Appendix H - Adaptive Management & Monitoring Plan

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Anacostia Watershed, Prince George's County
Monitoring and Adaptive Management Plan

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1. Project Background

The Baltimore District of the U.S. Army Corps of Engineers (USACE) is proposing to restore stream habitat utilizing natural channel design principles and to remove fish blockages within portions of the Anacostia River watershed in Prince George's County, Maryland. The recommended plan will restore degraded aquatic ecosystem structure and function within stream segments in Northeast Branch, Sligo Creek, Northwest Branch, Paint Branch, and Indian Creek.

The study area includes the Anacostia River watershed within Prince George's County. The study area includes six subwatersheds (Figure 1-6) in the non-tidal portion of the Anacostia River watershed, including Northwest Branch, Sligo Creek, Northeast Branch, Indian Creek, Paint Branch, and Little Paint Branch. Figure 1 shows the stream reaches selected for study. The Anacostia River watershed in Prince George's County is highly urbanized. About half of the total area of the Anacostia River watershed in Prince George's County consists of developed area, including low to high intensity residential, commercial, and industrial uses.

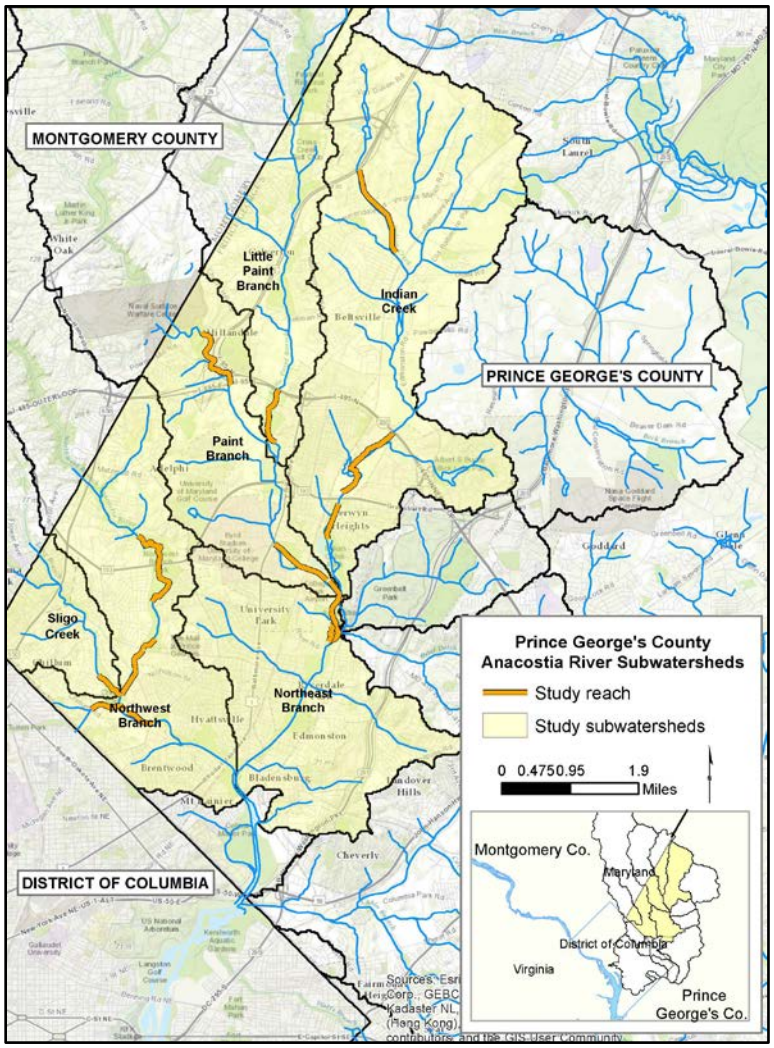

Figure 1. Anacostia River watershed and subwatersheds in Prince George's County, MD

1.1 Project Planning Objectives

The objectives of Anacostia stream restoration projects are to:

1. Restore physical habitat within streams with degraded aquatic conditions in the mainstem and tributaries of both the Northwest and Northeast Branch subwatersheds of the Anacostia River in Prince George's County.
2. Enhance aquatic ecosystem resilience by restoring fish passage for migratory and non-migratory fish and connecting existing higher quality habitat in the mainstem and tributaries of both the Northwest and Northeast Branch subwatersheds of the Anacostia River in Prince George's County.

