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Feasibility Study:
Stream Restoration of Beeson Creek and Tributaries
Located Near Ivey M. Redmon Sports Complex, Kernersville, NC

Submitted to Town of Kernersville, North Carolina

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This report describes results of a feasibility study for the restoration of Beeson Creek and tributaries located in and nearby the Ivey M. Redmon Sports Complex in Kernersville, North Carolina. This report is a compilation of results from two phases of the feasibility study completed in 2015 and 2016. The study streams are located to the West of the ball fields in the Sports Complex extending Southward from near Shields Road toward I-40. The total length of streams evaluated in this study is approximately 7,600 linear feet.

The Feasibility Study will be used for grant applications and funding allocations to implement a multi-phase restoration and environmental education project. Overall project objectives are to improve water quality, habitat, and public access for education by applying natural stream restoration techniques. Long-term benefits to the Town include recreational trails, environmental education opportunities, improved environmental quality, and native riparian vegetation.

1. Stream Condition Assessment

The streams were assessed to determine existing conditions regarding topography, hydrology, stream morphology, soils and geology, site constraints, property boundaries, utilities, vegetation, and aquatic biology. Additionally, spatial data provided by the Town of Kernersville were reviewed, including aerial photography, 2-foot topographic contours, property boundaries, and utility locations. This information is used to document existing stream stability problems, sediment loading downstream, and available land for reconnecting floodplains in areas with incised streams.

Based on morphological conditions, the streams were separated into 7 reaches. Reach 1 (East Branch) and Reach 2 (West Branch) flow together to form the mainstem of Beeson Creek. Reach 3 extends from this confluence downstream to the vicinity of an existing head cut in the main stream. Reach 4 begins at the head cut and ends where Beeson Creek exits the southern property boundary of the Sports Complex. Reach 5 is the mainstem of Beeson Creek downstream of the Town property boundary and upstream of I-40. Reach 6 is upstream of Reach 2 (West Branch). Reach 7 is an unnamed tributary on the Clarke property. A map showing reach locations is included in Sheet 2 of the attached plan set. Stream reach morphology characteristics are summarized in Table 1.

Table 1. Stream Reach Morphology Characteristics

Reach	Length (feet)	Drainage area (square miles)	Stream slope (feet/foot)	Rosgen stream classification
1 (East Branch)	1300	0.08	0.017	E5
2 (West Branch)	670	0.12	0.013	E5
3 (Beeson)	560	0.29	0.009	E5
4 (Beeson)	1680	0.33	0.011	G5c
5 (Beeson)	1290	0.79	0.005	G5c
6 (West Branch)	1080	0.06	0.018	G5c
7 (Tributary)	1040	0.06	0.019	E5

The following constraints to potential stream restoration projects were noted:

Property boundaries: Portions of Reaches 1, 2, 3, and 4 and nearly all of Reaches 5, 6, and 7 are located on parcels outside of the Sports Complex. The affected property owners and Homeowner Associations will need to be involved in the restoration process.

Utilities: A sewer main parallels Reaches 2, 3, 4, and 5. It crosses under the streambed at the upstream end of Reach 3 and again within Reach 4. Additionally, one closely parallels most of Reach 6, and crosses Reach 6 once, toward the downstream end. Reach 7 is not affected by sewer utilities, with the exception of a crossing near the confluence with Beeson Creek. There are restoration options that will co-exist with these sewer lines, while providing increased protection from erosion for the utilities.

Topography: Reaches 1, 2, 6, and 7 are located in narrow, deep valleys. The lateral constraints of the valley walls affect the potential restoration options. The other Reaches are in wider valleys that provide multiple options for stream and floodplain restoration.

Soils and local geology appear to be conducive for stream restoration. The predominant soil type in the Beeson Creek valley is Hatboro loam, which is typically found in low-slope floodplains. Streambed substrate is predominantly sand, with some small gravel. No bedrock was observed; however, this would present a lateral and/or vertical constraint if it does exist.

Cross-section channel dimensions were noted at the top of streambank, and were highly variable throughout all reaches. Cross-section dimensions are summarized in Table 2, with cross-section plots on Sheet 3 of the attached plan set. Field assessments indicated that Reaches 1, 2, 3 and 7 (downstream) are generally not incised or entrenched, with cross-section dimensions similar to what would be expected for their watershed sizes in the North Carolina Piedmont. The Rosgen stream classification of E5 for these reaches indicates a low-gradient (less than 2%), sand-bed, healthy stream system with good floodplain connection for dispersing erosive energy during high flows.

