foot)
1 (left)	50	203	8.2	0.16
2 (left)	150	56	2.3	0.02
3 (left)	100	60	2.4	0.02
4 (left)	120	36	1.5	0.01
5 (left)	120	36	1.5	0.01
6 (right)	80	40	1.6	0.02
7 (left)	100	38	1.5	0.02
8 (left)	100	50	2.0	0.02
Reach 1 Total	820	519	21.0	0.015

Table 2. Estimated river bank erosion rates, Reach 2.

Site	Length (feet)	Erosion Rate (cubic feet/year)	Erosion Rate (tons/year)	Average Erosion Rate (tons/year/linear foot)
9 (left)	40	12	0.5	0.01
10 (left)	180	162	6.6	0.04
11 (left)	100	68	2.7	0.03
Reach 2 Total	320	242	9.8	0.007

Table 3. Estimated river bank erosion rates, Reach 3.

Site	Length (feet)	Erosion Rate (cubic feet/year)	Erosion Rate (tons/year)	Average Erosion Rate (tons/year/linear foot)
12 (right)	100	160	6.5	0.06
13 (left)	60	23	0.9	0.02
14 (left)	230	173	7.0	0.03
15 (left)	60	429	17.4	0.29
16 (right)	80	123	5.0	0.06
17 (left)	130	237	9.6	0.07
18 (right)	40	40	1.6	0.04
19 (left)	20	31	1.2	0.06
20 (right)	50	80	3.2	0.06
21 (left)	80	616	25.0	0.31
Reach 3 Total	850	1,912	77.5	0.056

The 21 erosion sites are characterized by a Bank Erosion Hazard Index (BEHI) rating of High or Very High and Near Bank Stress (NBS) rating of Moderate, High, or Very High. The potential stream restoration approaches projects presented below in Section 3 address these most erodible areas. The BANCS analysis estimates an average annual sediment contribution of 108 tons from both banks of the 4,123 linear feet of the river. Per linear foot, Reach 3 is estimated to be the largest contributor of sediment, followed by Reach 1. These results should be considered to be general estimates but can be helpful in understanding the relative sediment contribution from each site. These relative observations among the sites can be helpful with prioritization of reaches for potential restoration/stabilization projects.

The NC Stream Quantification Tool (SQT) was applied to Little River to assess the overall stream functional condition and uplift potential based on several key stream physical and biological parameters (https://stream-mechanics.com/wp-content/uploads/2017/09/Data-Collection-and-Analysis-Manual_NC-SQT-v3.0.pdf). Results of this analysis are shown in Table 4, which is a printout of the SQT spreadsheet. The Existing Condition Functional Score is 0.19, and the Proposed Condition Score is 0.47, meaning that the potential functional uplift score if

restoration is implemented is 0.28 (147% change in percent condition). These metrics are often used by state agencies to evaluate proposed stream restoration projects in grant applications to compare relative cost-benefit of potential projects.

Table 4. NC Stream Quantification Tool (SQT) assessment results.

Site Information and Performance Standard Stratification	
Project Name:	Little River
Reach ID:	1
Restoration Potential:	Level 3 - Geomorphology
Existing Stream Type:	Gc
Proposed Stream Type:	C
Region:	Mountains
Drainage Area (sqmi):	4.5
Proposed Bed Material:	Gravel
Existing Stream Length (ft):	4123
Proposed Stream Length (ft):	4123
Stream Slope (%):	0.005
Flow Type:	Perennial
River Basin:	French Broad
Stream Temperature:	Coldwater
Data Collection Season:	Winter/Spring
Valley Type:	Unconfined Alluvial

Notes
1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

FUNCTIONAL CHANGE SUMMARY	
Exisiting Condition Score (ECS)	0.19
Proposed Condition Score (PCS)	0.47
Change in Functional Condition (PCS - ECS)	0.28
Percent Condition Change	147%
Existing Stream Length (ft)	4123
Proposed Stream Length (ft)	4123
Additional Stream Length (ft)	0
Existing Functional Foot Score (FFS)	783
Proposed Functional Foot Score (FFS)	1938
Proposed FFS - Existing FFS	1154
Functional Change (%)	147%

BMP FUNCTIONAL CHANGE SUMMARY	
Existing BMP Functional Feet Score (FFS)	0
Proposed BMP Functional Feet Score (FFS)	0
Proposed BMP FFS - Existing BMP FFS	0
Functional Change (%)	

FUNCTIONAL FEET (FF) SUMMARY	
Existing Stream FFS + Existing BMP FFS	783
Proposed Stream FFS + Proposed BMP FFS	1938
Total Proposed FFS - Total Existing FFS	1155
Functional Change (%)	148%

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	Function-Based Parameters	Existing Parameter	Proposed Parameter
Hydrology	Catchment Hydrology	0.70	0.70
	Reach Runoff		
Hydraulics	Floodplain Connectivity	0.00	0.89
Geomorphology	Large Woody Debris	0.07	1.00
	Lateral Stability	0.29	1.00
	Riparian Vegetation	0.53	0.74
	Bed Material		
	Bed Form Diversity	0.36	1.00
	Plan Form	0.00	0.00
Physicochemical	Temperature		
	Bacteria		
	Organic Matter		
	Nitrogen		
	Phosphorus		
Biology	Macros		
	Fish		

FUNCTIONAL CATEGORY REPORT CARD			
Functional Category	ECS	PCS	Functional Change
Hydrology	0.70	0.70	0.00
Hydraulics	0.00	0.89	0.89
Geomorphology	0.25	0.75	0.50
Physicochemical			
Biology			

3. Stream Restoration Approaches

Restoration project opportunities for each area of concern on Little River were evaluated based on existing conditions and site constraints. The proposed restoration work described below and shown on Sheets B1, B2, and B3 of the Appendix will apply natural river restoration techniques to reduce erosion from river banks, thereby protecting surrounding infrastructure and improving water quality and aquatic habitat. The following four categories of restoration approaches are recommended to address site-specific needs:

- Vegetation Enhancement
- Bank Grading
- Bank Grading with In-stream Structures
- Channel Realignment

Based on the watershed area and the reference stream morphology, the optimal bankfull cross-section dimensions for Little River are 25 to 30 feet channel width, 1.5 to 2.0 feet channel depth, and at least 50 feet of vegetated floodplain bench width to allow flood flows to spread

out and dissipate energy. Banks should be sloped to 3:1 (horizontal to vertical) or flatter to support deep-rooted native vegetation that locks the soil in place. Optimal riparian buffer widths are at least 25 feet from top of bank to provide soil strength, filtering during floods, and shade to control water temperature.

Stream reaches with high banks, narrow floodplain benches, tight meanders, and other conditions that create erosion susceptibility may be protected by adding in-stream vane structures and/or revetments. Vane structures consist of logs or rocks placed at an angle in the streambed to direct flow energy away from sensitive streambanks and maintain deep scour pools for fish habitat. J-hooks may be added to provide grade control and enhance streambed diversity. Toe wood revetments placed below the water surface may be used around the outside meander bends to resist erosion and enhance habitat. Rock revetments may also be placed at the bank toe to resist erosion as needed. Site-specific engineering details regarding channel and floodplain dimensions, structures, and buffer width will be finalized during the engineering and permitting phase of each project.