1.2 Proposed Action

Plan NW-C + NE-A is identified as the recommended plan. Plan NW-C + NE-A includes sites 3, 5, 9, 11, 13, and 15. The recommended plan will restore approximately 7 miles of in-stream habitat on six stream reaches, approximately 4 miles of fish passage, and connect a network of approximately 14 miles of restored habitat. The plan removes fish blockages on Northwest Branch and Sligo Creek providing anadromous fish species of concern access to their historical range on Northwest Branch and facilitating the migration of fish to higher quality habitat upstream of Northeast Branch.

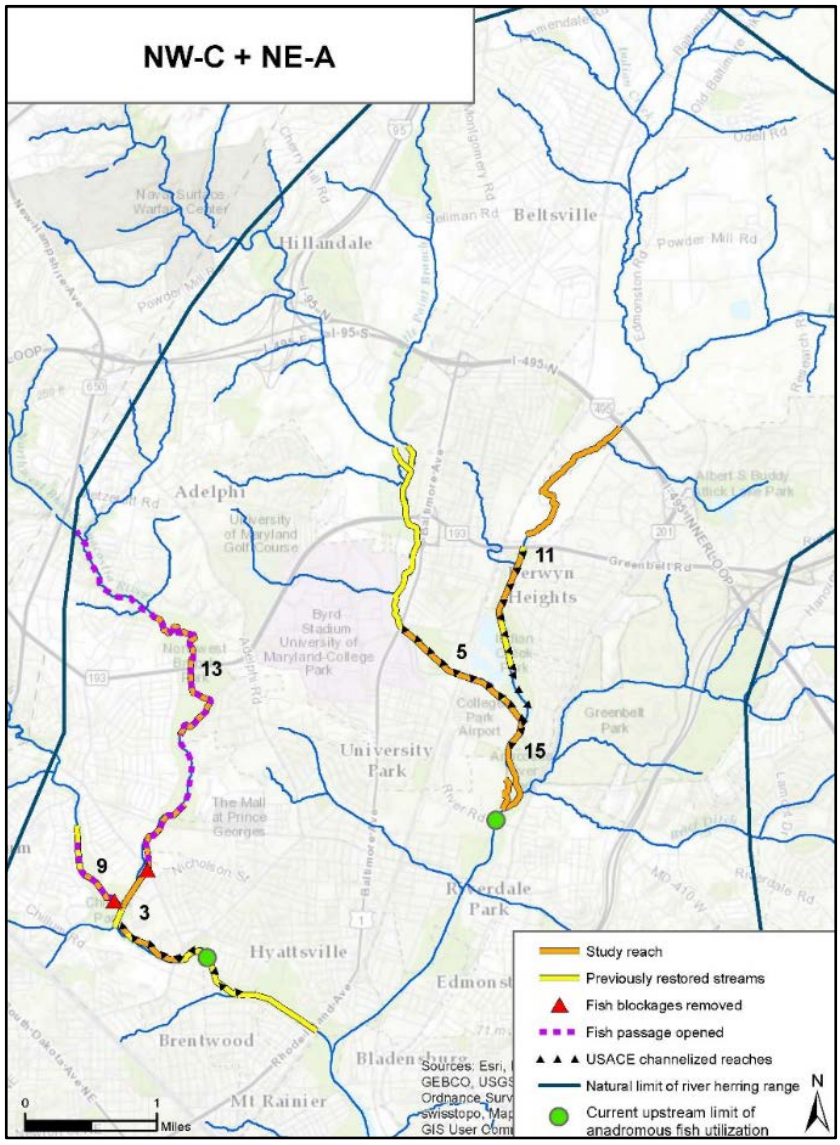

Figure 2. The Recommended Plan

2. USACE Guidance on Monitoring

U.S. Army Corps of Engineers (USACE) monitoring and adaptive management policy is required by the Water Resources Development Act of 2007 and presented in planning guidance (Engineering Regulation (ER) 1105-2-100, Engineering Circular (EC) 1105-2-409, and Memorandum on Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007, Monitoring for Ecosystem Restoration). Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management will be needed to attain project benefits. Adaptive management addresses the uncertainties about a project's actual performance that exist when implementation decisions are made to undertake a water resources project. This technique allows decision making and implementation to proceed with the understanding that outputs will be assessed and evaluated and that some structural or operational changes to the project may be necessary to achieve desired results. At the heart of adaptive management is an appropriate monitoring program to determine if the outputs/results are satisfactory, and to determine if any adjustments are needed.

