Feasibility Study Report

Reedy Creek Watershed Enhancement

Contract Number: 1100719

Charlotte, North Carolina

Prepared for:
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1.0 Introduction

The purpose of this report is to summarize the data collection, analysis, and professional opinion concerning the feasibility of restoring, enhancing, and/or preserving the headwater systems/tributaries to Reedy Creek. The study reaches are mostly contained on public land inside the Reedy Creek Park and Nature Preserve with the exception of the headwaters of two tributaries that start on adjacent privately owned parcels. The study area (area or site) is the top of the Reedy Creek Watershed. The site is located in eastern Mecklenburg County in the Yadkin River Watershed (USGS HUC 03040105010050 and DWQ 03-07-11) and is bordered by Grier Road to the north and Plaza Road Extension to the south (Figure 1).

The total study area contains approximately 44,060 feet of jurisdictional stream, three in-line lakes/ponds, and seven wetlands totaling approximately 3.3 acres. Of the above approximately 22,000 feet of stream and 1.9 acres of wetland are on property owned by Mecklenburg County. The site was identified as a potential mitigation site in the Stream Restoration Ranking Protocol (SSRP) Ranking Document prepared by Collins and Baker for Charlotte-Mecklenburg Storm Water Services (CMSWS).

The purpose of this report is to present a summary of:

- Information obtained during data collection
- Field assessment and constraints
- Existing conditions and unique features
- Alternative conceptual designs
    - Location and type of stream restoration
    - Location of storm water BMP or other improvements
    - Pros and cons of alternative
    - Preliminary opinion of cost of alternatives
    - Preliminary opinion of compensatory mitigation credits for each alternative

2.0 Data Collection

The following background data was collected for the project site:

- Mecklenburg County GIS mapping
    - Topography
    - Storm Drainage
    - Aerials
    - FEMA Zones
    - Water Quality Buffers
    - Parcel data
- Federal and State GIS Data Sources
    - Soils Mapping
    - National Wetland Inventory (NWI)
- Ordinances and Guidelines
    - Charlotte Post Construction Controls Ordinance (PCCO)
    - CMSWS Mitigation Monitoring Guidelines
    - USACE-Wilmington District and NC-DWQ Stream Mitigation Guidelines (2003)

    - County Floodplain Policy
    - NC DWQ's Interim, Internal Technical Guide – Benthic Macroinvertebrate Monitoring Protocols for Compensatory Stream Restoration Projects
- Environmental Data Resources (EDR) report
- Parks and Recreation's website on Reedy Creek http://www.charmeck.org/mecklenburg/county/ParkandRec/InsideTheDepartment/Divisions/StewardshipServices/NaturePreserves/Pages/Reedy.aspx)

The following data was collected in the field:

- Qualitative field assessment
- Quantitative field assessment
    - Geomorphic survey and stability
        - Rosgen classification of each Reach 1-11
            - Cross-section and profile locations shown on Figure 3
        - Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS)
    - Geotechnical and soils
        - Soil strata and classification
            - Collection locations shown on Figure 3
    - Constraints Analysis
        - Utilities and other infrastructure (roads, paths, bridges, and ponds)
        - Mature trees and unique vegetation
        - Construction footprint and access
        - Topography and unique features
    - Jurisdictional determinations
        - DWQ stream origins classification for the watershed
        - 1987 routine wetland determination data for 7 wetlands
        - Rapanos forms
        - Stream data points and wetland data points shown on Figure 2
    - Biological
        - Benthic Macroinvertebrate per NC DWQ guidelines
            - Modified Qual-4 collection method
        - Monitoring locations shown on Figure 3
    - Physiochemical
        - Same monitoring location as biological
        - Physical conditions measured using a calibrated handheld water quality sonde
            - Measurements include temperature, pH, dissolved oxygen, turbidity, and conductivity
        - Grab samples taken to measure: fecal coliform, total phosphate, nitrate, biological oxygen demand, and total dissolved solids.

3.0 Assessment Summary and Constraints Analysis

Overview:
The project site is the top of the watershed. As a result, there are varieties of hydrologic and jurisdictional features. These features include ephemeral channels, seasonal and perennial streams, linear wetlands, and

open water (in-line lakes/ponds) in Figure 2. There are eleven (11) distinct stream segments and seven (7) unique wetlands.

Approximately 40-50% of the studied streams and corresponding watersheds are contained in the Reedy Creek Park and Nature Preserve (Figure 2). Overall, the site is generally wooded (hardwood and pine forests) with the exception of some open space around the largest in-line lake and the upstream reaches of Reach 4, and 8, which are contained on private property. The Reedy Creek Nature Preserve is 727 acres of the 1630-acre watershed and provides active and passive recreation. The areas around the streams and wetlands are mostly undisturbed forested corridors with the exception of some hiking trail footbridge crossings in the upper reaches and a maintained sewer easement along some of the lower reaches.