Reach 1 (1,431 feet)

- Along the right (southern) stream bank, no grading is required, except for approximately 100 feet where the riparian buffer is composed of mowed grass. In this area, repair minor areas of right bank erosion by grading streambanks to a stable slope. Eliminate grass mowing within the riparian area, and plant appropriate deep-rooted native vegetation.
- For approximately 210 feet on the left (northern) bank at the upstream end of Reach 1, repair areas of bank erosion by grading streambanks to a stable slope. As needed in areas of high stress, install toe wood revetment and/or in-stream structures.
- Immediately downstream of the prior area, repair areas of bank erosion by grading streambanks to a stable slope within approximately 800 feet along the left bank.
- As a part of any of the above restoration projects, plant a riparian buffer of deep-rooted native trees, shrubs, and grasses.

Reach 2 (1,315 feet)

- The right stream bank is generally stable throughout Reach 2, with no grading required.
- For approximately 280 feet along the left streambank, repair areas of bank erosion as needed by grading streambanks to a stable slope. This area includes the confluence with

the outlet of a pond, which is formed by an impounded stream that flows through the golf course. The stability of this confluence must be considered as a part of a restoration project.

- Immediately downstream of the prior area, bank erosion is more severe. In this area, approximately 270 feet in length, repair areas of left bank erosion by grading streambanks to a stable slope. As needed in areas of high stress, install toe wood revetment and/or in-stream structures.
- As a part of any of the above restoration projects, plant a riparian buffer of deep-rooted native trees, shrubs, and grasses.

Reach 3 (1,377 feet)

- For approximately 120 feet downstream of the culverts under Cardinal Road, repair areas of right bank erosion by grading streambanks to a stable slope. As needed in areas of high stress, install toe wood revetment and in-stream structures for flow direction and bank protection.
- Across from the prior area, and for approximately 390 feet in length, the left bank is eroding and severely undercut. In this area, repair streambanks by grading them to a stable slope. As needed, install toe wood revetment and in-stream structures for bank protection and streambed diversification. A small tributary enters the Little River from the north in this area; the stability of this confluence must be considered as a part of a restoration project.
- Downstream of the prior projects, along approximately 190 feet, repair areas of erosion on both streambanks by grading them to a stable slope.
- Immediately downstream of the prior area, the river is highly unstable for approximately 500 feet. With active erosion along vertical streambanks (generally six to eight feet in height), a sinuous channel, and lack of floodplain access, this area represents the most severe river instability within the study area. Additionally, a tributary enters the Little River from the north within this area. This 500-foot length of river should be realigned as a meandering riffle-pool channel with appropriate dimension, pattern, profile, and floodplain access. Based on watershed size, approximate design channel dimensions would include a cross-section area of 60 square feet, top width of 30 feet, mean depth of 2 feet, and a width/depth ratio of 15. In-stream structures should be included in the design as needed for grade control, bank protection, and streambed diversification.

- As a part of any of the above restoration projects, plant a riparian buffer of deep-rooted native trees, shrubs, and grasses.

Outside of specific project areas, additional actions may be taken to promote a healthy riparian buffer and reduce the likelihood of future erosion. As needed, the riparian vegetation throughout the entire study area should be enhanced through additional planting of native trees, shrubs, and grasses, as well as removal of any invasive/exotic species such as multi-flora rose and privet.

The Cardinal Road bridge crossing is a special concern for ecological health and public safety (Figure 6). The crossing consists of several culverts which restrict flow during floods, increase water velocity causing erosion, and restrict the upstream passage of fish and other aquatic animals. This crossing should be considered for replacement with a free spanning bridge properly sized based on the bankfull width of the Little River.

Figure 6. Cardinal Road Bridge Crossing.

4. Cost Estimates, Funding Opportunities, and Permitting

Cost Estimates

Stream restoration work similar to that proposed for Little River typically ranges from $50 to $250 per foot depending on the amount of excavation and structure installation required to achieve objectives. Following are estimated ranges of costs for restoration implementation, including engineering design, permitting, construction, and planting to achieve stream stabilization and ecological enhancement objectives:

Reach 1 (1,431 feet): $90,000 to $160,000
Reach 2 (1,315 feet): $60,000 to $100,000
Reach 3 (1,377 feet): $180,000 to $320,000
Cardinal Road Bridge Replacement: $250,000 to $400,000

Cost estimates are based on typical fees for design, permitting, and implementation of similar river restoration projects in Western North Carolina in 2022. Cost savings may be incurred by grouping projects together and/or using existing labor and materials. Additional costs may be required for infrastructure improvements associated with stream crossings or utilities.

Funding Opportunities

Funding opportunities have been identified for the potential projects described above. Based on the specific details of the potential projects, a variety of funding sources will likely be required to achieve restoration goals. Potential funding sources include the following grant programs, many of which require local matching funds:

- NC Land and Water Fund:
  - https://nclwf.nc.gov/
  - Applications are due annually in February.
- NC DEQ Water Resources Development Grant Program:
  - https://deq.nc.gov/about/divisions/water-resources/water-resources-grants/financial-assistance
  - Applications are due semi-annually in June and December.
- NC DEQ 319 Grant Program:
  - https://deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/319-grant-program
  - Applications are due annually in May.

- NC Streamflow Rehabilitation Assistance Program (StRAP):
    - https://www.ncagr.gov/SWC/watershed/StRAP.html
    - The previous application window was January 24 – March 31, 2022.
- USFWS Partners for Fish and Wildlife Program:
    - https://www.fws.gov/southeast/our-services/partners-program/
    - The application process can be initiated by contacting USFWS.
- NC Community Conservation Assistance Program (CCAP):
    - http://www.ncagr.gov/SWC/costshareprograms/CCAP/index.html
    - The previous application window closed on March 25, 2022.

Other private foundation grants available for watershed restoration are described on the NC Department of Environmental Quality web site:

https://deq.nc.gov/about/divisions/water-resources/planning/basin-planning/use-restoration-watershed-programs/funding

