VOLUME 6

MONITORING & EVALUATION REPORT

CARPENTER CREEK & BAYOU TEXAR WATERSHED MANAGEMENT PLAN

TASK 6.0 MONITORING AND EVALUATION RECOMMENDATIONS

ESCAMBIA COUNTY

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REPORTING

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EXECUTIVE SUMMARY

This technical report provides a monitoring strategy that includes a sample design, specified locations, sample frequency, survey design, protocols, and standard methods to help managers evaluate and monitor the implementation of the Watershed Management Plan (WMP) and achievement of goals and objectives.

1 INTRODUCTION

Watershed management programs require a broad and effective monitoring and evaluation system to track performance against objectives and provide information to help managers at all levels with implementation of the WMP. The following narrative provides a variety of tools that may be used by Escambia County (County) and/or City of Pensacola (City) staff for measuring the successful implementation of this plan.

The WMP team has developed conceptual plans for 15 site-specific project recommendations, all designed to execute watershed management goals and objectives. These projects were organized by segments beginning near the headwaters of Carpenter Creek (Headwater Sites), further downstream along Carpenter Creek (Creek Sites), and finally progressing into and ending at Bayou Texar (Bayou Sites) (Figure 1).

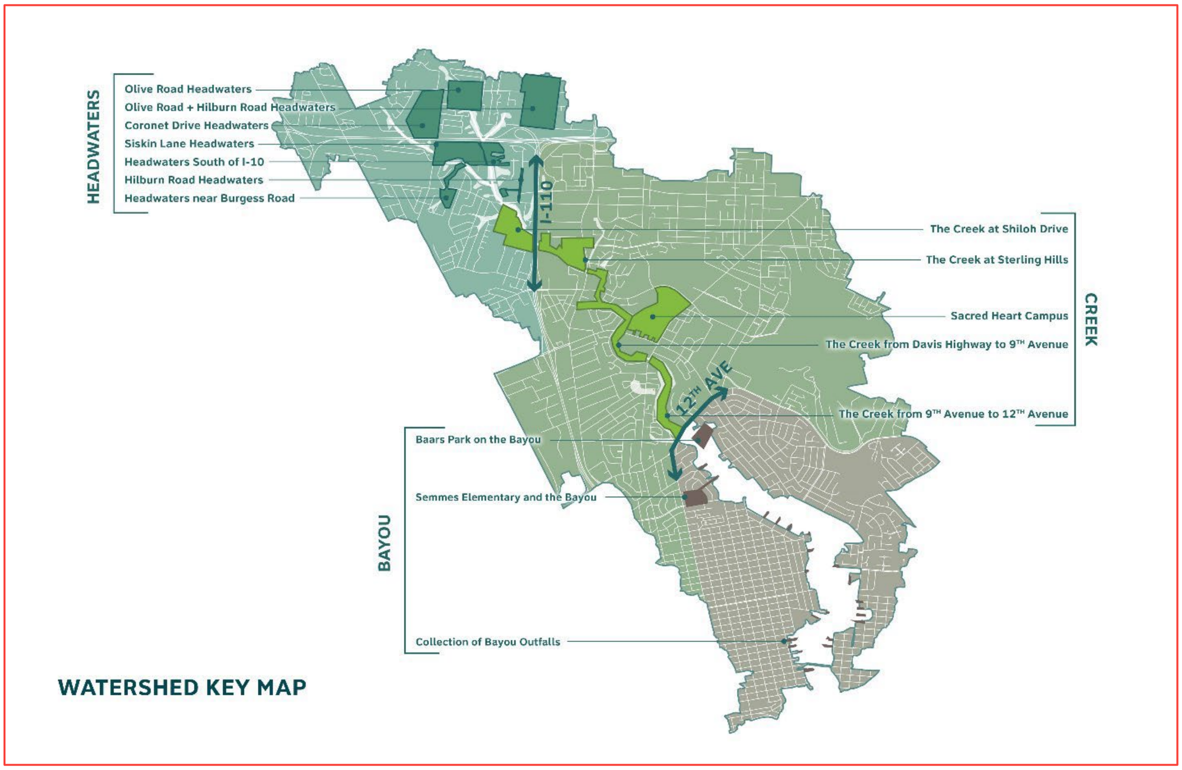

Figure 1 - Location of 15 site-specific WMP concepts, by segment

Each of the 15 identified projects is unique with differing goals and implementation strategies. To effectively understand the true benefits of each project it is important to develop metrics that may be monitored to evaluate improvements to the Carpenter Creek and Bayou Texar watersheds (collectively referred to herein as the Watershed) resulting from the implementation of each project. Hopefully, the WMP will have a long life and will be used as a guide by County and City officials to continually find new opportunities to further program goals. As such, monitoring and evaluation should be reactive and adaptive to the continual progression of the WMP. This plan should be periodically reviewed and, if necessary, updated to address the evolution of the plan.

The recommendations contained herein are merely a starting point and are designed to provide a variety of metrics to address the 15 site-specific projects identified as part of this WMP. As new projects (beyond the 15 already identified under this WMP) are developed and implemented, County and City officials should periodically review the metrics suggested within this report and /or determine their applicability. Depending on the scope and nature of new projects, these recommended metrics may be applied, or new metrics may be required.

2 MONITORING METHODOLOGY

2.1 SURFACE WATER QUALITY MONITORING

Chemical analyses of water samples are an essential component of any watershed management plan. The collection of water quality data allows managers to assess whether water quality improvement strategies are having the intended effect, or whether adjustments need to be made within the adaptive management framework. Water quality monitoring shall align with the implementation of management strategies to determine if the strategic goals (e.g., a reduction in the TN, TP, and TSS loading) are being achieved.

Each of the 15 site-specific projects will occur within a singular area or subbasin within the Watershed; therefore, the surface water quality monitoring plan will follow an above/below approach for most project sites (Figure 2). In this method, design stations are located upstream (up-gradient) and downstream (down-gradient) of the respective project site.

Ambient water quality will be measured both pre- and post-project implementation with at least one fixed station above and one fixed station below the project site. Stations shall be selected once the design is finalized and all aspects of the project are understood.

Pre- and post-implementation surface water grab samples should be taken manually at each station and analyzed for parameters that may be improved because of the project. Additional physical parameters should be collected at each sample site including, dissolved oxygen (DO), oxygen saturation, temperature, pH, and specific conductivity. Instantaneous measurements of flow should be determined during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via installation of a stream gauge and direct measurements taken during the sampling event.

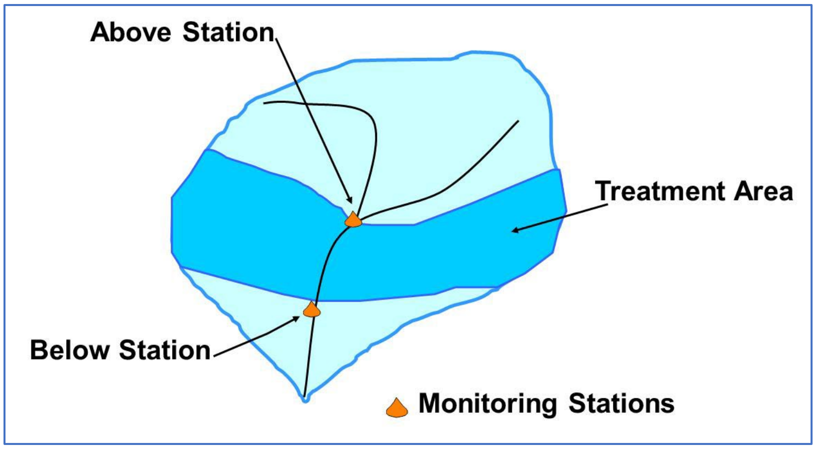

Figure 2: Above/below sample design (Steven A. Dressing and Donald W. Meals. 2005)

2.2 BIOLOGICAL MONITORING

2.2.1 BENTHIC MACRO INVERTEBRATES – STREAM CONDITION INDEX

The chemical analysis of water quality has its limitations as it provides information about water quality at the time of measurement. An effective way to assess the ability of a watershed to support living things is to look at those living things. The use of bio-monitoring tools that evaluate living organisms can provide information about past and/or episodic pollution and the cumulative effects of a suite of watershed impacts including benefits that may be attributed to the implementation of the WMP recommendations. In theory, improvements in water quality and quantity should have a positive impact on the biological communities of the receiving waterbody.