Streams:
Being a headwater system, the hydrologic features start at the top of the watershed/site as ephemeral draws or linear wetlands. These ephemeral channels transition into seasonal, relatively permanent waters (RPW) and then change to perennial RPWs (Figure 2). The streams' relative stability is most stable in the top of the watershed. The bed scour is sever in the middle reaches. The lower reaches in the site all are highly entrenched (bank height ratios over 4). The lower reaches of all project streams classify as Rosgen Type G and/or F channels. The combined linear footage of these unstable reaches is 24,000+ feet. These unstable channel reaches have abandoned their active floodplains. The effective rooting depth of the adjacent trees and buffer (Photos 1-9 and 11-12 in Appendix 2) no longer provides bank protection. Both the bed and banks of these reaches are unstable as indicated by the many headcuts, and vertical exposed banks. These systems mostly are in the G->F channel evolution phase. These reaches lack the riffle pool sequences typically found in stable systems. Reaches 1, 9, 10, and 11 lack almost any pavement or sub-pavement variation. Reach 1 has down-cut into weathered rock and reaches 9-11 has filled in with 2-3 feet of sands and fines. Along the banks of reach 1, 9, 10, 11 and lower reach 2, 3, 4 and 5 there is visual evidence of historical dredging and/or straightening in the remnant casting piles along the top of the stream banks. However, it is evident by the mature trees (some over 30 years old) that this was done pre 1980.

On Reaches 2 and 6, the dam/embankment of Dragonfly Pond and a relic pond has prevented the headcut from migrating upstream respectively, and on reach 5 and 7 a large bedrock outcrop and dense root mass has done the same. Above these points, reaches are visually stable. Much of the upstream areas of reach 5 and 7 are in a reference condition (Photo 10 and 15, Appendix 2).

Table 1 summarizes the geomorphic survey and Rosgen stream classifications.

Table 1: Summary of Geomorphology and Rosgen Stream Classification

Assessment Reach	Drainage Area (mi²)	Entrenchment Ratio	Width/Depth Ratio	Sinuosity	Slope (ft/ft)	Rosgen Stream Type
1	0.58	1.14	19.4	1.01	0.0049	F5
2	0.52	1.19	12.2	1.01	0.0151	G5/F5
3	0.26	1.39	13.8	1.05	0.0149	F5
4	0.17	1.39	6.6	1.06	0.0112	G5
6	0.24	1.31	8.5	1.05	0.0059	G5
7	0.27	1.39	7.5	1.07	0.0133	G5
8	0.19	1.25	8.1	1.02	0.0059	G5
9	0.78	1.14	9.3	1.01	0.0051	G5
10	1.67	1.10	14.0	1.00	0.0027	F5
11	2.55	1.71	5.0	1.00	0.0026	B5/G5

As part of the Rosgen BANCS model, Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) were determined using guidelines from Watershed Assessment of River Stability and Sediment Supply (WARSSS) to better define level of instability and sediment export from bank erosion. Table 2 summarizes the results of that analysis.

Table 2: Sediment Loading Assessment (BANCS Model)

Reach	Bank Length (ft.)	Total (tons/yr.)	Total (tons/yr./ft.)
1	3,709	2,206	0.59
2	3,435	1,093	0.32
3	2,834	1,332	0.47
4	3,684	986	0.27
5	974	390	0.40
6	9,042	860	0.10
7	4,014	475	0.12
8	7,672	853	0.11
9	3,269	51	0.02
10	9,500	595	0.06
11	1,788	63	0.04
TOTAL	49,921	8,905	0.18

The BANCS model uses BEHI and NBS to predict the annual sediment loss from stream bank erosion in tons per year. Based on the results of the analysis, it is estimated that the stream reaches (identified for restoration only) produce 8,905 tons of sediment from stream bank erosion per year, which is an approximate average of 0.18 tons per year per foot of bank for the reaches identified as restoration candidates on this site.

Environmental Data Resources:

An Environmental Data Resources (EDR) report (Appendix 1) was reviewed to determine the presence of documented hazardous materials in the project vicinity. A records search revealed two noted sites in the search

that fell inside the project site watershed. One site is a historic auto station and the other is a leaking above ground storage tank (LAST) at Fire Station #34 on Rocky River Road. This LAST is reported in the EDR as a "spill from emergency generator." There were other known sites of concern that appear in the EDR search area, however, all other sites were outside the watershed(s) of the study streams.

Biological Assessment:

Benthics

Ephemeroptera+Plecoptera+Trichoptera (EPT) species are used to determine the biotic integrity and water quality rating. Total EPT is the number of EPT species that occur in the sample. The weighted EPT score is determined by a weighted average of the number of EPT species, the number of individuals of that species, and their pollution tolerance. The biotic index is similar to the weighted EPT score except it is measured by using a weighted average of all species (not just EPT). The weighted biotic index score is a correlation between the biotic index and a range of values for various qualities (fair, poor, etc).

Benthic macroinvertebrate samples were collected at two locations in May of 2011 and six additional locations in April and May of 2012. The Qual-4 collection method (intended for perennial streams having catchment sizes of less than 640 acres) was utilized were appropriate. The Qual-4 collection method involves four samples taken at each bio-monitoring site: a kick net sample, a sweep net sample, a leafpack, and a "visual." In this method, organisms collected are "picked" and preserved in the field. The collected samples were sent to Lenat Consulting Services (Lenat) in Raleigh, NC. Lenat identified specimens to the lowest possible taxonomic level, providing relative abundance (rare, common, and abundant) for each taxon. The calculation of metrics from a Qual-4 method includes total and EPT taxa richness, EPT abundance and biotic index values.

The laboratory results are summarized in Table 3 below.