Permitting

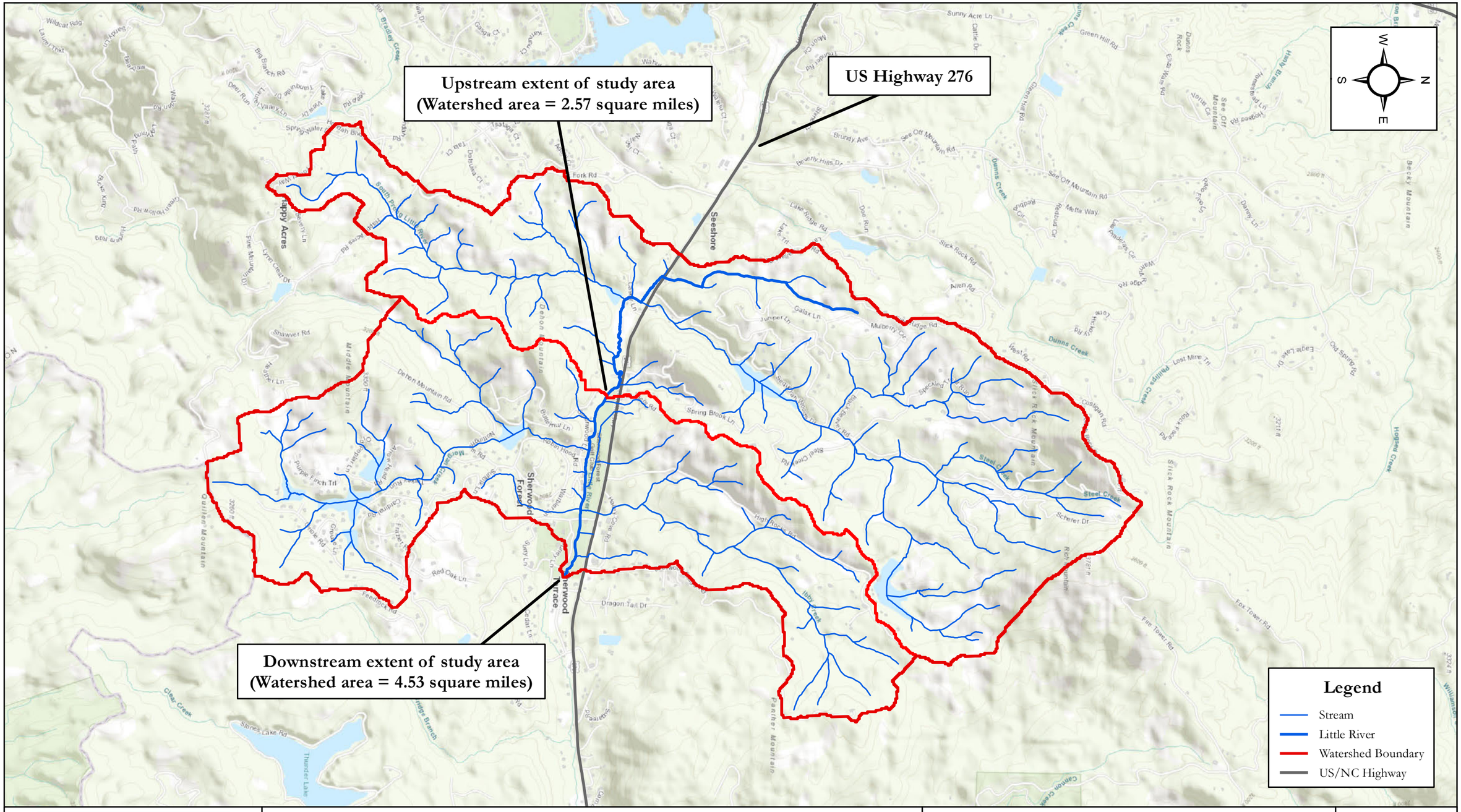
Stream restoration projects require permitting at the federal, state, and local levels for environmental and floodplain impacts. Environmental permitting is coordinated by the NC Division of Water Resources and US Army Corps of Engineers using the web-based Pre-Construction Notification (PCN) Form:

https://edocs.deq.nc.gov/Forms/Pre-Construction_Notification_Form

Other permit approvals may be required by NC Wildlife Resources Commission, US Fish & Wildlife Service, and the State Historic Preservation Office.

Stream restoration work in this area will require a Floodplain Development Permit from Transylvania County. The County Floodplain Administrator should be consulted to determine specific engineering requirements for a “No-Rise” Certification or a Letter of Map Revision (LOMR).

Construction activities that disturb more than 1 acre of land require Erosion and Sediment Control Plan approval by County and State agencies depending on funding source and property ownership.



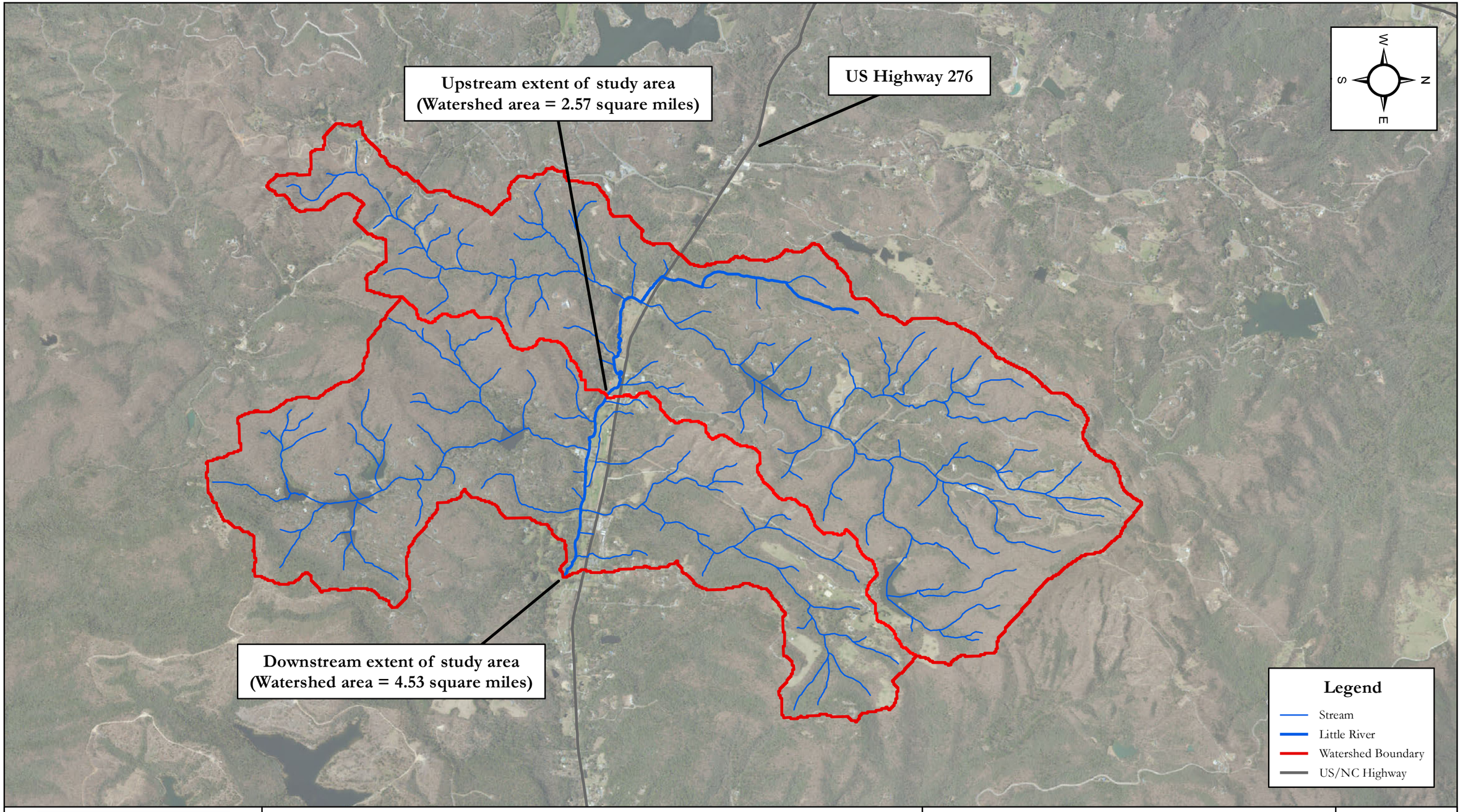
Jennings Environmental

Watershed Overview

0 1,000 2,000 4,000 6,000 8,000 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A1