The Florida Department of Environmental Protection (FDEP) has developed several bio-monitoring tools for streams, lakes, and wetlands. The Stream Condition Index (SCI) is one tool that compares observed assemblages of benthic macroinvertebrates to those expected from reference streams. FDEP has comprehensively validated and calibrated this tool, and its application is widely accepted. It provides a scientifically robust method of assessing and describing conditions over time and in response to restoration actions.

Stated briefly, the SCI is a composite macroinvertebrate index for use in flowing streams. Sampling consists of 20 dipnet sweeps of the most productive habitats found in a 100-meter stretch of a stream. FDEP Standard Operating Procedure (SOP) SCI 1000 outlines the protocol to be used in SCI sampling. Organisms collected in the 20 sweeps are preserved and brought back to the laboratory for processing in accordance with the FDEP SOP SCI 2000. Data generated on the taxonomy and abundance of these organisms are used to calculate ten biological metrics, each of which has been shown to respond predictably to human disturbance. The metrics are:

- Total number of taxa,
- Number of long-lived taxa (those that require more than one year to complete their life cycle),
- Number of Ephemeroptera (mayfly) taxa,
- Number of Trichoptera (caddisfly) taxa,
- Number of sensitive taxa,
- Number of clinger taxa,
- Percent dominant taxon,
- Percent Tanytarsini,
- Percent very tolerant taxa, and
- Percent filterer individuals.

Eight of ten metrics decrease in response to adverse human influences, while two (% dominant taxon and % very tolerant taxa) increase in response to human disturbance. Once the metrics are calculated, points are assigned for each metric based on criteria that have been regionally calibrated and are contained in FDEP SOP SCI 2000. The points from each of these ten biological metrics are then summed to determine an overall score of biological health, with scores of 64-100 considered exceptional, scores from 40-63 considered healthy, and scores of 0-39 considered impaired (FDEP, 2014)

2.2.2 PLANT COMMUNITY STRUCTURE

2.2.2.1 WETLAND – FORESTED WETLAND CONDITION INDEX

The Forested Wetland Condition Index (WCI) (Riess and Brown, 2005) may be utilized to assess changes within the plant community structure at the restoration site. The WCI is a biological assessment tool developed for isolated forested wetlands and has not been verified for other types of wetlands. The target community within the restoration site will be a forested wetland but not hydrologically isolated. In the absence of an appropriate tool to assess the health of the plant community structure, individual metrics of the WCI will be calculated. In our opinion, these individual metrics shall be used to gauge success within the project site. This idea will be discussed in later sections of this document. Certain individual metrics are useful outside the total WCI score because they have been shown to be relevant across wetland types and regions.

The WCI shall be performed by sampling vegetation along a single transect, identifying individuals to the species level, and calculating individual metric values based on attributes of the plant community that change predictably along an independent gradient of human disturbances. All field and laboratory biological methods followed Bureau of Laboratories and Biology Section Standard Operating Procedures (see http://www.dep.state.fl.us/labs/library/lab_sops.htm and http://www.dep.state.fl.us/water/sas/sop/sops.htm for details) and met FDEP quality assurance/quality control standards (see http://www.dep.state.fl.us/water/sas/qa/index.htm).

The vegetation WCI for isolated, forested wetlands has six metrics:

1. Percent tolerant indicator species
2. Percent sensitive indicator species
3. Percent exotic macrophyte species
4. Average Coefficient of Conservatism (CC) score
5. Percent native perennial species
6. Percent wetland status species

Tolerant indicator and exotic species increase with increasing development intensity; whereas, sensitive indicator species, CC Score, native perennial species, and wetland status species display the opposite trend.

Percent tolerant indicator species metric

The percent tolerant indicator species metric suggests certain species tolerate conditions of impaired biological integrity. The list of tolerant macrophytes indicator species for isolated forested wetlands is provided in **Table 1**.

Table 1: Tolerant Macrophyte Indicator Species for Isolated Forested Wetlands, Panhandle Region

Boehmeria cylindrica
Cynodon dactylon
Diodia virginiana
Paspalum urvillei
Phytolacca americana
Polygonum hydropiperoides
Polygonum punctatum

To calculate this individual metric, the number of tolerant species identified at each monitoring station is recorded. Next, the percent tolerant indicator species is calculated as the number of tolerant indicator species divided by the total number of species, using the list in Table 1. The result is multiplied by 100. This is the raw metric value. The natural log (ln) of the raw metric value + 10 is calculated. This value is inserted as “x” in the following metric calculation equation for percent tolerant species.

Percent tolerant indicator species metric = 10-[(x-2.30)(10/1.86)]*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Percent sensitive species metric

Sensitive species are those species which are most sensitive to biological impairment. The list of sensitive macrophyte indicator species for isolated forested wetlands is provided in Table 2.

To calculate this individual metric, the number of sensitive species identified at each monitoring station is recorded. Next the percent tolerant indicator species is calculated as the number of sensitive indicator species divided by the total number of species, using the list in Table 2. The result is multiplied by 100. This is the raw metric value. The natural log (ln) of the raw metric value + 10 is calculated. This value is inserted as “x” in the following metric calculation equation for percent sensitive species.

Percent Sensitive Species Metric = (x-2.30)(10/1.98)*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Table 2: Sensitive Macrophyte Indicator Species for Isolated Forested Wetlands.

Andropogon virginicus	*Hypericum chapmanii*
Lycopodiella alopecuroides	*Rhexia petiolata*
Aristida beyrichiana	*Ilex glabra*
Panicum erectifolium	*Rhus copallinum*
Aristida purpurascens	*Ilex myrtifolia*
Panicum rigidulum	*Rhynchospora filifolia*
Eriocaulon compressum	*Lachnanthes caroliniana*
Pinus elliottii	*Scleria triglomerata*
Eriocaulon decangulare	*Lachnocaulon anceps*
Polygala cymosa	*Serenoa repens*
Fuirena scirpoidea	*Lobelia floridana*
Rhexia alifanus	*Vaccinium corymbosum*
Gaylussacia frondosa	*Lophiola aurea*
Rhexia lutea	*Xyris caroliniana*

Percent exotic macrophyte species metric

The proportion of exotic species is significantly correlated with the gradient of development intensity in the surrounding landscape. The proportion of exotic species increases with level of disturbance in the surrounding landscape. The Institute for Systematic Botany's Atlas of Florida Vascular Plants shall be consulted to determine native versus exotic (not native) status (Wunderlin and Hansen 2008).

To calculate this individual metric, the number of exotic species identified at each monitoring station is recorded. Next the percent exotic species is calculated as the number of exotic species divided by the total number of species for which nativity could be determined. The result is multiplied by 100. This is the raw metric value. The natural log (ln) of the raw metric value + 10 is calculated. This value is inserted as "x" in the following metric calculation equation for percent exotic species.

Percent Exotic Species Metric = 10-[(x-2.30)(10/1.33)]*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Average Coefficient of Conservatism (CC) score metric

This metric is based on a coefficient of conservatism score (CC), between 0-10, being assigned to each native plant species by a panel of regional experts. A high CC is assigned to those species that are more conservative in their requirement for native plant communities. Species with lower CC's are generally found in a broader range of habitats and are most likely to colonize disturbed ground, abandoned fields, etc.

To calculate this individual metric, the CC score for each taxa identified at each station is determined. Then the average of the CC scores is calculated for each monitoring station. The average CC score is the raw metric value. This value is inserted as "x" in the following metric calculation equation for average coefficient of conservatism score.

Average CC Score Metric = (x-2.68)(10/3.43)*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Percent native perennial species metric

This metric assumes that impaired systems favor annual species over perennial species and promotes the invasion of nonnative perennials in wetlands.