3. Purpose of the Plan

The purpose of this plan is to demonstrate ecological success of the project. This success is determined by monitoring metrics that are specifically tied to project objectives, and setting performance targets. In addition, the plan identifies what adaptive management (contingency) is proposed if the performance targets are not met. This plan presents the framework for the above methodology, and will be refined as the project proceeds into Pre-construction, Engineering, and Design (PED) phase in collaboration with the non-Federal sponsors, as well as other stakeholders who may take responsibility for monitoring ecological variables in the watershed.

4. Project Monitoring

Stream restoration is an evolving field and the urban stream environment presents the possibility for rapid, unpredicted changes in conditions that would affect the success of the project. It is expected that this site will be dynamic and evolve. To verify that project objectives are met, it will be necessary to monitor the restored stream following a multiple faceted cost-shared, post-construction monitoring plan. To evaluate the success of the stream restoration measures, collaborative monitoring efforts and information sharing would occur between the team, the non-Federal sponsor, and other organizations involved in assessing the health of the stream.

Monitoring efforts will be performed by using monitoring metrics listed in section 5 (Evaluation of Specific Objectives). All post-construction monitoring will be performed by qualified biologists and hydraulic engineers.

Evaluating the evolution of restored habitats will be based on the establishment of the targeted habitat within the restoration site and on the ecological functioning of those habitats. All post-construction monitoring will be cost shared between USACE and the non-Federal sponsor. A maximum of ten years of cost-shared monitoring effort is allowed per guidance. A ten year

monitoring period was selected because stream restoration is still a relatively new science, and it is uncertain how long it will take to gauge the ecological success of the project and to make necessary adjustments. Monitoring will be discontinued once ecological success is determined. It is expected that riparian plantings will be established within a five year period of time and that recolonization of fish and benthic organisms will occur within one year or less. Over time, the structures and streambanks will be stabilized by riparian plantings and sediment accumulation, such that it can be seen whether restoration features are having the desired effect with regards to sediment emplacement or removal for habitat (riffle/pool) restoration. Data collection will be used to determine success of the project with the focus on the development of in-stream and riparian habitats. USACE and the non-Federal sponsor will use the knowledge gained through this monitoring to adaptively manage the project sites. At this time, feasibility level designs (35%) have been prepared, but these do not include the detail of fine features such as the locations of woody debris or rootwads, which will be added at a higher level of design. Accordingly, this plan will be refined during PED.

The following section lists monitoring metrics, performance targets, and potential adaptive management associated with the effectiveness monitoring, which aims to demonstrate how well the habitat is developing according to performance criteria.

5. Evaluation of Specific Objectives

Pre-project (baseline) physical and biological data were collected in each stream segment in 2015 during the feasibility study. Data collected includes measurements of in-stream physical habitat and sampling of fish assemblages. Physical habitat was assessed using Physical Habitat Index (PHI) established by the Maryland Department of Natural Resources (MDDNR) Maryland Biological Stream Survey (MBSS; Section 5.1). Following construction, physical habitat and biological condition will be assessed in 5 of 10 post-construction years, including in years 1, 3, 5, 8, and 10 using the metrics outline in Table 1. Differences between pre- and post-project physical and biological data will be evaluated to monitor changes. These changes will be compared to water quality and other data being collected concurrently and independently of this study by Prince George's County to characterize project effects versus ambient effects (i.e., changes resulting from effects other than from in-stream habitat improvements, such as from water quality variations or the strength of the annual herring run, for example).

At this time, it is expected that monitoring will be achieved through a combination of efforts (e.g., USACE, state (MDDNR), and Prince George's County). It is also possible that work could be performed through a contract with local universities. All data collected will be shared among partners to evaluate project success and performance. USACE will develop a geodatabase to house all data collected by USACE. Monitoring reports will be developed and circulated among key agencies, as well as posted on the project website.