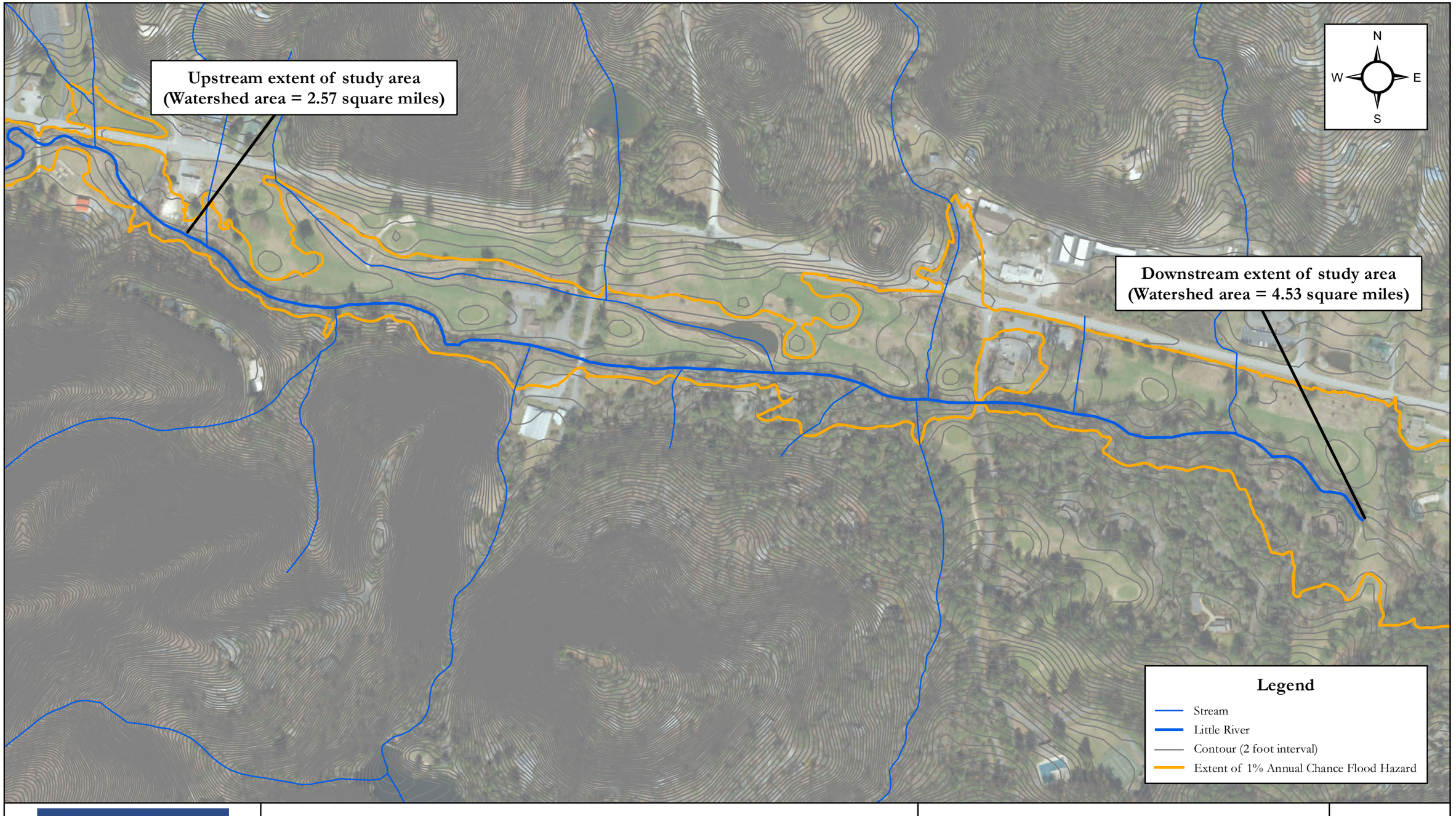
Jennings Environmental

Aerial Photography

0 1,000 2,000 4,000 6,000 8,000 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A2



Jennings Environmental

Topography and FEMA Flood Zones

0 150 300 600 900 1,200 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A3

Reach 1
(Length = 1,431 linear feet)

Reach 2
(Length = 1,315 linear feet)

Reach 3
(Length = 1,377 linear feet)