The Institute for Systematic Botany's Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008) shall be consulted to determine native versus exotic (not native) status. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Plant Database (http://plants.usda.gov/java) shall be consulted to determine duration (annual vs. perennial) for each species. If the taxon is native and listed as annual/perennial, it was included in the native perennial group. For each station, the percent native perennial species is expressed as the number of native perennial species, divided by the total number of species for which status of nativity and duration could be determined. The result is multiplied by 100. This value is inserted as "x" in the following metric calculation equation for percent native perennial species score.

Percent Native Perennial Species Metric = (x-67.72)(10/32.28)*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Percent wetland status species metric

Wetland indicator status denotes the probability of individual species of vascular plants occurring in wetlands. Chapter 62-340.450 F.A.C., Vegetative Index provides the Florida wetland indicator status for each species. The indicator status categories include:

- Obligate wetland (OBL). Almost always occurs in wetlands (estimated probability > 99%) under natural conditions.
- Facultative wetland (FACW). Usually occurs in wetlands (estimated probability 67% – 99%), but occasionally found in non-wetlands.
- Facultative (FAC). Equally likely to occur in wetlands (estimated probability 34% – 66%) or non-wetlands.
- Facultative upland (FACU). Usually occur in non-wetlands (estimated probability 67% – 99%), but occasionally found in wetlands (estimated probability 1% – 33%).
- Obligate upland (UPL). Occur almost always in non-wetlands (estimated probability > 99%) under natural conditions.

To calculate this metric, each species indicator status is recorded. Next, the percent wetland status species is calculated as the number of species with facultative wetland (FACW), or obligate wetland (OBL) status divided by the total number of species for which wetland status could be determined. The result is multiplied by 100. This value is inserted as "x" in the following metric calculation equation for percent wetland status metric score.

Percent Wetland Status Metric Score = (x-38.28)(10/38.81)*

If the resulting metric score is less than zero, the value is replaced with zero. If the metric score is greater than ten, the value is replaced with ten.

Final Vegetation WCI Score

The six individual metric scores are added together to generate the final vegetation WCI score for the sample transect within the restoration site. This effort will result in a single pre-implementation and post implementation scores at 1-, 3-, 5-, and 7-year intervals. Comparisons to the pre-implementation and post implementation scores shall be made. Ideally, WCI scores should increase following completion of the project.

Final vegetation WCI scores both pre- and post-implementation scores should be compared to determine relative improvement of the plant community resulting from the project.

2.2.2.2 UPLAND

2.2.2.2.1 Quantitative – Modified Line Intercept

To track changes in the upland plant community structure, species composition, and species diversity, specific quantitative and qualitative methods were designed. A single 50-meter transect should be established within the upland enhancement area that shall receive the most benefit because of the project. Standardized data shall be collected at intervals along the transect. At 10-meter intervals, quadrat plots should be sampled for groundcover and shrubs.

The primary methodology for describing changes in the plant community involve a quantitative transect-based series of methods to objectively measure changes in habitat structure. Habitat structural categories include groundcover and shrubs (with some notes given to vines and subcanopy when present). Each of these structural habitat categories and the specific quantitative methods for evaluating each category are listed and described below:

Groundcover, Shrubs, and Vines

1. Identify and choose one polygon to represent the enhance sandhill habitat.
2. Establish one permanent 50 meter linear transect in the polygon chosen for sampling.
3. Establish sample points every 10 meters. The first sampling point is located at 10 meters and the fifth point is located at 50 meters. Each point should be georeferenced and permanently marked by inserting an iron stake.
4. Establish permanent plots along the transect. These are placed every 10 meters. Measure and apply three adjacent 1-meter x 1-meter quadrats. These three quadrats are arranged perpendicular to the transect. Therefore, 15 total quadrats will be used to sample each transect. The plots should be arranged such that the plots flank the transect to create a rectangle of 3 square meters perpendicular to the transect. Thus, at each point 3 square meters will be sampled.
5. Record cover, density, and frequency.

All groundcover, shrub, and vine coverage data collected for each plot should include species name, percent cover by species, number of individuals, percent bare ground, and notes. The total coverage of each species within the plot shall be estimated using the following percentage classes: 100%, 75%, 50%, 25%, 12%, 6%, and 3%. These classes represent successive divisions of the square by one-half (after 75%) and are readily and consistently applied in the field. Bare ground will also be measured using the same coverage classes listed above.

This data shall be used to determine the importance value of each species which is the sum from the relative density, relative density, and relative dominance.

Frequency shall be calculated as the number of plots where a species is observed divided by the total number of survey plots. Relative frequency shall be calculated by dividing the frequency by the sum of the frequencies of all species, multiplied by 100 (to obtain a percentage).

Density shall be calculated as the total number of individuals of a species. Relative density is calculated by dividing the density by the sum of the densities of all species, multiplied by 100 (to obtain a percentage).

Dominance is calculated as the total percent cover of a species. Relative dominance is calculated by dividing the dominance by the sum of the dominance of all species, multiplied by 100 (to obtain a percentage).

Importance value for each species is calculated by summing the three relative values (frequency, density, and dominance) and diving the total by 3.

These parameters shall be evaluated to determine the response to the plant community structure because of the project.

2.2.2.2.2 Qualitative Method

The qualitative monitoring method should use a single walking transect to record species diversity and observations on the overall health, fecundity, distribution, wildlife usage and natural history, as well as any sightings of invasive exotics. The specific parameters to be observed and recorded on the walking transect should include the following:

1. Estimated dominance of graminoids (grasses, sedges, and rushes) based on the following cover classes as per the Braun Blanquet scale (Braun-Blanquet 1932): 1=0-1%, 2 = 1-5%; 3=5-25%; 4= 25-50%; 5=50-75%; 6=75-100%.
2. Estimated dominance of canopy (if present) based on the following cover classes per the Braun Blanquet scale: 1=0-1%, 2 = 1-5%; 3=5-25%; 4= 25-50%; 5=50-75%; 6=75-100%.
3. Estimated height class of the majority of woody shrubs using the following scale: 1=less than 0.5 m; 2=0.5-2 m; 3=2-5 m; 4=5-10 m; 5=10 m or greater.
4. Estimated abundance of weedy or ruderal species based on the following scale: 1 =absent; 2= uncommon, less than 5% of a given area; 3=occasional, greater than 5% to 50% of a given area; 4=common, greater than 50% of a given area. In conjunction with these observations a list of commonly seen ruderal or weedy native species will be compiled.
5. Estimate of appropriateness of tree density and health.
6. Wildlife usage and natural history notes. Observations concerning the fauna and their life histories as reflected in footprints, scat, herbivory, nests, etc. In addition, the calls of frogs, insects, and birds will be identified whenever possible.
7. Invasive exotics will be georeferenced.
8. Any notes on the general aspect of the site and how adaptive management techniques might be used toward enhancement target goals.
9. Photographs of noteworthy additions to the species richness such as evidence of successful reproduction of ecologically appropriate species especially threatened and endangered species.
10. Floristic summary of dominant plant species encountered or witnessed within the sandhill community.

Enhancement efforts should result in greater diversity and relative abundance of herbaceous species. To track these changes, at least one pre-implementation sample should be collected and analyzed with post-implementation sampling occurring at the 1-, 3-, 5-, and 7-year intervals.

2.2.3 FISH

Fish abundance, diversity, and biomass may provide clues on the overall benefit of the receiving waterbody. Habitat degradation via anthropogenic impacts generally favors common, generalist species (such as *Gambusia sp.*) while specialist and sensitive taxa (such as *Lepomis sp.* or *Micropterus salmoides*) become less common, and communities become less distinct from one another, which is a common ecological principle that has been observed over a variety of ecosystems.

Fish may be sampled in a single 100-meter reach of the receiving waterbody within and/or downstream of the project. At least one sampling effort should be completed pre-implementation and post-implementation samples should be collected at 1-, 3-, 5-, and 7-year intervals.

A single-pass effort should be sampled in an upstream direction. The first pass through a reach should provide the best opportunity to collect fish while they are still naive to sampling. A single-pass approach may provide a better estimate of relative abundance than a depletion approach, especially if some species are more likely to develop avoidance behaviors (Edwards et al. 2003). Fish may be collected using backpack electrofishing units and a 3.0-m x 1.2-m straight seine. Fish may be shocked into the seine when applicable or collected with dip nets. Fish shall be sorted by species, counted, and then released. Specimens not identifiable in the field may be preserved for later identification.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages.