Reaches 4, 5, and 6 are incised and entrenched, with cross-section areas, widths, and depths much greater than expected for a stable stream with a watershed drainage areas of less than one square mile in the Piedmont ecoregion. Incision is a result of vertical cutting such that flood flows no longer spread onto the floodplain, thereby dissipating erosive energy. Entrenchment is the lateral confinement of flood flows within a narrow channel resulting in high bank erosion and tree falling during high flows. The Rosgen stream classification of G5c indicates a low-gradient (less than 2%), sand-bed, entrenched stream which is rapidly eroding and causing downstream sediment impacts. This is a very unstable stream type which provides a good opportunity for restoration benefits to the ecosystem.

The downstream portion of Reach 7 is not incised or entrenched. Further upstream on Reach 7, the stream transitions to an incised, entrenched gully, with eroding head cuts migrating up valley during storm events.

Table 2. Channel Cross-section Dimensions (measured at top of bank)

Reach	Area (square feet)	Width (feet)	Depth (feet)	Valley width (feet)
1	3 to 4	5 to 7	0.5 to 1.0	30 to 40
2	8 to 12	7 to 10	1.0 to 1.2	20 to 30
3	9 to 12	10 to 12	1.0 to 1.2	60 to 90
4	35 to 100	12 to 30	3 to 5	70 to 150
5	70 to 100	15 to 25	3 to 5	90 to 150
6	30 to 40	12 to 15	2 to 4	30 - 60
7 downstream	8 to 15	6 to 8	1 to 2	50 - 90
7 upstream	50 to 200	10 to 20	5 to 12	30 - 60

Streambank erosion rates were estimated for the stream reaches using the combination of Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS). Predicted erosion rates are summarized in Table 3. Streambanks within reaches 1, 2, and 3 predominantly had a 'Low' BEHI, with some areas of 'Moderate' and 'Very Low'. This resulted in relatively low streambank erosion rates predicted for Reaches 1, 2, and 3.

BEHI scores for Reaches 4 and 5 were generally 'High' and 'Moderate', with some areas of 'Very High'. In Reach 4, this high erodibility, combined with a large streambank height (approximately 5 feet), resulted in very high predictions for streambank erosion rates. It is estimated that 174 tons per year of sediment is generated by streambanks within Reach 4 (compared to <10 tons per year for Reaches 1, 2, and 3 combined). This high erodibility in Reach 4 is supported by visual observations of eroding banks, fallen trees, and downstream sediment deposition.

BEHI scores for Reach 6 were generally either 'Low' or 'High,' with instances of 'Moderate' and 'Very Low' (through the piped section). The upper third (approximately 350 feet) of Reach 7 had 'High' and 'Very High' BEHI, while the remainder of the reach had 'Low' and 'Moderate' BEHI. Within Reaches 6 and 7, the BEHI/NBS analysis likely did not fully capture erosion potential, due to the presence of head cuts and eroding bluffs. The high erodibility in all reaches is supported by visual observations of eroding banks, fallen trees, and downstream sediment deposition.

Table 3. Streambank Erosion Rates (Estimated using Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS)

Reach	Length (feet)	Erosion rate (tons/year)	Erosion rate (tons/year/linear foot)
1 (East Branch)	1300	3.2	0.002
2 (West Branch)	670	2.9	0.004
3 (Beeson)	560	2.6	0.005
4 (Beeson)	1680	174	0.104
5 (Beeson)	1290	20.4	0.016
6 (West Branch)	1080	27.6	0.026
7 (Tributary)	1040	12.4	0.015

The riparian vegetation community is a mix of native hardwood trees and invasive shrubs, including Chinese Privet (*Ligustrum sinense*). Many areas of Reaches 1, 2, 3, 6, and 7 contain mostly healthy native trees that should be preserved. The vegetation in Reaches 4 and 5 is dominated by invasive plants that should be removed and prevented from re-establishing in order to promote a healthy, diverse streamside forest.

2. Restoration Opportunities

Stream restoration and stormwater management projects may be implemented for each stream reach as described below to improve water quality, aquatic habitats, floodplain functions, streamside vegetation, and environmental education opportunities. For each phase, one or more conceptual restoration plans are presented in the attached plan set with estimated implementation costs in Table 4.