N
W E
S

Robin Hood Road bridge

Cardinal Road bridge

Golf cart bridge

Legend

Stream

Little River

Jennings Environmental

Stream Reach Overview

0 150 300 600 900 1,200 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A4

N
W E
S

Site 1 (50 linear feet, left bank)
Estimated erosion rate: 8.2 tons/year

Site 3 (100 linear feet, left bank)
Estimated erosion rate: 2.4 tons/year

Site 4 (120 linear feet, left bank)
Estimated erosion rate: 1.5 tons/year

Site 2 (150 linear feet, left bank)
Estimated erosion rate: 2.3 tons/year

Legend

Stream

Little River

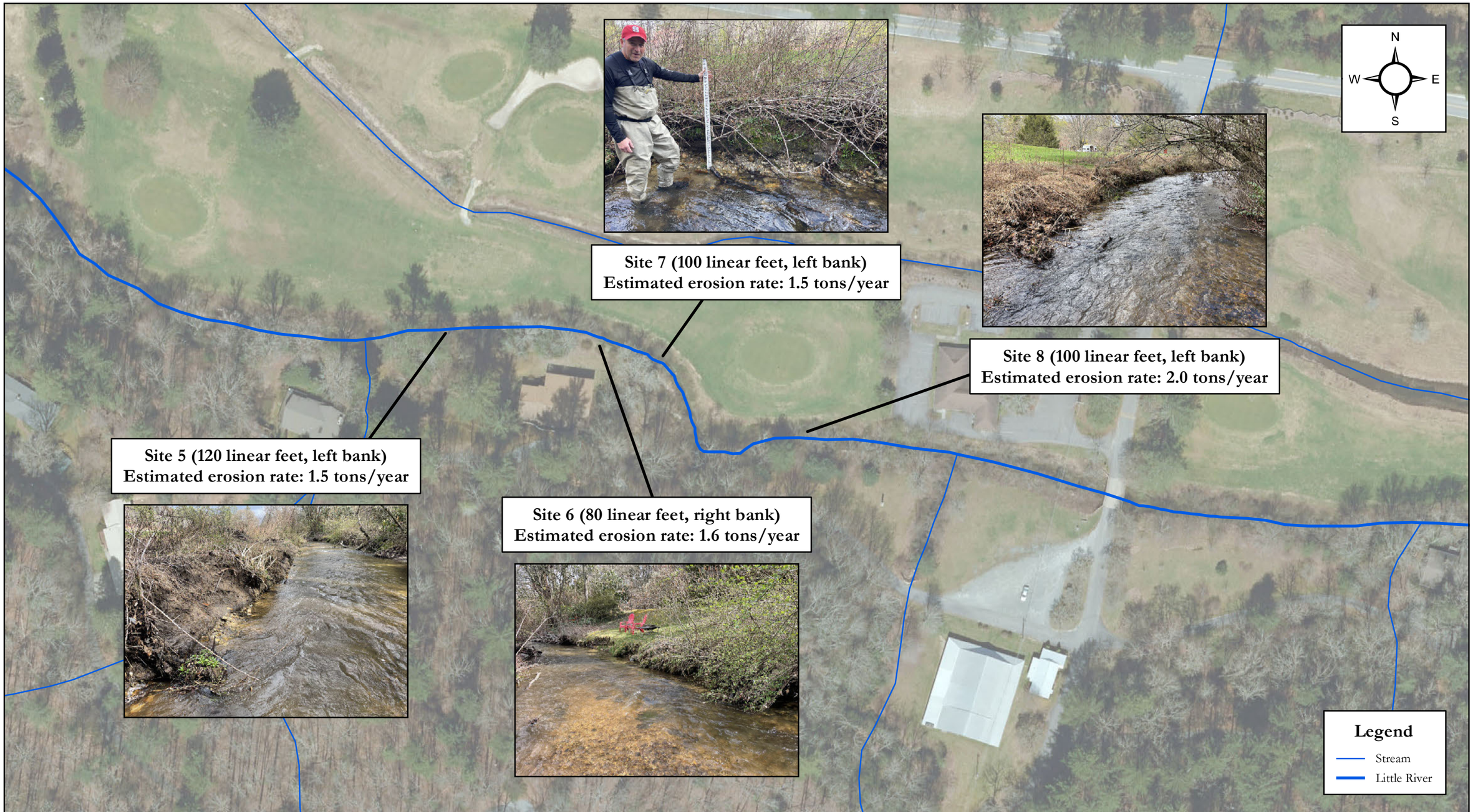
Jennings Environmental

Reach 1 Existing Conditions (Sites 1-4)

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A5



Jennings Environmental

Reach 1 Existing Conditions (Sites 5-8)

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A6

Site 11 (100 linear feet, left bank)
Estimated erosion rate: 2.7 tons/year

Site 9 (40 linear feet, left bank)
Estimated erosion rate: 0.5 tons/year

Site 10 (180 linear feet, left bank)
Estimated erosion rate: 6.6 tons/year

N
W E
S

Legend
- Stream
- Little River

0 50 100 200 300 400 Feet

Jennings Environmental

Reach 2 Existing Conditions (Sites 9-11)

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A7

Site 12 (100 linear feet, right bank)
Estimated erosion rate: 6.5 tons/year

Site 14 (230 linear feet, left bank)
Estimated erosion rate: 7.0 tons/year

Site 16 (80 linear feet, right bank)
Estimated erosion rate: 5.0 tons/year

Site 13 (60 linear feet, left bank)
Estimated erosion rate: 0.9 tons/year

Site 15 (60 linear feet, left bank)
Estimated erosion rate: 17.4 tons/year

N
W E
S

Legend
Stream
Little River

Jennings Environmental

Reach 3 Existing Conditions (Sites 12-16)

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A8

Site 17 (130 linear feet, left bank)
Estimated erosion rate: 9.6 tons/year

Site 19 (20 linear feet, left bank)
Estimated erosion rate: 1.2 tons/year

Site 21 (80 linear feet, left bank)
Estimated erosion rate: 25.0 tons/year

Site 18 (40 linear feet, right bank)
Estimated erosion rate: 1.6 tons/year

Site 20 (50 linear feet, right bank)
Estimated erosion rate: 3.2 tons/year

N
W E
S

Legend
- Stream
- Little River

Jennings Environmental

Reach 3 Existing Conditions (Sites 17-21)

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet A9

Table A1
Little River Restoration Master Plan
Estimated Streambank Erosion Rates

Site	Bank	Length (ft)	Height (ft)	BEHI	NBS	Erosion Rate (ft/yr)	Erosion Rate (cu ft/yr)	Erosion Rate (cu yd/yr)	Erosion Rate (tons/yr)	Erosion Rate (tons/yr/ft)
1	Left	50	4.5	Very High	High	0.90	202.5	7.5	8.2	0.16
2	Left	150	2.5	High	Moderate	0.15	56.25	2.1	2.3	0.02
3	Left	100	3	High	High	0.20	60	2.2	2.4	0.02
4	Left	120	2	High	Moderate	0.15	36	1.3	1.5	0.01
5	Left	120	2	High	Moderate	0.15	36	1.3	1.5	0.01
6	Right	80	2.5	High	High	0.20	40	1.5	1.6	0.02
7	Left	100	2.5	High	Moderate	0.15	37.5	1.4	1.5	0.02
8	Left	100	2.5	High	High	0.20	50	1.9	2.0	0.02
Reach 1 Total		820						19.2	21.0	0.015
9	Left	40	2	High	Moderate	0.15	12	0.4	0.5	0.01
10	Left	180	4.5	High	High	0.20	162	6.0	6.6	0.04
11	Left	100	4.5	High	Moderate	0.15	67.5	2.5	2.7	0.03
Reach 2 Total		320						8.9	9.8	0.007
12	Right	100	8	High	High	0.20	160	5.9	6.5	0.06
13	Left	60	2.5	High	Moderate	0.15	22.5	0.8	0.9	0.02
14	Left	230	5	High	Moderate	0.15	172.5	6.4	7.0	0.03
15	Left	60	6.5	Very High	Very High	1.1	429	15.9	17.4	0.29
16	Right	80	5.5	High	Very High	0.28	123.2	4.6	5.0	0.06
17	Left	130	6.5	High	Very High	0.28	236.6	8.8	9.6	0.07
18	Right	40	5	High	High	0.20	40	1.5	1.6	0.04
19	Left	20	5.5	High	Very High	0.28	30.8	1.1	1.2	0.06
20	Right	50	8	High	High	0.20	80	3.0	3.2	0.06
21	Left	80	7	Very High	Very High	1.1	616	22.8	25.0	0.31
Reach 3 Total		850						70.8	77.5	0.056

Repair areas of bank erosion by grading streambanks to a stable (3:1 or flatter) slope. As needed, install toe wood revetment and in-stream structures for bank protection and streambed diversification.

As needed, repair areas of bank erosion by grading streambanks to a stable (3:1 or flatter) slope.

Plant/enhance a riparian buffer of native trees, shrubs, and grasses on both banks of the river

Remove invasive vegetation throughout project areas

Start Reach 1

End Reach 1

As needed, repair minor areas of right bank erosion by grading streambanks to a stable (3:1 or flatter) slope. Eliminate grass mowing within the riparian buffer.