2.3 GEOMORPHIC STREAM MONITORING

Specific geomorphic stream monitoring recommendations were incorporated within the Stream Assessment Guidance Manual and Summary Report, developed by the Wood team, and included in Volume 3C. The physical monitoring recommendations contained herein were taken directly from that report.

Geomorphic stream monitoring shall include the utilization of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach undertaken at 1-, 3-, 5-, and 7-year post-implementation intervals.

Bank pins are weatherproofed steel rods driven horizontally into the stream banks, initially flush with the surface of the bank (Figure 3). Cross sections are surveyed (typically in relative datum) to capture the geometry of the bank. The site is revisited regularly, and the length of the exposed rod along with the change in area of the surveyed cross sections are used to measure the erosion of the banks.

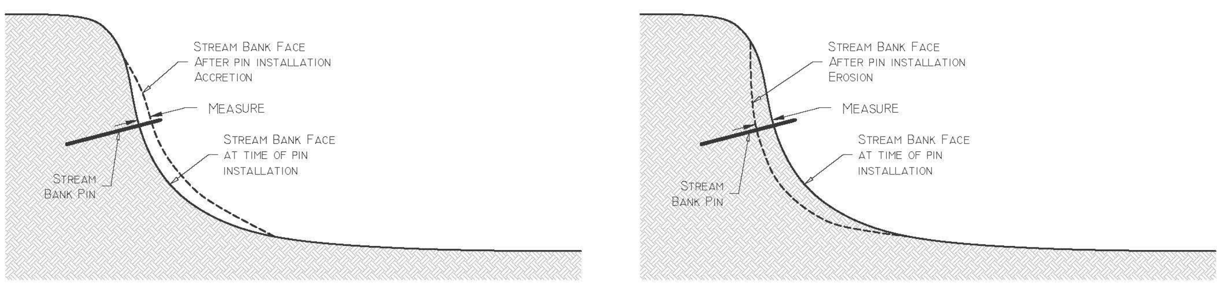

Figure 3: Graphic depiction of stream bank pin.

Scour chains are installed in the riffle bed of the stream at the repeat cross-section site to measure the depth of bed scour or deposition (Rosgen, 2014). The chain is buried vertically into the bed substrate so that the top of the chain is flush with the bed surface. If scour occurs, the chain will be exposed and lay on the bed. If deposition occurs after scour, the chain will lay horizontally, but be buried. If only deposition occurs, the chain will be buried, but still vertical. The depths to the chain are recorded, and if the rate of scour and deposition are relatively equal, the bed of the stream is stable. If the deposition rate is higher, the stream is aggrading; if the scour rate is higher, the stream is incising. See Figure 4 for a diagrammatic representation of the full range of scour chain behavior.

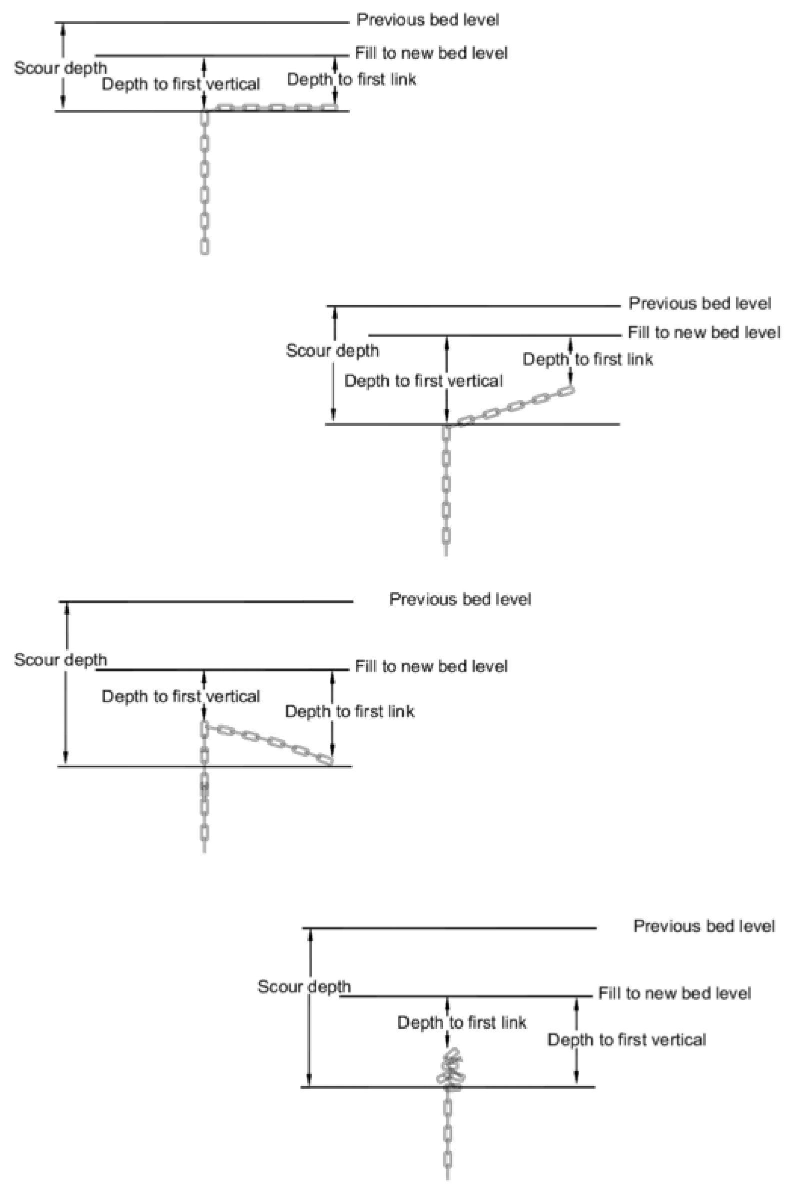

Figure 4: Diagrammatic representation of the full range of scour chain behavior. From cross-sectional and scour and fill changes in the Ngarradj catchment between 1998 and 2003 by Saynor, Mike & Erskine, Wayne & Evans, Kenneth. (2004)

2.4 SAMPLE COLLECTION, DOCUMENTATION, AND DATA ANALYSIS PROCEDURES

Sample collection, documentation, and data analysis shall conform to Florida Department of Environmental Protection (DEP) Standard Operating Procedures (SOP) as referenced in DEP QA Rule, Chapter 62-160, F.A.C. effective April 16, 2018. **Table 3** lists the individual DEP SOPs applicable to this monitoring effort. **Table 3**. DEP SOP applicable to the proposed monitoring efforts.

Each of the fifteen projects will benefit the watershed each in unique ways; therefore, not all of the monitoring metrics described herein will be applied to each project. Only those metrics which may benefit due to the implementation of the project will be evaluated. **Table 4** summarizes monitoring metrics that may be applied to each project.

Table 3: Monitoring metrics per site specific project.

WATERSHED SEGMENT	SITE SPECIFIC PROJECT	SURFACE WATER QUALITY	BENTHIC MACRO INVERTEBRATES - STREAM CONDITION INDEX	FISH	PLANT COMMUNITY STRUCTURE - FLORIDA WETLAND CONDITION INDEX	PLANT COMMUNITY STRUCTURE - QUANTITATIVE - MODIFIED LINE INTERCEPT AND QUALITATIVE OBSERVATIONS	GEOMORPHIC STREAM MONITORING
HEADWATERS	Olive Road Headwaters	X	X	X	X	-	-
	Headwaters near Burgess Road	X	-	X	X	-	X
	Coronet Drive	X	-	-	-	-	-
	Olive & Hilburn Headwaters	-	-	-	-	-	-
	Siskin Lane Headwaters	X	-	-	-	-	-
	Headwaters South of I-10	X	X	-	-	-	-
	Hilburn Road Headwaters	X	X	-	-	-	-
CREEK SITES	The Creek at Shiloh Drive	X	-	-	X	-	X
	The Creek at Sterling Hills	X	X	X	X	-	X
	The Creek from David Highway to 9th Ave	X	X	X	X	-	X
	The Creek from 9th Ave to 12th Ave	X	X	X	X	-	X
	Sacred Heart Campus	X	-	-	-	-	-
BAYOU SITES	Baars Park on the Bayou	-	-	-	-	X	-
	Semmes Elementary School and the Bayou	X	-	-	-	-	-
	Collection of Bayou Outfalls	X	-	-	-	-	-

3 HEADWATERS SITES

Seven site-specific projects were identified in the headwaters segment of the Watershed. The "Olive Road Headwaters" project has potential to be one of the most transformative projects and is likely to provide measurable changes to the receiving stream, if designed according to the conceptual plan.