Table 3: Summary of Benthic Macroinvertebrate

Parameter	Monitoring Site								
	Reach 1	Reach 2	Reach 4	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11
Total Taxa Richness	16	17	22	33	25	35	38	31	18
Total Abundance	66	55	82	175	105	170	143	102	49
EPT Taxa Richness	4	2	9	13	5	9	13	9	4
EPT Abundance	34	8	48	117	11	58	61	30	15
NCBI (Biotic Index)	6.5	7.1	4.9	4.82	6.43	5	5.67	5.87	6.23
Bioclassicification	Fair	Poor	Good	Good	Fair	Good	Good-Fair	Fair	Fair

Based on the sampling results above, reaches 1, 2, 7, 10, and 11 lack the species count and/or diversity typically associated with a stream capable of supporting a healthy community. Reach 4, 6, 8, and 9 showed indications of a healthier macroinvertebrate community and had several intolerant species present. The EPT Taxa richness of 13 observed at Reach 6 and 9 are notably high for small streams in urban areas.

Based on the observed geomorphology and field observations the smaller order streams (Reach 1, 2, 4, 6, 7, 8, 9) are sediment exporters and the higher order downstream reaches (Reach 10 and 11) visually appear to be sediment sinks (i.e. silted in pools and riffles). This high sediment load coming from the upstream reaches may be contributing to the reduced habitat score on these downstream reaches.

Water Quality:
The Reedy Creek watershed is classified as Class C surface waters. Reedy Creek is listed on the 2010 North Carolina 303(d) list of impaired waters for ecological/biological integrity benthos.

We collected water quality samples at the same two locations as the benthic samples. A water quality meter was used to measure ambient water quality conditions including dissolved oxygen, pH, and conductivity. Grab test samples were gathered and analyzed in a laboratory to assess contaminants such as fecal coliform, phosphorus, nitrates, and total solids. The parameters were collected during normal flow conditions and will be used to determine a water quality index (WQI).

The laboratory results are summarized in Table 4 below.

Table 4: Summary of Water Quality Data

Testing Parameter		Monitoring Site									Class C Water Quality Standards or Typical Range
	Units	Reach 1	Reach 2	Reach 4	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	
Nitrate	mg/L	0.49	0.086	1.3	0.52	0.16	1.8	0.68	0.28	0.28	<1mg/L [3]
Phosphorus	mg/L	0.054	0.021	0.025	0.089	0.09	0.12	0.094	0.077	0.08	<0.4 mg/L [3]
BOD5	mg/L	ND	ND	ND	16	2.1	ND	ND	20	13	<5 mg/L [3]
Fecal Coliform	Col/100ml	520	100	690	62	350	200	740	1000	470	< 200/100ml mean [2]
Turbidity (lab)	NTU	ND	4.4	1.2	2.8	11	1.8	4.4	2.6	2.9	< 50 NTU [2]
pH	--	6.95	6.26	7.44	7.75	7.98	8.18	8.18	8.01	8.01	Between 6.0 and 9.0 [2]
DO	mg/L	9.22	6.54	8.93	7.18	8.67	8.91	8.41	8.11	8.11	>5.0 mg/L [2]
Temperature	°C	19.3	18.4	19.2	14.2	13.2	11.6	14.2	16	15.5	<2.8° C above natural water temperature [2]
TS	mg/L	96	100	93	110	100	120	100	90	90	<200 mg/L [3]
WQI[1]	--	83.5	77.4	83.6	71.9	76.7	79.4	75.7	68.4	71.0	-

Mg/L=milligram per liter; col/100ml = colonies per 100 milliliters; NTU=nephelometric turbidity unit, SU=standard units; °C =degrees Celsius; ND=Not detected
[1] WQI Scores: 0-25 = poor; 26-50 = fair; 51-70 = average; 71-90 = good; and 91-100 = excellent
[2] Class C Water Quality Standards
[3] Typical Ranges

Highlighted values are outside of typical range and/or exceed Class C Water Quality Standards

All of the reaches except 10 have a "good" WQI score. Reaches 1, 3, and 7-11 have elevated levels of fecal coliform. Reach 4 and 8 exceed typical nitrate ranges. This elevated nitrate could be linked to agricultural/pasture land-use in the headwaters of these reaches. Based on the water quality results, it appears that the downstream reach benthic community is impaired by the lack of in-stream habitat and not by water quality. There are visual signs of bed and bank scour likely producing episodic stressors. In conclusion, it is likely that the benthic integrity of the reaches could improve if some of the stressors were mitigated and/or in-stream habitat was improved.

Geotechnical and Soils:
Based on the hand-auger borings performed by Boyle Consulting Engineers, PLLC there is a consistent silt layer approximately 3-feet-deep, followed by a 1-2 foot sand layer across the site. Detailed boring logs are contained in Appendix 4.