N
W E
S

Legend

- Stream
- Little River
- Vegetation Enhancement
- Bank Grading
- Bank Grading with Instream Structures
- Channel Realignment

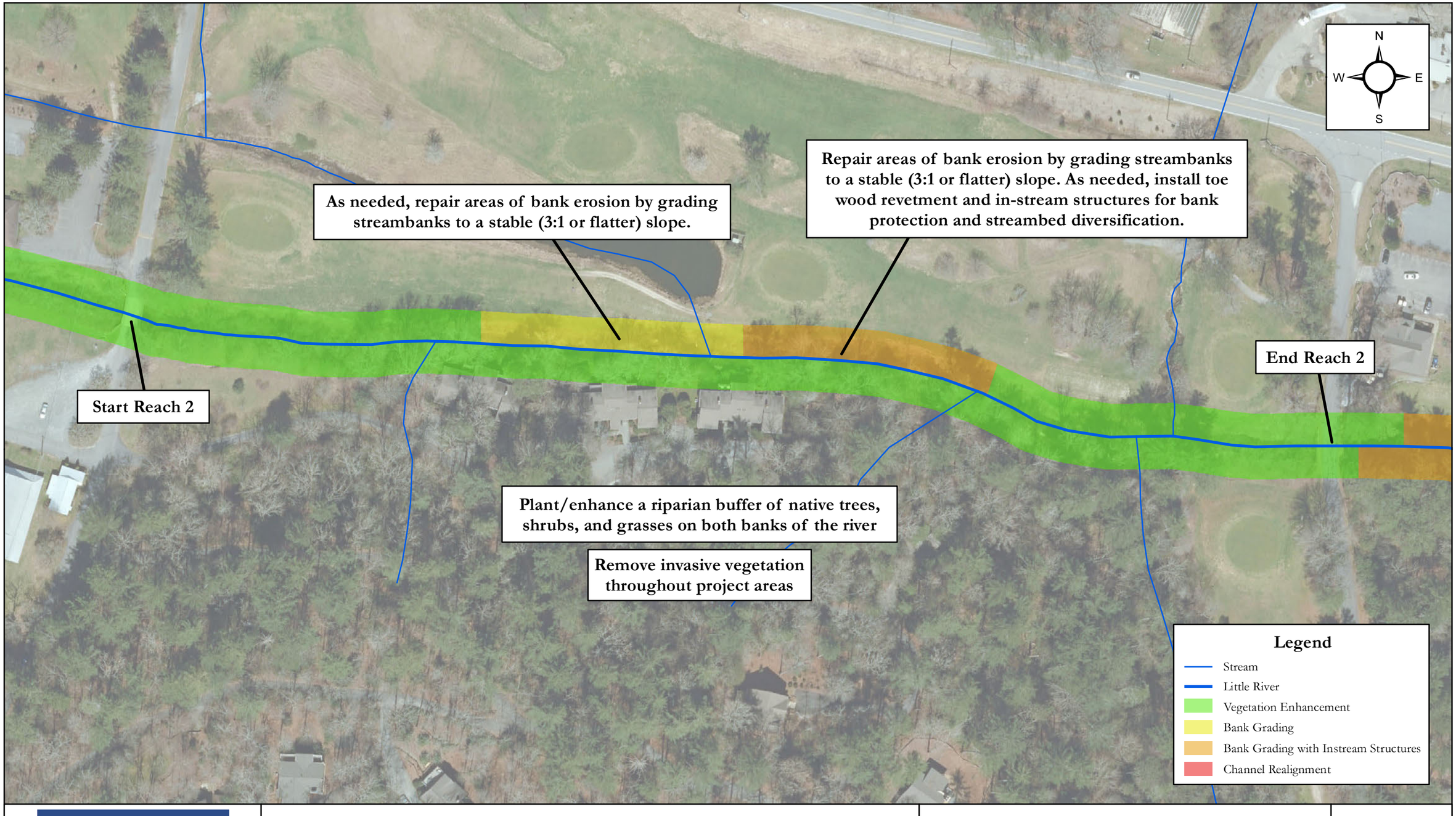
Jennings Environmental

Reach 1 Conceptual Design

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet B1



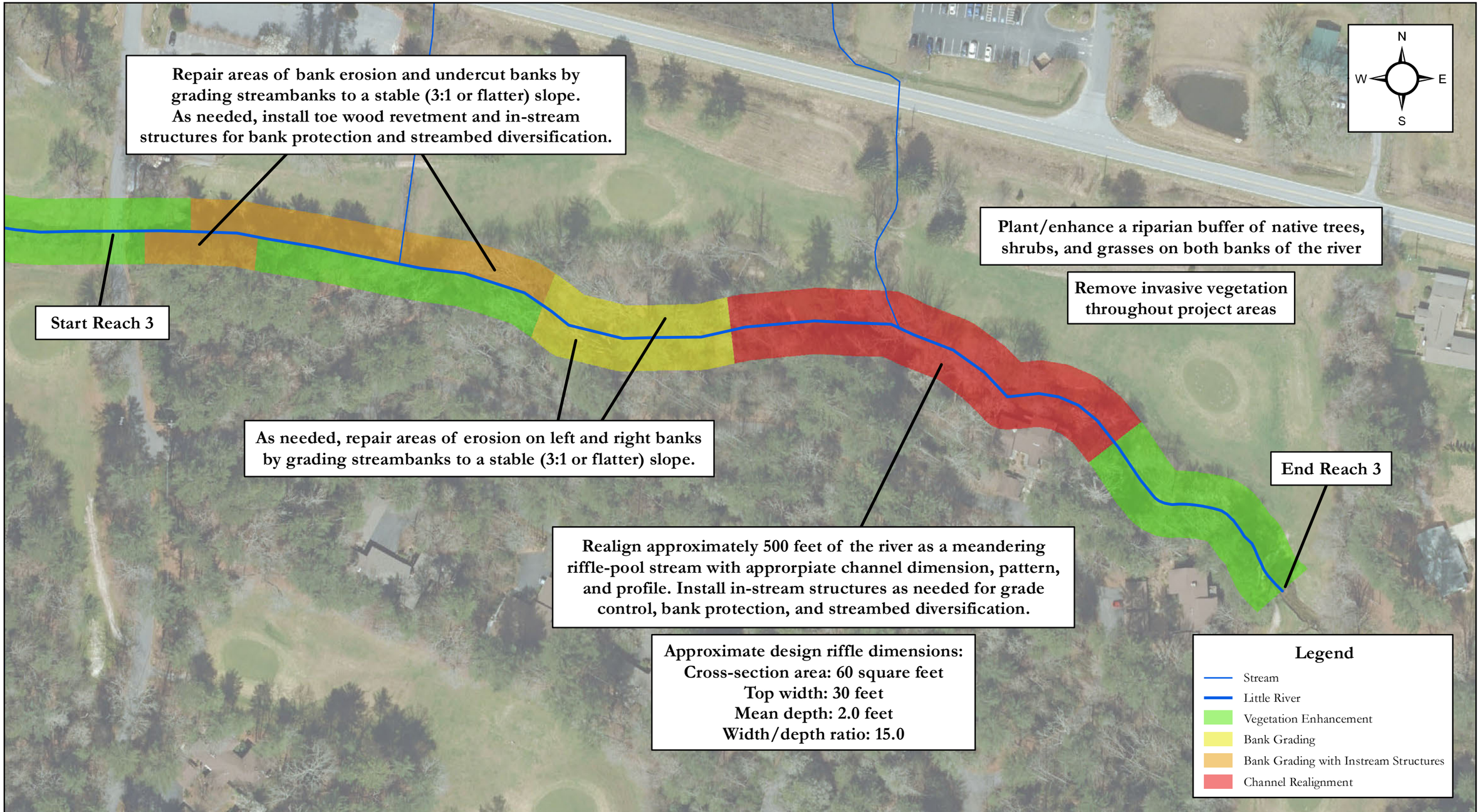
Jennings Environmental

Reach 2 Conceptual Design

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet B2



Jennings Environmental

Reach 3 Conceptual Design

0 50 100 200 300 400 Feet

Little River Restoration Master Plan
Transylvania County, North Carolina

Sheet B3

APPENDIX G

DAVIDSON RIVER
ASSESSMENT AND RESTORATION PLAN

Jennings Environmental

7 Samuel Ashe Drive, Asheville, NC 28805 | 919-600-4790 | greg@jenningsenv.com

Davidson River Assessment and Restoration Plan

The Davidson River has a 165 square mile watershed with over 25% of the watershed located within the boundary of the Pisgah National Forest. All but one mile of the mainstem of the river lies within the national Forest. The Davidson River is home to two species of concern: the Hellbender Salamander and the French Broad Crayfish. The Davidson River is on NC DEQ's list of impaired waters (303d) due to low pH.

Survey and evaluation efforts began in early 2021 at the request of the US Forest Service in collaboration with Lorie Stroup, USFS Fisheries Biologist and Brady Dodd, USFS Hydrologist. The focus of this efforts was the stream reach from Sycamore Flats and the area adjacent to the Davidson River Campground. This area is heavily used by multiple recreational user groups including hikers, bikers, tubers, swimmers, campers, and fishermen.

In July 2021 Jennings Environmental staff met with Lorie Stroup and members of the Pisgah Chapter of Trout Unlimited to begin to develop a strategy to evaluate the Davidson from the Forest Boundary in Pisgah Forest up stream to the Daniels Ridge Bridge. An outcome of these discussions was to train and utilize TU Volunteers to systematically evaluate the target area by section based on a previous "Adopt a Section" program that was done several years ago.

In mid-August 2021 Tropical Storm Fred brought unprecedented (a 500 year) flood event to Western NC and the Davidson River Watershed. This event caused significant damage to infrastructure, streambank and stream habitat in the river corridor including the privately controlled mile section from the confluence with the French Broad up to the Forest Service boundary.

OUTCOMES:

- September 27-October 6th 2021: In response to TS Fred emergency repair work was done upstream of the Daniels Ridge bridge. Two large debris jams were cleared, and the river channel re-established to protect the integrity of the bridge.

- January 11th and 13th 2022: TU Volunteers participated in live staking of critical areas damaged by Tropical Storm Fred. 15 volunteers planted over 500 live stakes.