3.1 OLIVE ROAD HEADWATERS SITE

The conceptual design for this project includes four stormwater management and hydrological restoration components (herein referred to as "improvements") including:

1. Wet-Detention – Hydromodification of wetland system north of Olive Road to allow for extended detention to occur.
2. Detention – Hydromodification of wetland system between Olive Road and existing access road to the south to allow for detention of storm flows. Storm flows will be passed through an up-flow biosorption activated media (BAM) system for additional pollutant removal.
3. Terraced Bioretention Ditches – Grade control/ditch block systems will be added to conveyance ditches along Olive Road at the project site. These structures will divert storm flows into newly constructed linear treatment ditches located parallel to the existing conveyance ditches and within the County-owned property. The linear treatment ditches will be vegetated and fitted with BAM supplemental bioretention features.
4. Olive Road Improvements Wet Detention Facility – the Olive Road Improvements project (neighboring County project) will include a 1.89-acre wet-detention facility to receive storm flows from 19.39 acres, of which 12.69 acres are from off-site residential areas.

3.1.1 METRICS

3.1.1.1 SURFACE WATER QUALITY

It is expected that this project will result in improvements to water quality. Initial modeling suggests the cumulative project could result in an estimated annual pollutant load reduction of up to 207.4 lbs. of Total Nitrogen (TN), 66.3 lbs. of Total Phosphorus (TP), and 8,164 lbs. of Total Suspended Solids (TSS).

Ambient water quality will be measured both pre- and post-project implementation with at least one fixed station above and one fixed station below the project site. Stations shall be selected once the design is finalized and all aspects of the project are understood.

Pre- and post-implementation surface water grab samples should be taken manually at each station and analyzed for TN, TP, and TSS. Additional physical parameters should be collected at each sample site including, dissolved oxygen (DO), oxygen saturation, temperature, pH, and specific conductivity. Instantaneous measurements of flow should be determined during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via the installation of a stream gauge and direct measurements taken during the sampling event. The up-gradient site will be separated from the down-gradient site via Olive Road and a cross culvert, which may create differences in flow between the two sites. Separate measurements of flow should be obtained from each site.

At least six pre-implementation samples should be taken at both sample locations and analyzed for TN, TP, and TSS. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the dry and wet seasons.

If the budget or resources do not allow pre-implementation sample collection, then the County may use existing water quality data from Watershed Information Network (WIN), Impaired Waters Rule (IWR) database, the County's Integrated Water Quality Monitoring Program, which includes an Ambient Water Quality Monitoring Program, Bacteria Pollution Control Plan (BPCP) Monitoring Programs (Carpenter Creek and Bayou Texar), and any data collected from the recommended monitoring options enumerated by the Wood team in two separate technical memoranda dated January 31, 2020 and May 13, 2020. For example, there is an existing water quality station at Olive Road and the Wood team's monitoring recommendations suggested two new monitoring stations between Olive Road and Interstate 10. These stations and the recommended parameters may provide the data needed to evaluate the potential beneficial effects of the Olive Road Headwaters project.

At least 12 post-implementation grab samples at both sample locations (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids, along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the Country to estimate loading rates and yields.

3.1.1.2 BIOLOGICAL

3.1.1.2.1 Benthic Macro Invertebrates

To measure the potential influence of this project within the downstream receiving waterbody, the Wood team recommends a single SCI station between the Olive Road Headwaters project and Interstate I-10. The station should be subject to an SCI prior to the implementation of the project to develop a baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. A post-project implementation sample should be taken 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 3-, 5-, and 7-year intervals post-project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

3.1.1.2.2 Fish

The Olive Road Headwaters project should improve habitat conditions and fish populations, if designed per the conceptual plans. Fish shall be sampled in a single 100-meter reach of the receiving waterbody and/or downstream of the project in accordance with the methods described in this report.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages.

3.1.1.2.3 Plant Community Structure - Florida Wetland Condition Index

A single sampling transect should be established within the wetland portions of the restoration site and ideally within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken, along with post-implementation samples at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

3.2 HEADWATERS NEAR BURGESS ROAD

This project has the potential of being the most physically transformative project in the headwaters segment since it includes priority-2 stream restoration of a 1,540 ft. segment of an unnamed headwater tributary of Carpenter Creek. Work within the creek segment is proposed to include a new bottomland area at least 65 feet wide within the existing forested wetland. A natural headwater channel approximately 6-ft. in width will be contoured to meander across the newly created forested meander belt. Additional stormwater retrofits are proposed to complement the stream restoration.

3.2.1 METRICS

3.2.1.1 SURFACE WATER QUALITY

The proposed restoration at the Headwaters near Burgess Road site is primarily designed to mitigate erosion of a headwater stream. The project should reduce total suspended solid loading within the downstream segments of Carpenter Creek. The results from the pollutant load model, developed as part of the WMP, indicate that TSS loading for the attributing subbasin is 1551.62 lbs. per year. Accounting for a removal efficiency of 90% results in a removal of approximately 1400 lbs. per year of TSS, 1.96 lbs. per year of TN, and 0.3 lbs. per year of TP.

The upstream segment of the unnamed headwater tributary does not exhibit perennial flow and may be characterized as ephemeral. This will present practical difficulties with using an above/below sampling approach to quantify pollutant removal. Escambia County, as part of the Carpenter Creek BPCP,

has an established water quality monitoring station located in Carpenter Creek at Burgess Road which is located immediately downstream of the proposed restoration site. As part of the County's integrated water quality monitoring program, this station is monitored for the following constituents:

- Field Measurements
  - Temperature, Dissolved Oxygen (mg/L and percent saturation), pH (SU), Salinity (PPT), Specific Conductance (µohms/cm), and Turbidity (NTU).
- Laboratory Analyses
  - Microbiology: *Escherichia coli* bacteria.
  - Microbial Source Tracking: as resources allow and merited by follow-up investigations.
  - As part of the WMP, the Wood team provided a preliminary review of potential data gaps associated with the existing ambient water quality and BPCP monitoring

programs in the Carpenter Creek watershed. In addition to the BPCP constituents listed above, the Wood team recommended several additional parameters including, but not limited to, TSS, Ammonia Nitrogen, Nitrate+Nitrite, Total Kjeldahl Nitrogen, and TP. It is recommended that Escambia County collect pre-implementation samples from the existing Carpenter Creek water quality station at Burgess Road and analyze for the ambient and additionally recommended parameter list provided in the Wood team's gap analysis. The station is currently sampled monthly per the BPCP program. It is recommended that the additional parameters recommended in the Wood team's gap analysis be added to the monthly sampling frequency to assist with the evaluation of this project.

Instantaneous measurements of flow should be collected during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via installation of a stream gauge and direct measurements taken during the sampling event.

At least six pre-implementation samples should be taken at the sample station. At least 12 post-implementation grab samples should be taken at the sample station during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

3.2.1.2 BIOLOGICAL

3.2.1.2.1 Plant Community Structure - Florida Wetland Condition Index

A single sampling transect should be established within the wetland portions of the stream restoration site and subject to the Florida Wetland Condition Index according to the means and methods previously described in this report. The sample transect should be placed within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken, along with post-implementation samples taken at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

3.2.1.2.2 Fish

The Headwaters near Burgess Road project should improve habitat conditions and fish populations, if designed according to the conceptual plan. Fish may be sampled in a single 100-meter reach of the receiving waterbody within and/or downstream of the project according to the methods prescribed in this report. At least one sampling effort should be completed pre-implementation, and post implementation samples collected at 1-, 3-, 5-, and 7-year intervals.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages among seasons for each site.