The *Soil Survey of Mecklenburg County, North Carolina* (USDA, 1980) indicates that the floodplain of the project area contains Monacan loam (MO), Helena sandy loam (HeB), Vance sandy loam (VaD), Wilkes loam (WkE), Pacolet sandy loam (PaE), Enon sandy loam (EnB and EnD), and Cecil sandy clay loam (CeB2 and CeD2) soils. Monocan (MO) and Helena soils, classified as having hydric inclusions, are somewhat poorly drained and nearly level--typical characteristics of soils found on floodplains along streams and drainage ways. Wilkes loam (15-25% slopes) and Pacolet sandy loam (25-45% slopes) are well drained soils on the side slopes adjacent to drainage ways. The organic content for both is low and permeability is moderate. Cecil (CeB2) soils are well drained and typically found on eroded slopes ranging between 2-8%, defined as interfluves or uplands. The soils were classified using the Unified Soil Classification System. There were no observed relic Hydric soils. Soils identified as Hydric per NRCS mapping were inspected for relic indicators but were observed to be uniform alluvial piedmont floodplain soils with no indicators of a relic Hydric condition. A soils map of the project area is shown in Figure 5.

Wetlands:
An overall site review was performed using a 4-inch dutch auger to dig soil samples approximately 12 inches deep. Seven small wetlands were found in the project site ranging in size from 0.03 to 1.6 acres. Wetland A, F, G was a linear headwater wetland at the top of reach 2, 6 and 6-A. Wetland B also is a linear wetland located in a small draw that feeds into Slider Pond. The ponds embankment visually appears to maintain the hydrology of Wetland B. Wetland C, D, and E are floodplain wetlands. Wetland D is currently threatened by a stream head cut moving up reach 7 and based on visual evidence is actively moving up valley through the stream wetland system.

Despite the presence of mapped hydric soils (Monacan and Helena Sandy loam) in the floodplain of lower reach 2, 8, 9, 10, and 11, there were no other jurisdictional wetlands identified. The stream reaches in these locations are highly incised/entrenched and the change to the stream channel has altered (lowered) the water table and reduced the frequency of over bank flood events. In addition, the surface layer in this area appeared to be highly disturbed based on hand borings. The combination of the incision/entrenchment and soils alteration would have affected the historic wetlands that may have existed.

The locations of the site's jurisdictional features, including the above wetlands are shown on Figure 2. The United States Army Corp of Engineers (USACE) has approved the Jurisdictional determination (JD) for Reaches 1-5 and Wetland A and B. An amendment to this previously approved JD that adds stream reaches 6-11 and wetlands C-G was submitted to the USACE on May 25, 2012.

Open Water (Manmade Ponds):
There are three ponds that exist inside the nature preserve: Slider, Kingfisher, and Dragonfly. All three are in-line ponds on Reach 2. Both Kingfisher and Dragonfly Ponds are used for active recreation (fishing). Kingfisher Pond has an accessible fishing dock. Based on direction from the City and Parks and Recreation, Kingfisher and Dragonfly Ponds will remain, based on their recreation value/uses. The feasibility of removing the embankment and restoring Slider Pond back to a natural stream was investigated. The current pond is a high quality open water habitat with a well-defined littorial shelf and a good native plant diversity of trees, shrubs, and herbaceous species.

Photo. Slider Pond

Removing the pond would not provide a high level of connectivity because there are in-line ponds below and it is near the top of the watershed.

Detailed investigations of any of the outlet structures or earthen embankments (i.e. geotechnical borings) were not performed as part of this study.

FEMA:
The Mecklenburg County Digital Flood Insurance Rate Map (DFIRM) panel 4585 (effective March 2, 2009) shows that Reach 10 and 11 inside the Study Area are included in detailed studied streams or mapped within any floodplain or floodway areas. Work within this study area will require a floodplain development permit from Mecklenburg County and a corresponding flood impact study (FIS). The FIS will require detailed (HEC-RAS) modeling and if changes to base flood elevations or floodplain boundaries occur a Conditional Letter of Map Revision (CLOMR) will be required by FEMA/Mecklenburg County prior to construction. A Letter of Map Revision (LOMR) also will be required post construction.

Endangered Species:
Under the provisions of Section 7 of the Endangered Species Act (ESA) of 1973, as amended, Federal Law requires that any action likely to affect a federally protected species adversely be subject to review by the U.S. Fish and Wildlife Service (USFWS). A search of the USFWS website (http://www.fws.gov) indicates that four federally endangered species exist in Mecklenburg County, NC: Carolina heelsplitter (*Lasmigona decorata*), Michaux's sumac (*Rhus michauxii*), smooth coneflower (*Echinacea laevigata*), and Schweinitz's sunflower (*Helianthus schweinitzii*). Each species, its habitat, and its status are described in Table 5. A pedestrian survey did not reveal the presence of any of these species. Further investigation is not needed to meet the requirement of Section 7 consultation.

On August 8, 2011, the North Carolina Natural Heritage Program Office records were reviewed to determine the presence of threatened and endangered species. Records did not show any of the four federally endangered species within the project vicinity.

Carolina heelsplitter
The North Carolina Natural Heritage Program has no records of Carolina heelsplitter in the project vicinity. No species were observed during pedestrian surveys.

BIOLOGICAL CONCLUSION: NOT LIKELY TO ADVERSELY EFFECT

Michaux's sumac

The North Carolina Natural Heritage Program has no records of Michaux's sumac in the project vicinity. No species were observed during pedestrian surveys. No appropriate habitat is located in the project vicinity.

BIOLOGICAL CONCLUSION: NO EFFECT

Schweinitz's sunflower
The North Carolina Natural Heritage Program has no records of Schweinitz's sunflower in the project vicinity. No species were observed during pedestrian surveys. No appropriate habitat is located in the project vicinity.