Table 1. Stream habitat restoration metrics

Resource	Metrics	Specific Parameters
Physical Habitat	Physical Habitat Index, including individual habitat metric component scores (MDDNR, 2003)	Embeddedness, epibenthic substrate, instream habitat, instream woody debris/rootwads, erosion extent and severity; and riffle/run quality
Finfish	Fish Index of Biotic Integrity, plus consideration of individual species and guilds	Number of fish by species above and below removed blockages, classification as native/invasive, tolerant/intolerant, trophic composition, and biomass

5.1 Evaluation of Objective 1

- Restore physical habitat within streams with degraded aquatic conditions in the mainstem and tributaries of both the Northwest and Northeast Branch subwatersheds of the Anacostia River in Prince George's County.

Within each reach, a representative 75 m length measured along the channel thalweg capturing the range of conditions in that reach was field-identified to investigate baseline conditions. Those reaches are presented in Table 2 and Figure 3, and will be confirmed at time of monitoring that they remain suitable sampling locations.

Table 2. Sampling locations for Objective 1

Site ID	Stream Name	Strahler Order	Latitude	Longitude
03	Northwest Branch	3	38.96176	-76.97173
05	Paint Branch	3	38.98008	-76.91894
09	Sligo Creek	3	38.95959	-76.97582
11A	Indian Creek	3	38.98356	-76.91869
11B	Indian Creek	3	39.00517	-76.91356
13	Lower Northwest Branch	3	38.97889	-76.96356
15	Northeast Branch	4	38.97275	-76.91803

Monitoring of physical habitat and resident aquatic life would be accomplished using established methods of MBSS that were used in baseline stream assessments and plan formulation (MD DNR 2013). The physical and biological monitoring methods are based on U.S. Environmental Protection Agency (USEPA) methods and have been used for two decades in Maryland. The metrics (Table 1) selected for monitoring were chosen because they are projected to be responsive to project implementation and representative of the physical and biological health of the project sites and stream networks.

The habitat will be sampled per MBSS procedures (MD DNR 2013). Only parameters pertinent to PHI analysis will be collected. The stream reach will be assessed per MBSS field protocols and the data recorded onto MBSS data sheets (MD DNR 2013). Not all habitat metrics collected on the data sheet will be used to calculate PHI, but it is proposed that all habitat metrics be collected for consistency with past and future monitoring efforts. Watershed area and remoteness were also determined as part of the protocol, but would be unaffected by the project. The distance from the stream to the nearest road was recorded in meters, utilizing GIS and aerial photography. This distance was used to determine the remoteness score.

Desired outcomes are an improvement in physical habitat index score resulting from increased habitat heterogeneity and/or stability, and improved biological condition resulting from increased species richness and/or increase in proportion of specialist/less tolerant species. Within the PHI determination, specified parameters will be targeted for monitoring. An improvement in individual parameters to the sub-optimal (a PHI score of 11-15) or optimal (16-20) stage is targeted and described below. Table 3 provides guidelines for rating parameters. Table 4 shows the required conditions to achieve scores of sub-optimal to optimal. Current conditions for these metrics are provided in Appendix B. Table 6 provides a summary of success criteria and timeframes.

Table 3. Guidelines for rating physical habitat parameters.

Metric	Units	Value Range*	Notes
Epibenthic Substrate	Unitless	0-20	Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, flocculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.
Instream Habitat	Unitless	0-20	Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Metric	Units	Value Range*	Notes
Total number instream woody debris and rootwads	Enumerated	0-32	
Erosion Extent	Meters	0-75**	Based on procedures in MDDNR 2013.
Severity	Unitless	0 = none; 1=min; 2=mod; 3=severe	

Table 4. Metric scores to achieve sub-optimal to optimal physical habitat conditions.

Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
Instream Habitat	Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, root wads, aquatic plants, or other stable habitat	30-50% of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat availability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
Epibenthic Substrate	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abundance of cobble with gravel &/or boulders common; or woody debris, aquatic veg., undercut banks, or other productive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
Woody debris and rootwads - Based on a count of instream woody debris and streambank rootwads. A higher amount of woody material is desirable.				
Erosion extent and severity - Determined within a 75 meter section, rated from none to severe. A lower score is desirable.				