3.2.1.3 GEOMORPHIC STREAM MONITORING

Geomorphic stream monitoring consisting of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach should be undertaken at 1-, 3-, 5-, and 7-year post-implementation intervals.

3.3 CORONET DRIVE

Proposed improvements to the Coronet Drive site include the installation of four baffle boxes or continuous deflection separators to treat stormwater runoff before it reaches the creek system. Modeling efforts conducted as part of this WMP suggest the removal of up to 71 lbs. of TN per year and 11.45 lbs. of TP per year.

The receiving waterbody downstream of the proposed improvements is an unnamed headwater tributary of Carpenter Creek that does not exhibit perennial flow and may be characterized as ephemeral. This will present practical difficulties with using an above/below sampling approach to quantify pollutant removal. Escambia County, as part of the Carpenter Creek BPCP, has an established water quality monitoring station located in Carpenter Creek at Burgess Road which is located downstream of the proposed project site. Under the BPCP plan, this station is monitored for the following constituents:

- Field Measurements
  - Temperature, Dissolved Oxygen (mg/L and percent saturation), pH (SU), Salinity (PPT), Specific Conductance (µohms/cm), and Turbidity (NTU).
- Laboratory Analyses
  - Microbiology: *Escherichia coli* bacteria.
  - Microbial Source Tracking: as resources allow and merited by follow-up investigations.

As part of the WMP, the Wood team provided a preliminary review of potential data gaps associated with the existing ambient water quality and BPCP monitoring programs in the Carpenter Creek watershed. In addition to the BPCP constituents listed above, Wood recommended the additional several parameters including but not limited to TSS, Ammonia Nitrogen, Nitrate+Nitrite, Total Kjeldahl Nitrogen, and TP. The station is currently sampled monthly per the BPCP program. It is recommended that Escambia County collect pre-implementation samples from the existing Carpenter Creek water quality station at Burgess Road using the recommended parameter list provided in the Wood technical memoranda. These parameters should be added to the monthly sampling frequency.

Instantaneous measurements of flow should be collected during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via installation of a stream gauge and direct measurements taken during the sampling event.

At least six pre-implementation samples should be taken at the sample station. At least 12 post-implementation grab samples should be taken at the sample station during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

3.4 OLIVE & HILBURN ROAD HEADWATERS

This is a flood-reduction project conceptually designed to alleviate flooding for property owners located on the east side of Sabra Road and the west side of Whitmire Road. The recommended project includes a constructed bioswale that will capture the excess water and allow it to flow through a new ditch-bottom inlet near the portion of Sabra Road that runs in the east-west direction and tie it into the existing stormwater infrastructure. It is expected that the improved site conditions will reduce flooding from approximately 44 residential properties and subsequent roadways. In total, the proposed recommendations should result in a 1.25-inch flood reduction. Improvements to water quality and fish and wildlife was not a significant consideration at this site, therefore site-specific monitoring was not included.

3.5 SISKIN LANE HEADWATERS

The conceptual design proposed at this location includes the installation of BAM and outfall level spreaders within three existing stormwater ponds. Preliminary modeling efforts, conducted during the WMP, suggest the removal of up to 1551.62 lbs. per year of TSS, 1.96 lbs. per year of TN, and 0.3 lbs. per year of TP. The proposed recommendations are designed to improve the efficiency of existing stormwater management systems, which should result in positive impacts to the downstream receiving waterbody.

The receiving waterbody downstream of the proposed improvements is an unnamed headwater tributary of Carpenter Creek that does not exhibit perennial flow and may be characterized as ephemeral. This will present practical difficulties with using an above/below sampling approach to quantify pollutant removal. Escambia County, as part of the Carpenter Creek BPCP, has an established water quality monitoring station located in Carpenter Creek at Burgess Road, which is located downstream of the proposed project site. Under the BPCP plan, this station is monitored for the following constituents:

- Field Measurements
  - Temperature, Dissolved Oxygen (mg/L and percent saturation), pH (SU), Salinity (PPT), Specific Conductance (µohms/cm), and Turbidity (NTU).
- Laboratory Analyses
  - Microbiology: *Escherichia coli* bacteria.
  - Microbial Source Tracking: as resources allow and merited by follow-up investigations.

As part of the WMP, the Wood team provided a preliminary review of potential data gaps associated with the existing ambient water quality and BPCP monitoring programs in the Carpenter Creek watershed. In addition to the BPCP constituents listed above, Wood recommended the additional several parameters including but not limited to TSS, Ammonia Nitrogen, Nitrate+Nitrite, Total Kjeldahl Nitrogen, and TP. The station is currently sampled monthly per the BPCP program. It is recommended that Escambia County collect pre-implementation samples from the existing Carpenter Creek water quality station at Burgess Road using the recommended parameter list provided in the Wood technical memoranda. These parameters should be added to the monthly sampling frequency.

Instantaneous measurements of flow should be collected during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via installation of a stream gauge and direct measurements taken during the sampling event.

At least six pre-implementation samples should be taken at the sample station. At least 12 post-implementation grab samples should be taken at the sample station during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

3.6 HEADWATERS SOUTH OF I-10

The recommendations proposed at this location include the installation of BAM in pond bottoms and at existing outfall structures, and outfall level spreaders within three existing stormwater ponds.

3.6.1 METRICS

3.6.1.1 SURFACE WATER QUALITY

It is expected that this project will result in improvements to water quality. Preliminary modeling efforts, produced during the WMP, suggest the removal of up to 55.4 lbs. of TN per year and 8.5 lbs. of TP per year. The proposed recommendations are designed to improve the efficiency of existing stormwater management systems which should result in positive impacts to the downstream receiving waterbody.

Ambient water quality should be measured both pre- and post-project implementation with at least one fixed station above the project site and one fixed station below the project site. Stations shall be selected once the design is finalized and all aspects of the project are understood.

Pre- and post-implementation surface water grab samples shall be taken manually at each station and analyzed for total nitrogen, total phosphorus, and total suspended solids. Instantaneous measurements of flow should be determined during each sampling event. Measurement of flow may be obtained via the use of continuous flow measurement devices or via installation of a stream gauge and direct measurements taken during the sampling event. Additional physical parameters should be collected at each sample site including dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

At least six pre-implementation samples should be taken at both sample locations. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the dry and wet seasons.

At least 12 post-implementation grab samples at both sample locations (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids including the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the Country to estimate loading rates and yields.

3.6.1.2 BIOLOGICAL – BENTHIC MACRO INVERTEBRATES – STREAM CONDITION INDEX

To measure the potential influence of this project within the downstream receiving stream, the Wood team recommends a single Stream Condition Index sample station immediately downstream of the project site, preferably just south of the overhead electric transmission line easement. The station should be subject to an SCI prior to the implementation to develop as baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. Post–project implementation samples should be taken after 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 1-, 3-, 5-, and 7-year intervals post-project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

3.7 HILBURN ROAD HEADWATERS

The Hilburn Road Headwaters project includes the construction of a bioswale along the east and west sides of Hilburn Avenue and the installation of a baffle box at the discharge location of the bioswale to reduce concentrations of TSS, TN, and TP.

3.7.1 METRICS

3.7.1.1 SURFACE WATER QUALITY

Preliminary modeling results, developed during the WMP, suggest a TSS removal of up to 1551.62 lbs. per year, TN removal of up to 1.96 lbs. per year, and TP removal of up to 0.3 lbs. per year. Sample design shall follow an above/below watershed approach as previously described in this report. For the below watershed sample location site, Escambia County has an existing station located in Carpenter Creek at Burgess Road. For the above watershed sample location site, the Monitoring Program Options for Carpenter Creek and Bayou Texar technical memorandum, developed by the Wood team, recommended a new station on a natural reach of Carpenter Creek located just north of Interstate 10 in the vicinity of 819 Brookmeadow Drive.

Using the recommended station at 819 Brookmeadow Drive and the existing station at Burgess, at least six pre-implementation samples are recommended to be taken at both locations. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the dry and wet seasons.