- March 11th and 24th 2022: Volunteer trainings were held for TU members interested in doing section assessments. 12 sections were identified, and volunteers were trained to use the TU RIVERS App. to log observations and photos. TU Members and Jennings Environmental staff led the trainings. To date 12 volunteers have logged 46 hours and marked 151 data points with 273 photos.

Data can be found on the RIVERS App. : https://www.tu.org/science/science-engagement/community-science/rivers/ Scroll down the page to find the link to view "disturbance data".

STRATEGIES/NEXT STEPS:

- Continue working with partners to evaluate and prioritizing sites to match available and future funding for remediation/regeneration.
- Continue to review the TU RIVERS data to identify high priority sites for closer evaluation. From the initial review it appears that the section from Looking Glass Creek confluence to the Fish hatchery will be high priority due to a significant number of sites including debris jams, channel instability, streambank erosion and recreational impacts.
- Continue working with TU Volunteers and encourage continuing the section surveys on a regular basis using the RIVERS App.
- Revisit the already designated High Priority section from Sycamore Flats to Averys Creek and note significant disturbances and issues caused by recreational use and natural causes and begin planning for possible solutions.
- Continue conversations with property owners on the private section of the river to look for opportunities for improvements both instream, streambank and adjoining land uses to include:

    - Significant streambank erosion and debris jams
    - Habitat improvements
    - Erosion threatening DOT infrastructure (Davidson River Rd.)
    - Removal of abandoned RR Trestle
    - Moving or upgrading County Solid waste collection and transfer facility

Addendum

Upper French Broad River
Watershed Restoration Plan

Transylvania and Henderson Counties
North Carolina

Prepared for:

CONSERVING CAROLINA
MOUNTAINS • FOOTHILLS • RIVERS • FARMS

NORTH CAROLINA LAND & WATER FUND

Prepared by:

Jennings Environmental

January 2023

This document supplements the Upper French Broad River Watershed Restoration Plan by adding two additional project sites identified by new property owners after the initial screening was completed in 2022. These potential projects on properties owned by the Coopers and McCabes include areas critical to improving water quality, reducing streambank erosion, and providing floodplain resilience in Transylvania County. Both property owners are committed to donating conservation easements for the restoration project areas. Project information is summarized below with conceptual plans following.

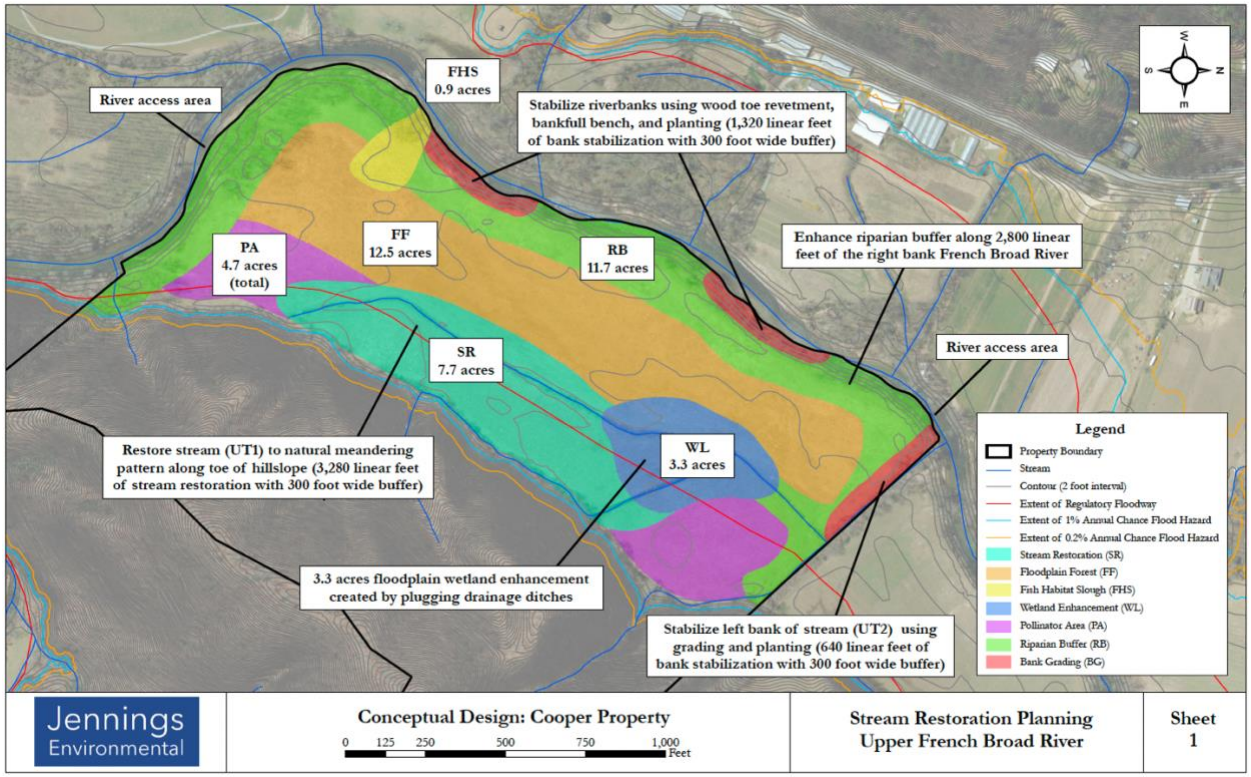
Name	Parcel Size (acres)	PIN	Owner
Cooper Property	134	8562-28-2874	Cooper
McCabe Property	68	9507-62-4832	McCabe