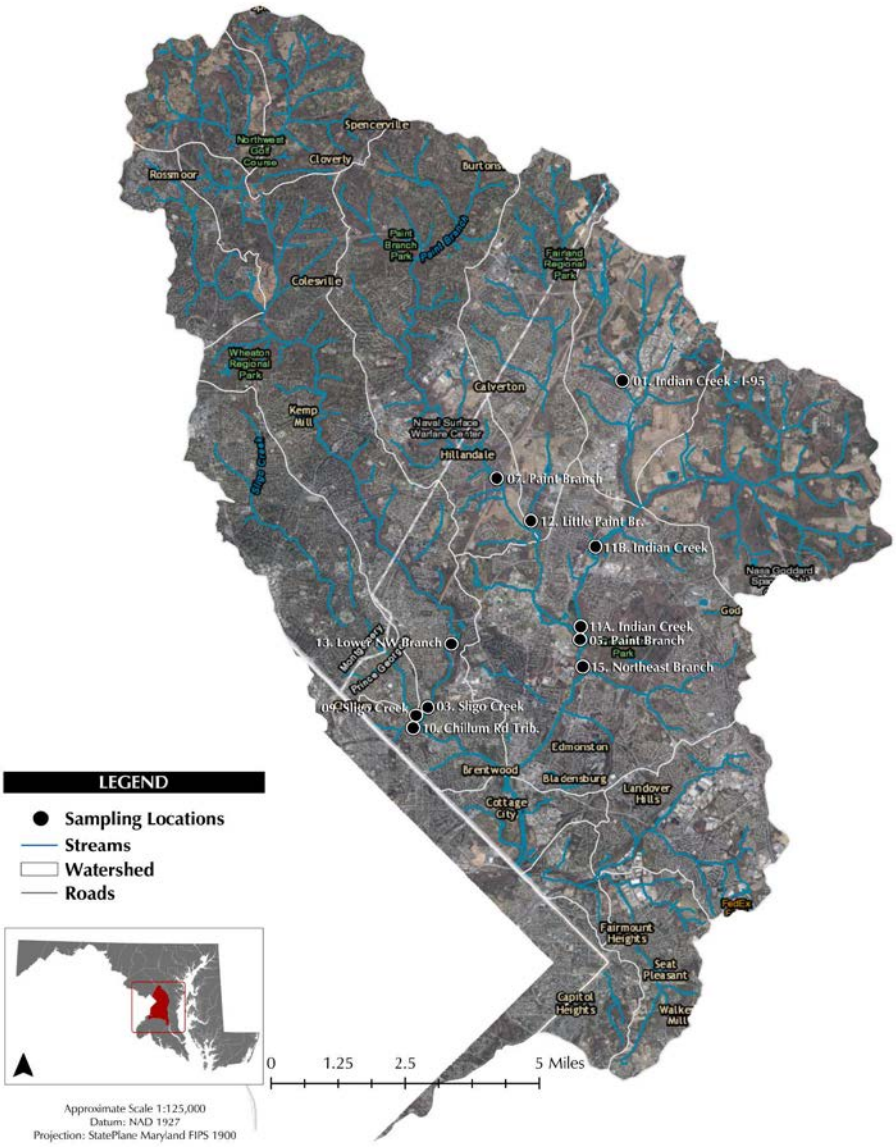

Figure 3. Sampling Site Locations for baseline monitoring.

5.1.2 Monitoring metric 1: Epibenthic substrate

Methods and Timing: Sampling will be conducted during the index period (March-April) using protocols in accordance with MBSS, and outlined in PGDOE (2015). Epibenthic substrate is rated (0–20) based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates.

Success Criteria: To be determined as a success, the epibenthic substrate needs to have certain qualities and characteristics, and rated greater than 11 (sub-optimal). This is not a quantified success criteria. Epibenthic substrate must have an abundance of cobble with gravel and/or boulders (see Table 3 and 4), and be characterized as stable. Woody debris or other productive

surfaces are desired to be common to prevalent with substrate that is being colonized by epibenthics.

Timeframe: Monitoring in years 1 and 3 will be utilized to evaluate if the correct substrate is being established. The substrate must meet the success criteria established above by year 5 to be considered a success. If it does not, adaptive management measures will be taken following year 5 monitoring. This metric will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

5.1.3 Monitoring metric 2: Instream habitat

Methods and Timing: Sampling will be conducted during the index period (March-April) using protocols consistent with those of the MBSS, and outlined in PGDOE (2015). Instream habitat is rated (0 – 20) based on the perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

Success Criteria: The success criteria is a score of at least 11 (sub-optimal). This represents instream habitat where greater than 30 percent of the habitat is stable and exhibits a variety of cobble, boulder, submerged logs, snags, root wads, aquatic plants, or other stable habitat (see Tables 3 and 4).