At least 12 post-implementation grab samples at both sample locations (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

3.7.1.2 BIOLOGICAL – BENTHIC MACRO INVERTEBRATE – STREAM CONDITION INDEX

To measure the potential influence of the Hilburn Road Headwaters project within the downstream receiving stream, the Wood team recommends a single Stream Condition Index sample station immediately downstream of the project site, preferably just south of the overhead electric transmission line easement. The station should be subject to an SCI prior to the implementation to develop a baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. Post–project implementation samples should be taken after 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 1-, 3-, 5-, and 7-year intervals post-project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

4 CREEK SITES

4.1 THE CREEK AT SHILOH DRIVE (SITE 5)

The proposed project includes priority-2 stream restoration of 510-ft. of stream reach located within a bottomland hardwood forest north of Shiloh Drive between existing residential developments. The design approach is to give the drainage corridor a larger alluvial floodplain and lower bottomland forest that it requires to stabilize the valley and its stream channel. Work will include the creation of a new 0.5-acre forested meander belt at least 40-ft. wide embedded within the existing 300-ft wide forest. A natural headwater channel about 4 to 5 feet wide will be contoured to meander across the newly created forested meander belt. Stream Condition Index and fish sampling were not contemplated due to the ephemeral nature of the project site. The following monitoring metrics are suggested.

4.1.1 METRICS

4.1.1.1 SURFACE WATER QUALITY

It is expected that the priority-2 stream restoration will remove up to 55 lbs. of TN per year and prevent the erosion of up to 45 tons of sediment per year.

Escambia County has existing sample stations that are above and below the site's affected basin, which are the Carpenter Creek at Burgess station and Carpenter Creek at Davis station. Using these stations, at least six pre-implementation samples should be taken at each sample location. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the dry and wet seasons.

At least 12 post-implementation grab samples at each sample location (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, Chlorophyl a, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

4.1.1.2 BIOLOGICAL - PLANT COMMUNITY STRUCTURE - FLORIDA WETLAND CONDITION INDEX

A single sampling transect should be established within the 0.5-acre forested wetland meander belt that will be created and subject to the Florida Wetland Condition Index (WCI) according to the means and methods previously described in this report. The sample transect should be placed within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken along with post-implementation samples taken at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

4.1.1.3 GEOMORPHIC STREAM MONITORING

Physical stream monitoring consisting of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach should be undertaken at 1-, 3-, 5-, and 7-year post-implementation intervals.

4.2 THE CREEK AT STERLING HILLS (SITE 8)

The Creek at Sterling Hills project includes 670 linear feet of priority-1 stream restoration, 830 linear feet of priority-2 stream restoration, and modifications to existing stormwater management systems including installation of continuous monitoring and adaptive control at an existing FDOT pond located east of Interstate I-10 and south of Carpenter Creek.

4.2.1 METRICS

4.2.1.1 SURFACE WATER QUALITY

Water quality benefits of the proposed stream restoration would include approximately 444 lbs. per year of TN reduction and 90 tons per year of sediment reduction.

Escambia County has existing sample stations that are above and below the affected basin, known as the Carpenter Creek at Burgess station and the Carpenter Creek at Davis station. Using these stations, at least six pre-implementation samples should be taken at each location. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the dry and wet seasons.

At least 12 post-implementation grab samples at each sample location (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, chlorophyl a, and total suspended solids along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

4.2.1.2 BIOLOGICAL

4.2.1.2.1 Plant Community Structure - Florida Wetland Condition Index

Sampling transects should be established within each of the proposed restoration segments (Segments A & B depicted in Figure 2-1 of Volume 4) and subject to the Florida Wetland Condition Index (WCI) according to the means and methods previously described in this report. The sample transect should be placed within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken, along with post-implementation samples taken at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

4.2.1.2.2 Benthic Macro Invertebrates – Stream Condition Index

To measure the potential influence of this project, the Wood team recommends Stream Condition Index sample stations within each of the restored reaches (Segments A & B depicted in 2-1 of Volume 4). Each station should be subject to an SCI prior to implementation to develop a baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. Post-project implementation samples should be taken after 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 1-, 3-, 5-, and 7-year intervals post-project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

4.2.1.2.3 Fish

The Creek at Sterling Hills project should improve habitat conditions and fish populations, if designed according to the conceptual plan. Fish should be sampled in a single 100-meter reach in each of the restoration segments (Segments A and B) in accordance with the methodologies described in this report. At least one sampling effort should be completed pre-implementation, and post-implementation samples collected at 1-, 3-, 5-, and 7-year intervals.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages among seasons for each site.

4.2.1.3 GEOMORPHIC STREAM MONITORING

Physical stream monitoring consisting of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach should be undertaken at 1-, 3-, 5-, and 7-year post-implementation intervals.

4.3 THE CREEK FROM DAVIS HIGHWAY TO 9TH AVENUE

The concept plan for The Creek from Davis Highway to 9th Avenue considers 7,500 linear feet of priority-2 stream restoration that will create an 80- to 100-foot-wide meander belt and sloped bottomland forested with a 17- to 20-foot-wide meandering open channel coursing through the meander belt, resulting in an estimated 34.9 acres of enhanced/restored habitat. Additional considerations of this project include retrofitting existing stormwater management systems with BAM and programmatic low-impact design (LID) retrofitting.

4.3.1 METRICS

4.3.1.1 SURFACE WATER QUALITY

The overall TN reductions for The Creek from Davis Highway to 9th Avenue stream restoration will be approximately 1,954 lbs. per year. The distribution of this is 410, 842, and 702 lbs. per year for the north, middle, and south sub-sections, respectively.

The potential site-wide sediment reduction is 2000 tons/year, distributed among the three sub-sections at 900, 600, and 500 tons per year from north to south. The bedload reduction estimates are based on model predictions. Bedload yield may be measured using scour chains as described in Section 4.3.1.3.

Escambia County has existing sample stations that are above and below the affected basin, referred to as the Carpenter Creek at Davis station, and the Carpenter Creek at N 9th Ave. station. Using these stations, at least six pre-implementation samples should be taken at each location. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions.

At least 12 post-implementation grab samples at each sample location (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, chlorophyl a, and total suspended solids, along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

4.3.1.2 BIOLOGICAL

4.3.1.2.1 Plant Community Structure - Florida Wetland Condition Index

Sampling transects should be established within each of the proposed restoration segments (Segments A, B, and C depicted in Figure 2.2-1 of Volume 4) and subject to the Florida Wetland Condition Index (WCI) according to the means and methods previously described in this report. The sample transect should be placed within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken, along with post-implementation samples taken at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

4.3.1.2.2 Benthic Macro Invertebrates – Stream Condition Index

To measure the potential influence of this project, the Wood team recommends Stream Condition Index (SCI) sample stations within each of the restored reaches (Segments A, B, and C depicted in Figure 2.2-1 of Volume 4). Each station should be subject to an SCI prior to the implementation to develop a baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. Post-project implementation samples should be taken after 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 1-, 3-, 5-, and 7-year intervals post-project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

4.3.1.2.3 Fish

The project should improve habitat conditions and fish populations, if designed according to the conceptual plan. Fish should be sampled along a 100-meter reach in each of the restoration segments (Segments A, B, and C as referenced in 2.2-1 of Volume 4) in accordance with the methodology previously described in this report. At least one sampling effort should be completed pre-implementation, and post-implementation samples collected at 1-, 3-, 5-, and 7-year intervals.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages among seasons for each site.

4.3.1.3 GEOMORPHIC STREAM MONITORING

Physical stream monitoring consisting of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach should be undertaken at 1-, 3-, 5-, and 7-year post-implementation intervals.

4.4 THE CREEK FROM 9TH AVENUE TO 12TH AVENUE

The concept plan for The Creek from 9th Avenue to 12th Avenue site considers 2,190 feet of priority-1 stream restoration within three individual stream segments (identified as Segments A, B, and C in Figure 2.2-1 of Volume 4), creation of an anabranch just west of North 12th Avenue along the south side of the creek, and restoration of baygall wetland area just east of Drew Circle.