BIOLOGICAL CONCLUSION: NOT LIKELY TO ADVERSELY EFFECT

Smooth coneflower

The North Carolina Natural Heritage Program has no records of Smooth coneflower in the project vicinity. No species were observed during pedestrian surveys. No appropriate habitat is located in the project vicinity.

BIOLOGICAL CONCLUSION: NO EFFECT

Table 5: Endangered Species - Mecklenburg County

Scientific Name	Common Name	Habitat Requirement	State Status	Federal Status	Habitat Present	Likelihood of Presence
Carolina heelsplitter	*Lasmigona decorata*	Streams, rivers, and ponds	E	E	Yes	Unlikely
Michaux's sumac	*Rhus michauxii*	Sandy or rocky open woods in association with basic soils	E-SC	E	No	Unlikely
Schweinitz's sunflower	*Helianthus schweinitzii*	Roadsides, power line clearings, old pastures, woodland openings, and other sunny or semi-sunny situations	E	E	No	Unlikely
Smooth coneflower	*Echinacea laevigata*	Open woods, barrens, roadsides, clearcuts, dry limestone bluffs on magnesium- and calcium-rich soils	E-SC	E	No	Unlikely

Notes: E=Endangered; SC=Special Concern

The State defines an endangered plant species as "any species or higher taxon of plant whose continued existence as a viable component of the State's flora is determined to be in jeopardy" (GS 19B 106: 202.12).

The State defines an endangered animal species as "any native or once-native species of wild animal whose continued existence as a viable component of the State's fauna is determined by the Wildlife Resources Commission to be in jeopardy or any species of wild

animal determined to be an 'endangered species' pursuant to the Endangered Species Act" (Article 25 of Chapter 113 of the General Statutes; 1987).

The State defines a Special Concern as "any species of plant in North Carolina which requires monitoring but which may be collected and sold under regulations adopted under the provisions of [the Plant Protection and Conservation Act]" (GS 19B 106:202.12).

Cultural Resources:
The State Historic Preservation Office (SHPO) will be consulted during the permitting phase.

Vegetation/Buffers:
The buffers in the project corridor have been protected for the last 30 years in the nature preserve. The vegetation communities include Peidmont Bottomland Forest, a Shafely and Weakly classification.

Photo. Less mature emerging buffer lacking understory.

Photo. Mature forested buffer (Reach 8).

The hardwood species range in age from less than 5 to over 30 years old depending on the location in the preserve. Reach 8 has the most mature forested community with many trees over 36" in diameter. The Reaches outside the preserve have less mature vegetation and some Chinese Privet (*Ligusturm sinense)* was observed. Napalese Browntop (*Mictostegium vimineum*) was covering almost the entire floodplain floor along Reach 8 and in Reach 11 (but was less prevalent in the latter).

The proposed restoration reaches (Figure 6) have down-cut/incised to below the effective rooting depth of the trees along the stream banks. These unstable reaches are undercutting the trees at the top of the bank and many have fallen into the channel or are in jeopardy of falling. In addition, the stream incision likely has altered the hydrology of the adjacent floodplain and therefore probably has altered/suppressed some of the more wet species that would be found if the floodplain was more "active"/connected.

The mature vegetation buffer will be one of the major constraints for a restoration project because the goal would be to minimize impacts to the existing vegetation (i.e., large trees). The short-term ecological impact to small portions of the buffer would likely be unavoidable. However, the ecological functional lift of restoring the unstable stream channels and reducing the high bed and bank erosion will create a higher functioning ecological system in the long term. Alternatives that try to minimize tree loss while restoring/stabilizing the most severely degraded reaches are presented in section 4.0.

Park and Nature Preserve Uses:
The nature preserve has multiple active and passive uses. Two of the three ponds (Kingfisher and Dragonfly) are used for fishing as discussed above. The only other use in the proposed area for restoration (i.e., active construction) is the series of nature trails in the area. These trails (dirt paths) are outside the immediate riparian buffer of 50 feet with the exception of three perpendicular stream crossings (i.e., footbridges) and the Robinson Rockhouse Trail:

- Sierra Loop trail crosses Reach 1 (newly constructed foot bridge) just upstream of confluence with Reach 2
- Sierra Loop trail crosses Reach 1 (foot bridge) just downstream of confluence of Reach 3 and 4
- South Fork trail crosses Reach 2 (newly constructed bridge) just upstream of the confluence with Reach 1
- Robinson Rockhouse trail is within 50 feet of the existing stream (Reach 10).

None of these small pedestrian bridge(s) would be a major constraint to restoration construction. The Park has requested that the City work around each of the newly constructed bridges (i.e., "leave in place"). Robison Rockhouse trail and the Robinson Rockhouse Ruins will be preserved.

Visible Utilities:
There is a newly constructed sewer line (Hood Road Annexation) by Charlotte Mecklenburg Utility Department. This project construction occurred 2010-2012 and the sewer line runs along portions of Reach 6, 7, 9, 10, and 11. The maintained sewer easement is generally 20-50 feet from the top of bank on one side. The sewer line crosses Reaches 6, 7 and 11 in one location on each reach. The maintained sewer easement of these newly constructed sewer mains is visible on the aerial photography (Figure 3).