Timeframe: Monitoring in years 1 and 3 will be completed with the intent of meeting the success criteria by the year 5 monitoring. If monitoring in year 5 determines that the criteria is not met, adaptive management efforts will be undertaken. This metric will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

5.1.4 Monitoring metric 3: Instream woody debris/rootwads

Methods and Timing: Sampling will be conducted during the index period (March-April) using protocols consistent with those of the MBSS, and outlined in PGDOE (2015). This metric is determined by counting the total number of instream woody debris and rootwads.

Success Criteria: Streams with higher ecological and habitat value have a greater amount of woody debris/rootwads, but no relationship is available to connect a certain number to habitat value within a stream reach. Therefore, the success criteria is to maximize the number of woody debris/rootwads within a reach to provide habitat diversity.

Timeframe: As the woody debris/rootwads is expected to be incorporated into the stream environment directly as design features, it is not anticipated that the amount of woody debris/rootwads will change over time with monitoring. The goal is to stabilize stream banks so

that erosion is not occurring and leading to trees falling into the stream. Therefore, it is not expected that this metric will change over time. However, if the stream reaches are not broadly meeting the success criteria, the amount of woody debris/rootwads will be evaluated to determine if an increase would benefit stream health in year 5. If it is determined that a stream reach is lacking in woody debris/rootwads, adaptive management measures will be taken to increase the amount in the reach.

5.1.6 Monitoring metric 4: Erosion extent and severity

Methods and Timing: Sampling will be conducted during the index period (March-April) using protocols consistent with those of the MBSS, and outlined in PG DoE (2015). This metric is evaluated using the procedures described in MDDNR (2013) and is rated from 0=minimal to 3=severe.

Success Criteria: The success criteria is to minimize erosive expanses with no to minimal severity (rated based on best professional judgement as none to severe; see Tables 3 and 4).

Timeframe: Monitoring in years 1 and 3 will be completed with the intent of meeting the success criteria by the year 5 monitoring. If monitoring in year 5 determines that the criteria is not met, adaptive management efforts will be undertaken. This metric will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

5.1.7 Monitoring metric 5: Channel stability

Methods and Timing: Two reference cross-sections for each reach will be selected in the PED phase for periodic inspection and monitoring for any changes, especially after major flooding events. Reference points incorporated into current MBBS surveys should be considered and utilized as appropriate. Bankfull geometry will be determined. Cross-sections, including cross-sectional area will be evaluated for changes to channel geometry that indicate channel instability (deposition or erosion).

Success Criteria: The success criteria is minimal change in cross-sectional area. A variable cross-sectional area would indicate aggradation or degradation.

Timeframe: Monitoring in years 1, 3, and 5 will be completed to determine that the cross-sectional area is stable. If the monitoring record shows that the cross-sectional area is changing, adaptive management efforts will be undertaken following year 5. This metric will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

5.2 Evaluation of Objective 2

- Enhance aquatic ecosystem resilience by restoring fish passage for migratory and non-migratory fish and connecting existing higher quality habitat in the mainstem and

tributaries of both the Northwest and Northeast Branch subwatersheds of the Anacostia River in Prince George's County.

The project objective includes enhancing stream access for both migratory and resident fish. To assess the fish assemblage present in the stream segments, fish sampling was conducted for the baseline sampling performed in 2015. This included fish identification and counts, which were used in the calculation of Fish Index of Biotic Integrity (F-IBI).

5.2.1 Monitoring metric 1: Presence of migratory fish

Methods and Timing: Metrics used to determine whether the restoration projects provide fish passage to migratory fish require monitoring of fish densities by species above and below the fish blockages during the herring migratory season. Monitoring of fish passage will likely occur in the same manner as was done on Paint Branch (Section 206) previously by USACE and in a manner similar to the herring monitoring currently conducted by the Metropolitan Washington Council of Governments (MWCOG). The fish survey will be conducted both upstream and downstream of the former fish blockages on Sites 3 and 9 during the herring spawning season. Depending on the season's characteristics and initial results, 1 to 3 fish surveys will be conducted in years monitored (years 1, 3, 5, 8, and 10). Once targeted fish species are determined to be utilizing the stream reach above the corrected blockage, fish monitoring would cease. If a storm or other event would result in development of a blockage, fish presence monitoring would commence to confirm that the desired species are again utilizing the full stream reach after the new blockage has been addressed. Once targeted species are identified beyond this blockage, monitoring would cease again.