Reach 1: Reach 1 is currently not incised or entrenched, with a narrow valley and mature riparian vegetation. A stream restoration project on Reach 1 will focus on enhancing habitats and improving water quality through repair of localized bank erosion. Opportunities exist for stormwater management in the watershed of Reach 1, specifically in the vicinity of the cross-country running trail. Specific components of restoration on Reach 1 may include:

- Leave the stream channel in its existing planform location, with the exception of localized realignment to mitigate eroding streambanks
- As needed, grade streambanks to reduce erosion, provide floodplain access, and maintain the design channel width (approximately 6-7 feet)
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Vegetate bare areas and areas disturbed by grading with appropriate native riparian vegetation
- Manage stormwater within the watershed through use of sediment traps, bare area stabilization, vegetated swales, and infiltration

Reach 2: Much like Reach 1, Reach 2 is currently not incised or entrenched, with a narrow valley and mature riparian vegetation. A stream restoration project on Reach 2 will focus on enhancing habitats and improving water quality through repair of localized bank erosion. Opportunities exist for stormwater management in the watershed of Reach 2, specifically in the agricultural fields to the north and east, and in the residential area to the west. Specific components of restoration on Reach 2 may include:

- Leave the stream channel in its existing planform location, with the exception of localized realignment to mitigate eroding streambanks
- As needed, grade streambanks to reduce erosion, provide floodplain access, and maintain the design channel width (approximately 8-9 feet)
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Vegetate bare areas and areas disturbed by grading with appropriate native riparian vegetation
- Manage stormwater within the watershed through use of sediment traps, bare area stabilization, and infiltration

Reach 3: Reach 3 is a relatively short, stable reach below the confluence of Reach 1 and 2. Reach 3 is not currently not incised or entrenched, though upstream migration of the existing headcut in Reach 4 could change the morphology of Reach 3 over time. A stream restoration project on Reach 3 will focus on enhancing habitats and improving water quality through repair

of localized bank erosion, as well as protection of the sewer line the crossed under the stream channel. Specific components of restoration on Reach 2 may include:

- Leave the stream channel in its existing planform location, with the exception of localized realignment to mitigate eroding streambanks (Note: the valley width and utility locations would allow for realignment of portions of Reach 3 if needed to facilitate restoration of Reach 4)
- As needed, grade streambanks to reduce erosion, provide floodplain access, and maintain the design channel width (approximately 10-12 feet)
- Install boulder structure downstream of sewer line crossing to provide grade control and infrastructure protection
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Vegetate bare areas and areas disturbed by grading with appropriate native riparian vegetation
- Enhance existing stormwater basin to the east of Reach 3 by enlarging, grading and revegetating to enhance stormwater wetland function
- Manage stormwater within the watershed; specifically, by converting swales between ball fields to infiltration swales, bioretention areas, and/or stormwater wetlands

Reach 4: Reach 4 begins at a large head cut, which has left the entire reach incised and unstable, with eroding streambanks, poor floodplain access, and poor vegetation. Restoration of Reach 4 will create a stable, meandering stream with appropriate cross-section dimensions, a wide floodplain, and healthy riparian vegetation. Two conceptual options have been developed for Reach 4. Both options include:

- Create a new stream channel with appropriate meander pattern, bedform profile, cross-section dimension (channel width of approximately 10-12 feet), and stable streambanks
- Install boulder structure downstream of sewer line crossing to provide grade control and infrastructure protection
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Revegetate the streambanks and floodplain with appropriate native riparian vegetation
- Fill much of the old stream channel, with portions used to treat stormwater runoff from the ball fields

The primary difference between Option 1 and Option 2 for Reach 4 is the elevation of the realigned stream channel. Option 1 leaves much of Reach 4 at its current elevation, while Option 2 would raise the streambed elevation to reconnect it to its historic floodplain. Specific components of these options include:

Reach 4, Option 1:

- Replace the elevation drop over existing unstable head cut with a series of log and boulder step structures
- Downstream of the drop structures, excavate a wide (approximately 55 feet) floodplain through the length of the valley
- Realign the stream channel through the new valley at the existing streambed location

- Near the downstream end of Reach 4, transition the floodplain and channel to match conditions downstream of the project

Reach 4, Option 2:

- Eliminate the elevation drop over existing unstable head cut by filling the stream channel to design elevations and stabilizing with grade control structures
- Downstream of the existing head cut, realign the stream channel through the existing valley at a higher elevation
- Use the existing terrace as the new floodplain, with minimal floodplain excavation needed
- Near the downstream end of Reach 4, use a series of log and boulder step structures to lower the streambed elevation to match existing elevations downstream of the project

Reach 5: Reach 5 spans from the downstream end of Reach 4, at the Sports Complex property boundary, to I-40. The reach is generally incised, due to a head cut that has migrated upstream into Reach 4. Reach 5 does contain eroding streambanks, poor floodplain access, and poor vegetation. Restoration of Reach 5 would create a stable, meandering stream with appropriate cross-section dimensions, a wide floodplain, and healthy riparian vegetation. Two conceptual options have been developed for Reach 5. Both options include:

- Create a new stream channel with appropriate meander pattern, bedform profile, cross-section dimension (channel width of approximately 14-16 feet), and stable streambanks
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Revegetate the streambanks and floodplain with appropriate native riparian vegetation
- Fill much of the old stream channel, with portions used to treat stormwater runoff from the adjacent forest and sewer right-of-way
- Manage stormwater within the watershed through use of sediment traps, bare area stabilization, vegetated swales, and infiltration

The primary difference between Option 1 and Option 2 for Reach 5 is the elevation of the realigned stream channel. Option 1 leaves much of Reach 5 at its current elevation, while Option 2 would raise the streambed elevation to reconnect it to its historic floodplain. Options for restoration of Reaches 4 and 5 should be considered concurrently; Reach 4, Option 1 should be paired with Reach 5, Option 1, and similarly for Option 2. Specific components of these options include:

Reach 5, Option 1:

- At the upstream end, connect with the location and elevation at the downstream end of Reach 4, Option 1
- Excavate a wide floodplain through the length of the valley (up to 120 feet wide, though gradually narrower at upstream and downstream ends)
- Realign the stream channel through the new valley at the existing streambed location
- Near the downstream end of Reach 5, transition the floodplain and channel to match conditions downstream of the project (i.e., within the NCDOT right-of-way for I-40)

Reach 5, Option 2:

- Revise the design of Reach 4, Option 2 to not step down the streambed elevation at the downstream end of Reach 4; connect Reach 5 with the revised location and elevation at the downstream end of Reach 4
- Realign the stream channel through the existing valley at a higher elevation
- Use the existing terrace as the new floodplain, with minimal floodplain excavation needed
- Near the downstream end of Reach 5, use a series of log and boulder step structures to lower the streambed elevation to match existing elevations downstream of the project (i.e., within the NCDOT right-of-way for I-40)

Reach 6: A stream restoration project on Reach 6 would focus on enhancing habitats and improving water quality through repair of localized bank erosion, poorly vegetated banks, and one major head cut. All restoration activities within Reach 6 would take place downstream of the piped section under Emperor Lane, with differing approaches throughout the reach. Specific components of restoration on Reach 6 could include:

- Leave the stream channel in its existing planform location, with the exception of localized realignment to mitigate eroding streambanks
- Within the grassed area downstream of Emperor Lane, install appropriate riparian vegetation (e.g., live stakes) and repair localized bank erosion
- Within the forested area downstream of the residential area, grade streambanks to reduce erosion, provide floodplain access, and create the design channel width (approximately 6-7 feet)
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Within the lowest 200 feet of Reach 6, where the stream closely parallels the sewer line, make no changes to stream dimension or planform, but install appropriate riparian vegetation
- Stabilize the stormwater-driven head cut off of Constantine Place with one of two options that include a Regenerative Stormwater Conveyance (RSC):
    - Option 1: Install a rock-lined energy dissipation basin at an elevation near the upper elevation of the head cut; fill the head cut with a 56-foot long RSC, with multiple steps, to convey flow from the basin to Reach 6
    - Option 2: Install a stormwater inlet/drop structure at an elevation near the upper elevation of the head cut (build an earthen berm to force flow into the inlet); convey flow through a pipe for approximately 20 feet into an energy dissipation basin, then into a 36-foot long RSC
- Vegetate bare areas and areas disturbed by grading with appropriate native riparian vegetation
- Manage stormwater within the watershed through use of sediment traps, bare area stabilization, vegetated swales, and infiltration

Reach 7: The upper end of Reach 7 is characterized by severe head cuts and eroding banks. By the lower end of the reach, the stream has stable dimensions and some floodplain access. A stream restoration project on Reach 7 would focus on enhancing habitats and improving water

quality through repair of bank erosion, poorly vegetated banks, and the head cuts. Specific components of restoration on Reach 7 could include:

- Leave the stream channel in its existing planform location, with the exception of localized realignment to mitigate eroding streambanks and head cuts
- Remove dead, dying, or hazardous trees near the tops of eroding bluffs
- As needed, grade streambanks to reduce erosion, provide floodplain access, and create the design channel width (approximately 6-7 feet)
- As needed, install log and boulder structures in the streambed to enhance habitat, promote sediment transport, provide grade control, and protect streambanks
- Install a log or boulder grade control structure downstream of the sewer line crossing
- Stabilize the head cuts at the upstream end of the reach using a Regenerative Stormwater Conveyance (RSC) with multiple steps
- Vegetate bare areas and areas disturbed by grading with appropriate native riparian vegetation
- Manage stormwater within the watershed through use of sediment traps, bare area stabilization, vegetated swales, and infiltration