Overhead high transmission power lines cross over Reaches 7, 9, and 10 and the crossings are relatively perpendicular to the channel. The power line and maintained easement is visible in the aerial photography (Figure 3).

Site Access and Haul Roads:
Site access potentially could be from four locations. Final access locations will depend on final temporary and permanent easements. The primary access from the upstream end of the project will be through the nature preserve from the primary parking lot area for picnic areas 3-9 and the Frisbee golf course. The fields adjacent to Dragonfly Pond may provide a convenient area for staging and lay down areas for materials and equipment. The access road down to Reaches 1-4, and lower Reach 5 and upper Reach 10 could come from this upstream park access from either use of existing park paths (i.e., Sassafras trail, which is wide and has a gravel base) and/or newly constructed haul roads down to the proposed restoration reaches.

Primary access from the downstream end of the project will likely be from Plaza Road Extension adjacent to Reach 11. This was an access point for construction of the sanitary sewer. There is a cleared area in this location that may provide a temporary staging location. The haul road from the downstream end should utilize the areas previously disturbed by the sewer line construction to the maximum extent possible.

Additional access could come from the Hodges farm, Hood Road, and Rocky River Road. This may provide potential access to the upstream portions of Reaches 3, 4, 6, and 7. The exact details of access will be negotiated with Park and Recreation and/or the appropriate private property owners as the project moves forward.

All haul roads will need to support the movement of equipment and construction material (rock, silt fence, coir matting, etc.). All temporary haul roads and staging areas should be located to minimize tree impacts. It is recommended that a detailed tree survey be performed as part of the design phase.

We also recommended exploring the possibility of using beds of stream that will be restored as haul roads in some locations. This will help reduce impacts to adjacent buffers. However, erosion control will need to be adequate to account for equipment in the stream.

4.0 Conceptual Design Alternatives

The goal of the restoration project is to restore/enhance unstable stream systems and preserve a stable stream system to improve the water quality and aquatic/riparian habitat functions of the site's streams and floodplain through the following objectives:

- Reduce sediment input from stream bed and bank erosion by creating stable hydraulic channel geometries.
- Remove excess nutrients and sediment by using existing buffers and reconnecting the stream to either a constructed floodplain or its historic floodplain (reduces incision by correcting dimension and profile).
- Increase dissolved oxygen concentrations through use of in-stream structures and the turbulence they produce in pools.
- Stabilize stream banks using bioengineering and/or specific natural channel design techniques based on constraints and opportunities.
- Improve transport of sediment and wood to create bedform diversity and dynamic equilibrium.
- Improve substrate through use of structures and the elimination of major sediment sources (eroding bed and banks). Correcting the profile and creating localized bed slopes will allow the substrate to coarsen as the fines are transported. Bank source sediment will be greatly reduced by the bank stabilization techniques.
- Create habitat diversity by introducing woody structures such as log vanes, log sills, and/or log cross vanes.
- Protect upstream stable reaches and preserve high quality/unique vegetation and geologic features inside the Nature Preserve.
- Enhance ecological value and educational opportunities within the Park and Nature Preserve.
- Produce mitigation credit.

4.1 Stream Restoration Approaches

There are two restoration approaches/alternatives presented for this site to meet the above objectives. Both approaches are watershed-based and involve preserving stable upstream reaches, wetlands, and open water, as well as restoration of unstable downstream reaches to a stable form. Both concepts involve construction using heavy equipment and thus some impacts to trees will be unavoidable in order to stabilize the stream banks. However, both concepts would try to minimize impacts to trees that are not currently threatened by erosion.

Alternative 1 (Figure 6 and 7a) — Rosgen Priority 1 Restoration
A Rosgen Priority 1 restoration approach is proposed on the reaches labeled as restoration on Figure 6a as Alternative 1. Preservation is proposed on upper Reach 2-D, upper Reach 2-E, upper Reach 5-A, upper Reach

6, 6-A, upper Reach 7, 7-A, and 11-A. A Rosgen Priority 1 restoration is the process of re-establishing an incised channel back onto the previous floodplain by constructing a new bankfull/channel-forming discharge channel. The new channel dimension, pattern, and profile could be based on a stable/reference form found in the Park. The existing incised channel could be filled or partially backfilled to create oxbow lakes or vernal pools level with the new floodplain. The Priority 1 approach would start at a nick point/headcut or similar location conducive to bringing the channel up onto its historic floodplain. For lower Reach 2 and Reach 4 the restoration would start at outfall of the pond(s). These pond outfalls may need to be modified to allow for a Priority 1 restoration below. For Reaches 3, 6-8, and 10-C the restoration could start at the bedrock or vegetation feature that has stopped the head cut and separates the restoration (unstable) reach from the preservation (stable reach). Reaches 1, 9, and 10 also could be restored using Priority 1 if Priority 1 is chosen for the reaches above them. Reach 11 would be a transition reach (i.e., Priority 1 transitioning to Priority 2) to tie the upstream Priority 1 restoration to the existing culvert elevation at Plaza Road Extension at the downstream end of the project.

Based on Valley type and project constraints Reaches 1, 3, 4, and possibly 2 could be restored to a Rosgen C stream type. The remaining restoration reaches would likely be restored to a Rosgen Bc stream type.