The proposed design approaches for these projects are described below.

Cooper Property: This project addresses approximately 50 acres of land in the floodplain of the French Broad River. The proposed restoration project will include:

- French Broad River bank stabilization along 1,320 linear feet of right bank.
- River buffer enhancement 300 feet from bank totaling 11.7 acres.
- Stream restoration totaling 3,280 linear feet on a first-order tributary contained entirely within this parcel.
- Wetland enhancement totaling 3.3 acres associated with ditch plugging and planting.
- Excavate a fish habitat slough (approximately 0.9 acres in area) that is hydrologically connected to the French Broad River.
- Create floodplain forest and pollinator areas in existing open areas on the property.
- Manage invasive plants throughout the project area.

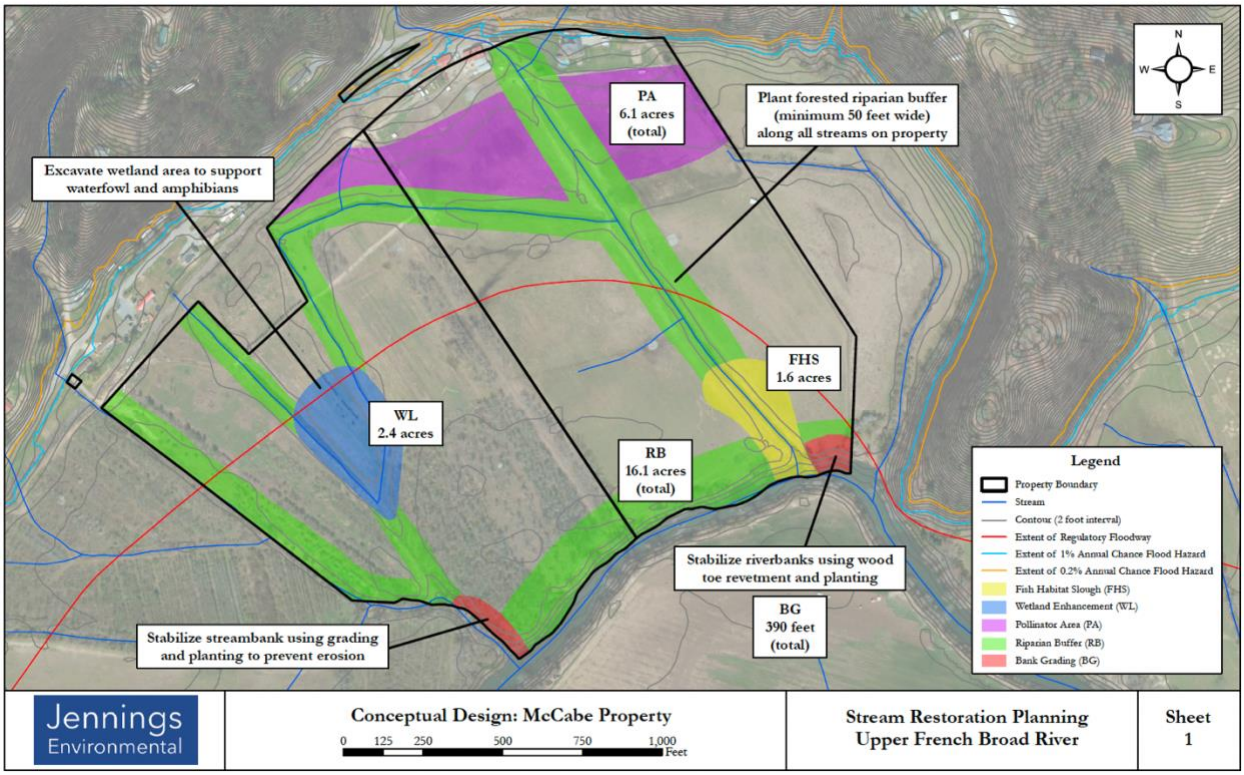
Estimated costs for this project are $1,400,000 for construction and planting in addition to $200,000 for engineering and permitting.



McCabe Property: This project addresses approximately 45 acres of land in the floodplain of the French Broad River. The proposed restoration project will include:

- French Broad River bank stabilization along 390 linear feet of left bank.
- River buffer enhancement 300 feet from bank totaling 16.1 acres.
- Stream restoration totaling 1,100 linear feet on a first-order tributary flowing through this parcel.
- Wetland enhancement totaling 2.4 acres associated with ditch plugging and planting.
- Excavate a fish habitat slough (approximately 1.6 acres in area) that is hydrologically connected to the French Broad River.
- Create floodplain forest and pollinator areas in existing open areas on the property.
- Manage invasive plants throughout the project area.

Estimated costs for this project are $700,000 for construction and planting in addition to $140,000 for engineering and permitting.


PA
6.1 acres
(total)
Plant forested riparian buffer
(minimum 50 feet wide)
along all streams on property
Excavate wetland area to support
waterfowl and amphibians
FHS
1.6 acres
WL
2.4 acres
RB
16.1 acres
(total)
Stabilize riverbanks using wood
toe revetment and planting
BG
390 feet
(total)
Stabilize streambank using grading
and planting to prevent erosion
N
W
E
S
Legend
Property Boundary
Stream
Contour (2 foot interval)
Extent of Regulatory Floodway
Extent of 1% Annual Chance Flood Hazard
Extent of 0.2% Annual Chance Flood Hazard
Fish Habitat Slough (FHS)
Wetland Enhancement (WL)
Pollinator Area (PA)
Riparian Buffer (RB)
Bank Grading (BG)
Jennings
Environmental
Conceptual Design: McCabe Property
0 125 250 500 750 1,000
Feet
Stream Restoration Planning
Upper French Broad River
Sheet
1