Stormwater Management: Based on field visits, and a review of aerial photography and topography, several potential Stormwater Control Measures (SCMs) were identified for the Sports Complex property. These include enhanced swales, bioretention areas, and constructed stormwater wetlands. A conceptual view of these is shown on Sheet 14 of the attached plan set. All potential SCMs do not have to be implemented at the same time; they could be phased based on funding and other constraints. Potential SCMs include:

- *SCM 1*: Create a sediment basin and/or bioretention area to the south of the maintenance building (approximately 3600 square feet)
- *SCM 2*: Enlarge and enhance the existing basin along Beeson Creek to function as a riparian stormwater wetland (approximately 6300 square feet)
- *SCM 3*: Create multiple floodplain wetlands in the abandoned stream channel in conjunction with a stream restoration project on Reach 4 of Beeson Creek
- *SCM 4*: Retrofit an existing swale between ball fields to function as a wet swale, with temporary water storage, microtopography and appropriate wetland vegetation (approximately 250 feet in length)
- *SCM 5*: Create a bioretention area in an existing low area among the ball fields; modify the existing outlet structure and soils to provide temporary storage and infiltration (approximately 9800 square feet)
- *SCM 6*: Retrofit an existing swale between ball fields to function as a vegetated infiltration swale (approximately 250 feet in length)
- *SCM 7*: Create a grassed swale downslope of the cross-country track to direct runoff to SCM 8 (approximately 260 feet in length)
- *SCM 8*: Enlarge and retrofit an existing sediment basin downslope of the cross-country track to function as a stormwater wetland, with a level spreader used at the outlet (approximately 5800 square feet)

- *SCM 9*: Create a grassed swale downslope of the cross-country track to direct runoff to SCM 8 (approximately 180 feet in length)
- *SCM 10*: Stabilize bare and sparsely vegetated areas within the headwaters of Reach 1 with appropriate ground cover (approximately 1.8 acres)

Table 4. Estimated Stream Restoration Implementation Costs

Reach	Estimated Cost
1	$60,000
2	$30,000
3	$30,000
4 – Option 1	$480,000
4 – Option 2	$400,000
5 – Option 1	$380,000
5 – Option 2	$320,000
6 – Head Cut Option 1	$240,000
6 – Head Cut Option 2	$280,000
7	$240,000
All Potential SCMs	$180,000

All reaches have high potential for improvement with regard to stream stability, water quality improvement, and habitat enhancement. The restoration options for Reaches 4 and 5 have advantages and disadvantages related to stability, cost, excavation volumes, floodplain composition, and vegetation. A full topographic survey would be needed to fully inform the choice between options for Reaches 4 and 5. Additionally, decisions related to design should only be made after a full evaluation of project goals and resources, with input from stakeholders.

3. Educational Opportunities

The Ivey M. Redmon Sports Complex is ideally suited to serve as an outdoor environmental education center. The parking, restrooms, and available space for walking trails support a wide range of target audiences including youth, gardeners, ecologists, engineers, and contractors. Workshops may be held year-round to teach groups about the following topics:

- Stream ecology
- Stream morphology assessment
- Stream stabilization and protection
- Streamside vegetation
- Soil science
- Wetland science
- Wildlife
- Invasive plant management
- Stormwater management
- Watershed protection

A recreational walking trail along the stream and nearby wetlands may include interpretive signs and exhibits to describe aspects of each of the above topics using attractive photos and graphics. This trail may include boardwalks and observation platforms in sensitive areas.

During implementation of restoration and stormwater management measures, workshops may be organized for professionals and interested citizens to learn about stream assessment, restoration design and implementation, construction, and planting. Follow-up workshop topics may include monitoring and plant management. All of these educational programs may be conducted in cooperation with NC Cooperative Extension and NC State University to provide continuing education credits for professionals as needed.

Appendix. Photographs

Reach 1 Typical Condition.

Reach 2 Typical Condition.

Reach 3 Typical Condition.

Reach 4 Typical Condition at Upstream End.

Reach 4 Typical Condition Near Sewer Line.

Reach 4 Typical Condition at Downstream End.

Reach 5 Typical Condition.

Reach 6 Typical Condition at Upstream End.

Reach 6 Typical Condition at Downstream End.

Reach 6 Side Channel Head Cut.

Reach 7 Typical Condition at Downstream End.

Reach 7 Typical Condition at Upstream End.

Reach 7 Head Cut at Upstream End.