The location and pattern of the new channel would be based on reference conditions as well as constraints (mature trees, topography, pedestrian bridges, and utility easement). The channel could be woven around/between the trees to maximize tree preservation. There is an opportunity on lower Reach 8 to utilize the abandoned relic stream channel for the lower 750 feet.

Photo. Example of Priority 1 – Shortly after construction

In-stream structures could be placed to add habitat, grade control, increase water quality, and provide bedform diversity. Structures are proposed to protect stream bed and banks and increase aquatic habitat diversity. The types of grade control and habitat structures that potentially will be incorporated into the restoration project

include rock cross vanes, log sills, single log vanes, log cross vanes, constructed log and rock riffles, and boulder and wood toe protection.

Advantages:

- Reduces bank height and stream bank erosion
- Reduces land loss
- Raises the water table (may help re-establish wetlands on Reach 10 and Lower sections of Reach 8)
- Improves aquatic habitats
- Improves aesthetics

Disadvantages:

- Tree Impacts
- Increases flooding of riparian areas in the Nature Preserve (although there are no impacted structures or roads)
- Downstream end of project will require a large grade control structure to transition back to incised condition at Plaza Road Extension.
- Change in hydro-period and groundwater elevation in floodplain could potentially impact riparian vegetation.

Alternative 2 (Figure 6 and 7b) — Rosgen Priority 2 and 3

A Rosgen Priority 2 and 3 restoration approach is proposed on the unstable reaches proposed for restoration in Figure 6b as Alternative 2. Preservation is proposed on the same reaches as it is in Alternative 1. A Rosgen Priority 2 restoration is the process of converting the bed of the existing incised channel to a new floodplain. Priority 3 is shaping the banks and stabilizing both bed and banks. If the belt width is too narrow, the stream bed walls are excavated for a Priority 2. However, this will increase tree loss. The ability to perform a Priority 2 restoration would dictated by how over-wide the existing streams currently are and how close the tree save areas are to the top of banks.

To minimize end-haul material from bank excavation, materials coulf be placed in the stream bed, with the new channel and floodplain being established on the fill. The new channels dimension, pattern, and profile would be based on a stable/reference form. The Priority 2 approach would start at a nick point/headcut or similar location where the channel becomes incised/unstable

The location and pattern of the new channel will be constrained by existing channel alignment and mature trees.

In-stream structures would be placed in the design channel to provide grade control (maintain overall design slope), add habitat, increase water quality, and provide bedform diversity. These structures are likely necessary due to the geology and constraints on pattern/belt width associated with a Priority 2, as well as the overall steepness of the valley. The structures would help maintain pools and dissipate energy vertically. Other potential structures could protect stream banks and increase aquatic habitat diversity. The types of grade control and habitat structures that potentially can be incorporated into the restoration project include rock cross vanes, log sills, single log vanes, log cross vanes, constructed log and rock riffles, and boulder and wood toe protection.

Photo. Example of Priority 2 – After construction.

Advantages:

- Decreases bank height ratios and stream bank erosion
- Allows riparian vegetation to help stabilize banks
- Establishes a small floodplain bench to reduce shear stress during floods
- Improves aquatic habitats
- Prevents wide-scale flooding of original land surface
- Reduces sediment
- Downstream grade transition is easier than Priority 1

Disadvantages:

- Tree Impacts
- Higher cost of materials (rock) for bed and stream bank stabilization
- Does not raise water table to previous levels
- Shear stress and velocity higher than Priority 1 during flood due to narrow floodplain
- Upper slopes need to be stabilized for flood events
- Higher erosion risk during floods due to excessive shear stress and velocity

4.2 Riparian Area Restoration Approach and Buffer Reforestation Scheme

The restoration approach would minimize impacts to trees in all reaches. Areas that are disturbed as part of construction or access would be replanted.

The buffer areas would be treated for removal of invasive species (i.e., Chinese Privet). Re-established or new buffer area would be planted according to the *United States Army Corps of Engineers Stream Mitigation*

Guidelines, 2003. To initialize the proposed riparian community, the restoration area could be planted with a mix of pioneer and climax species selected and arranged to meet the following objectives:

- Stabilize disturbed or high stress areas.
- Establish a mix of shade-intolerant canopy and shade-tolerant understory species.

4.3 Wetlands

The existing seven small wetlands would be preserved. Based on the presence of mapped hydric soils (Monacan loam and Helena sandy loam) in the floodplain of Reaches 2 and 6-11, there may be an opportunity to restore some small wetland pockets if Alternative 1 (Priority 1 restoration) is chosen. The quantity (acres) of the wetland restoration opportunities would need to be better defined by a detailed soil, groundwater topographic survey, and study. A licensed soil scientist should perform the soil survey.

5.0 Mitigation Summary

Restoration at 1:1 is proposed for the design linear feet for all locations where pattern, profile, and dimension would be altered to a stable condition. Preservation at 5:1 is requested for the stable upper reaches and the wetlands that are outside of the current Nature Preserve. No SMUs are proposed for preservation reaches of wetlands inside the Nature Preserve since these are already protected. Figures 6a and 6b summarize the mitigation credit for each alternative by reach and segregated based on public and private parcels.