4.4.1 METRICS

4.4.1.1 SURFACE WATER QUALITY

Water quality benefits of the proposed stream restoration at the Creek from 9th Avenue to 12th Avenue site include approximately 137 lbs. per year of TN reduction.

Escambia County has existing sample stations that are above and below the affected basin, referred to as the Carpenter Creek at Davis station and the Carpenter Creek at N 9th Avenue station. Using these stations, at least six pre-implementation samples should be taken at each location. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the wet and dry seasons.

At least 12 post-implementation grab samples at each sample location (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, chlorophyl a, and total suspended solids, along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

4.4.1.2 BIOLOGICAL

4.4.1.2.1 Plant Community Structure - Florida Wetland Condition Index

A single sample transect should be established within the baygall restoration site just east of Drew Circle and subject to the Florida Wetland Condition Index (WCI) according to the means and methods previously described in this report. The sample transect should be placed within the area most susceptible to a response from the plant community structure. A single pre-implementation WCI sample should be taken, along with post-implementation samples taken at 1-, 3-, 5-, and 7-year intervals. Pre- and post-implementation WCI scores may be compared to determine plant community response to restoration activities.

4.4.1.2.2 Benthic Macro Invertebrates – Stream Condition Index

To measure the potential influence of this project, the Wood team recommends Stream Condition Index (SCI) sample stations within each of the restored reaches (Segments A, B, and C depicted in Figure 2.2-1 of Volume 4). Each station should be subject to an SCI prior to the implementation to develop a baseline score. It is imperative that sample collection occurs during normal meteorological conditions, as sufficient flow is critical to stream biological health. Sample collection should not occur within 3 months of stream desiccation or during periods of stagnate water velocities. Post-project implementation samples should be taken after 12 months following the completion of the project to avoid any influences from disturbances between construction and final stabilization. Additionally, SCI sampling should occur at the 1-, 3-, 5-, and 7-year intervals following project implementation. Pre- and post-implementation scores may then be compared to determine potential impacts.

4.4.1.2.3 Fish

The project should improve habitat conditions and fish populations. Fish should be sampled in a single 100-meter reach in each of the restoration segments (Segments A, B, and C, including the created anabranch as referenced in Figure 2.2-1 of Volume 4) according to the methods previously described in this report. At least one sampling effort should be completed pre-implementation, and post-implementation samples collected at 1-, 3-, 5-, and 7-year intervals.

Abundance (N), relative abundance (%), species richness (number of species), and Shannon-Weaver Index of Diversity (H') should be used to analyze fish assemblages among seasons for each site.

4.4.1.3 GEOMORPHIC STREAM MONITORING

Physical stream monitoring consisting of bank pins and scour chains, cross-section surveys, and regular site assessments at fixed locations within the proposed restoration reach should be undertaken at 1-, 3-, 5-, and 7-year post-construction intervals.

4.5 SACRED HEART CAMPUS

The Sacred Heart Campus site is a commercial area that includes the Sacred Heart Memorial Hospital Complex. This site is characterized by high impervious area coverage. The project concept considers stormwater retrofits and recommendations to increase the efficiency of the existing stormwater management system and infrastructure. The project will directly benefit water quality of the receiving stream with indirect benefits to fish and wildlife.

Preliminary modeling results, developed as part of the WMP, suggest loading reductions of up to 357.43 lbs. of nitrogen per year, 61 lbs. of phosphorus per year, and 21,582.15 lbs. of TSS per year.

Escambia County has existing sample stations that are above and below the affected basin, referred to as the Carpenter Creek at Davis station and the Carpenter Creek at Brent station. Using these stations, at least six pre-implementation samples should be taken at each location. Since hydrologic conditions within a watershed may affect the variability of many chemical constituents, samples should be collected throughout a range of streamflow conditions during both the wet and dry seasons.

At least 12 post-implementation grab samples at each location (above/below) should be taken during varying hydrologic conditions and analyzed for total nitrogen, total phosphorus, chlorophyl a, and total suspended solids, along with the direct physical measurements of flow, dissolved oxygen, oxygen saturation, temperature, pH, and specific conductivity.

The measured concentration of each parameter should be compared to measured stream flow using a simple regression analysis. Additionally, the combination of flow measurements and water quality data will allow the County to estimate loading rates and yields.

5 BAYOU SITES

5.1 BAARS PARK ON THE BAYOU

In addition to the public access components of the concept plan, the Baars Park on the Bayou project considers the enhancement of existing sandhill ecological community that exists within the site. Restoration concepts include reduction in tree canopy and exotic species removal. Water quality and quantity improvements were not contemplated. The below monitoring metric was specifically recommended based on the target plant community.

5.1.1 METRIC – BIOLOGICAL - PLANT COMMUNITY STRUCTURE

The sandhill community is a forest with an open canopy of widely spaced longleaf and sand pine trees, with a sparse to dense groundcover of grasses, forbs, and shrubs. The upland soils are very

well drained, droughty, and sandy with low nutrient availability. The sandhill habitat has been impacted by the suppression of the natural fire regime which has likely caused a decline in species diversity, especially within the groundcover stratum. The objective of the concept plan is to restore the groundcover and increase the relative cover of herbaceous species. This objective will be achieved via the mechanical reduction of canopy and subcanopy stratums and treatment of exotic and nuisance species.

5.1.2 QUANTITATIVE METHOD

To track changes in the plant community structure, species composition, and species diversity, specific quantitative and qualitative methods were designed. A single 50-meter transect should be established within the proposed sandhill enhancement area with standardized data collected at intervals along the transect. At 10-meter intervals, quadrat plots should be sampled for groundcover and shrubs according to the methods described in this report.

5.1.2.1 QUALITATIVE METHOD

The qualitative monitoring method should use a single walking transect to record species diversity and observations on the overall health, fecundity, distribution, wildlife usage and natural history, as well as any sightings of invasive exotics. The specific parameters to be observed and recorded on the walking transect are enumerated in Section 2.2.2.2 of this report.

Enhancement efforts should result in greater diversity and relative abundance of herbaceous species. To track these changes, at least one pre-implementation sample should be collected and analyzed with post-implementation sampling occurring at the 1-, 3-, 5-, and 7-year intervals.

5.2 SEMMES ELEMENTARY SCHOOL AND THE BAYOU

The concept plan for the Semmes Elementary School and the Bayou site largely intends to improve public access to Bayou Texar and offer additional recreational opportunities. There is a small water quality component which would include the installation of BAM at the pond bottom to improve the removal efficiency of the existing stormwater management system. Pollutant load reductions were not quantified. Projects of this nature may provide indiscriminate, almost immeasurable, improvements to water quality, but when combined with the other projects recommended for implementation within the watershed, the overall effects may be dramatic. Therefore, it is suggested that the County rely on its existing ambient and BPCP monitoring efforts, including additional stations and parameters suggested by the Wood team in the technical memorandum titled “Monitoring Program Options for Carpenter Creek and Bayou Texar”, provided in Volume 2 Appendix F. No other metrics were contemplated.

5.3 COLLECTION OF BAYOU OUTFALLS

The Collection of Bayou Outfalls site is comprised of multiple parcels in residential neighborhoods along Bayou Texar. Each area is either County- or City-owned, and parcels predate modern-day stormwater water quality regulations, thus discharging untreated stormwater directly into Bayou Texar. Existing infrastructure at most sites appears to include a paved flume leading from the curb inlet into the bayou, which provides little to no treatment. The concept plan considers the installation of baffle boxes or placement of continuous deflective separators (CDS) at each location with the discharge being dissipated via either a level spreader, meandering bioswale, or spreader swale.

Pollutant load removal for each outfall was not calculated because individual contributions of each outfall will be minor. However, the cumulative effects related to the implementation of all six outfall recommendations associated with this concept are expected to be more dramatic. Therefore, it is suggested that the County rely on its existing ambient and BPCP monitoring efforts, including additional stations and parameters suggested by the Wood team in the technical memorandum titled “Monitoring Program Options for Carpenter Creek and Bayou Texar”, provided in Volume 2 Appendix F. No other metrics were contemplated.

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