Both alternatives preserve over 20,000 linear feet of stable stream and restore over 24,000 linear feet of unstable channel. Restoration and Preservation combined could generate approximately 26,590 stream mitigation units (SMUs) and 0.3 wetland mitigation units (WMUs) if all reaches and wetlands shown in Figure 6 are included. Final SMUs would depend on which alternative is pursued, how much pattern is added, if all easements are secured from the County and private owners, and all approvals are granted by the regulatory agencies.

Priority 1 is the recommended restoration approach and has the following advantages over Priority 2/Priority 3:

- The Priority 1 approach involves constructing a new stream channel in the ideal dimension, pattern and profile for its watershed based on a reference reach, achieving the maximum increase in water quality. The ability to alter the dimension, pattern and profile of the stream with the Priority 2/Priority 3 approach is restricted because the new channel must be constructed largely within the existing stream channel.
- Because the Priority I restoration approach raises the water table, it has the potential to create riparian wetlands where the original stream channel previously existed. The Priority 2/Priority 3 restoration approach does not raise the water table and does not create riparian wetlands.
- Priority 1 restores the channel by raising it to match its historic floodplain, maximizing the flood prone area and available storage area.
- Priority 2/3 would likely have increase amount of excavation compared to Priority 1 due to the depth of the channel and degree of benching and sloping required for Priority 2/3.

While Priority 1 is the preferred restoration approach for this stream, the Priority 2/Priority 3 approach has a few advantages worth noting:

- The Priority 2/Priority 3 approach involves constructing the new stream channel primarily within the path of the original stream, potentially reducing the soil that needs to be excavated.
- The Priority 2/Priority 3 approach is less likely to increase flood elevations.
- Third, the Priority 2 approach does not significantly alter surrounding groundwater and may not alter the hydro-period of some of the stable adjacent riparian vegetation communities as a Priority 1 might.

6.0 Project Recommendations

6.1 Summary of Recommendations and Cost/Benefit Explanations

It is recommended that reaches 1 through 11 be restored using natural channel design techniques and that the City seek mitigation credit generated for inclusion into its existing mitigation bank.

Table 6 below describes the costs and benefits of the alternatives as compared to each other.

Table 6: Cost/Benefit Summary

Alternative	Functional Benefit	Mitigation	Construction Cost (est.)	Engineering Cost (est.)*
1	• Reduced sedimentation • Transport sediment to create dynamic equilibrium • Increased dissolved oxygen content • Improves aquatic habitat. • Increased floodplain connectivity and infiltration	Up to 26,700 SMU and 0.3 WMUs	$2,160,000 - $3,500,000	$600,000 - $1,000,000
2	• Reduced sedimentation • Transport sediment to create dynamic equilibrium • Increased dissolved oxygen content • Improves aquatic habitat	Up to 26,700 SMU and 0.3 WMUs	$2,400,00 - $3,840,000	$600,000 - $1,000,000
No-build	None	None	None	None

**Engineering cost includes final planning, survey, permitting and design. It does not include post-construction services (i.e. monitoring, as-built, LOMR, etc.)*

Table 7: Estimated Cost Summary

Alternative	Estimated Total Construction Cost (millions)	Construction Cost/ LF Restoration	Construction Cost/SMU
1	$2.16-3.5	$90 - 145	$81 - 131
2	$2.4-3.84	$100 - 160	$90 - 144

For generating an estimated total cost, no land cost is assumed because the property is either public land or a donated conservation easement will be sought. For construction cost/SMU preservation, only credits on private land are included (No preservation in Nature Preserve).

The consequences of a "no-build" alternative include continued degradation of the stream reaches. The stream bed and banks could continue to erode as the stream seeks equilibrium. The impacts of the continued erosion typically are impaired biology activity, impaired habitat, lack of habitat availability, tree loss, increased turbidity, and excess sediment sent downstream.

6.2 Stakeholder Feedback

The following stakeholder meetings have been held with the following outcomes:

- IRT preliminary site review on November 22, 2011 of Reaches 1-5.
    - IRT members reviewed Reaches 1-5
    - The agencies supported the City further pursuing the site as a potential mitigation project
- Meeting with Parks and Recreation and Reedy Creek Nature Preserve staff on February 3, 2012.
    - Staff supported the project and recommended that it be presented to the Stewardship Advisory Committee (SAC) to gain their support
- Presentation to the SAC on May 9, 2012
    - THE SAC unanimously supported proceeding forward with a restoration project in the Park and Preserve
- IRT site review of Reaches 6-11 on June 21, 2012
    - IRT members (USACE and DWQ) support the City further pursuing the site as a potential mitigation project.
    - Through follow-up emails and communication with the City the IRT provided the following comments that will need to be addressed as the project moves forward:
        - Limit buffer disturbance. Tree surveys for dbh's smaller than 12 inches will likely be required.
        - Priority 10 restoration or an enhancement approach focusing on erosion reduction and habitat creation are preferred options.
        - Designs should incorporate woody structure and minimize use of rock
        - Wetland E is a high quality wetland area and should not be impacted
        - Reference streams on-site (Upper Reach 5 and Upper Reach 7) should be considered.
        - Post construction macroinvertebrates monitoring plan since upstream reaches scored high and downstream reaches low in pre-construction monitoring.

Meeting minutes and presentation materials and additional correspondents are located in Appendix 9. Private property owner coordination is on-going and not included in this version of the document.

7.0 References

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