Block nets would be set at the downstream (0m) and upstream (100m) ends of the reach. Backpack electrofishing and hoop nets or seines may be used, depending on the particular characteristics of the stream. For electrofishing, depending on the wetted width of the stream, either two backpack units would be employed, or an additional pram-based electrofisher could be added. In general, one shocking unit per 4m wetted width is recommended. Fish will be counted and identified to species in the field.

The species counts and proportions of anadromous fish to total fish would be compared between the upstream and downstream sites, as well as over the total monitoring period of the project to determine if the fish blockages have been remediated and if spawning fish have re-established themselves in the stream. The guidelines in pertinent MBSS protocols would be followed. MWCOG monitoring would supplement USACE post-project monitoring. Monitoring data from MWCOG will also be evaluated to determine the strength of the herring run and potentially identify other variables that could affect presence or absence of fish.

Success Criteria: The desired outcome is to provide a stream reach where fish have the ability to pass the former blockage. To determine success, monitoring is aimed at documenting the presence of anadromous fish species, primarily alewife and blueback herring, in the stream reach above where the blockage was removed.

Timeframe: If anadromous fish species are not detected above the former blockage by year 5, an evaluation to understand the factors limiting the presence of anadromous fish will be completed.

Following the evaluation, adaptive management measures will be taken, if suitable to addressing the identified limitations. Fish presence will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

5.2.3 Monitoring metric 2: Fish- Index of Biotic Integrity (F-IBI)

Methods and Timing: Fish metrics would be calculated in accordance with Southerland et al. (2007) for all sites, and resulting metric values compared to reference criteria and scored on a scale from 5 to 1 (5=nearest to reference, 3=neutral, 1=greatest deviation from reference) (Table 5). The mean value for the F-IBI would be compared to scoring criteria for attaining the condition narrative for Coastal Plain and Piedmont streams, respectively.

Table 5. Fish IBI score ranges and corresponding narrative ratings

Scoring Criteria	Narrative Rating
4.0-5.0	Good
3.0-3.9	Fair
2.0-2.9	Poor
1.0-1.9	Very Poor

Evaluation of fish assemblage will be conducted using the electrofishing methods described for objective 2 metric 1; however, sampling will occur at the location shown in Table 2. Sampling for F-IBI would be conducted at the time that the physical habitat parameters are collected for evaluating Objective 1. Water quality parameters such as dissolved oxygen, clarity, pH, temperature, and flow measurements will be also be obtained using calibrated field meters with the physical habitat condition monitoring. Water quality is not a metric for the project objectives, but will be collected for consideration with results of fish monitoring and F-IBI results.

Success Criteria: F-IBI of streams would show an improvement to the degree that physical habitat conditions control biological condition (MDDNR, 2003; MDDNR, 2005b) and would be compared to data collected previously by the State of Maryland and through baseline monitoring. Other stressors, particularly degraded water quality, may prevent or limit biological improvement even with habitat restoration projects in place (MDDNR, 2005a).

Timeframe: Monitoring in years 1, 3, and 5 will be completed to determine the F-IBI of each stream reach. If the monitoring record shows that F-IBI is not improving, an evaluation will be completed to determine the factors that are contributing to the reduced F-IBI. Following the evaluation, adaptive management measures will be taken, if suitable to address the identified limitations. F-IBI will then be measured again in year 8 and 10 to confirm that the substrate continues to meet the success criteria, or determine that it does now meet the criteria following adaptive management.

Table 6. Physical and Biological Monitoring Success Criteria and Timeframes

Parameter	Success Criteria	Monitoring Years
Epibenthic substrate	>11 (sub-optimal)	1, 3, 5, 8, 10
Instream	>11 (sub-optimal)	1, 3, 5, 8, 10
Woody debris/rootwads	Maximize	1, 3, 5, 8, 10
Erosion extent and severity	None to minimal severity (score of 0 or 1)	1, 3, 5, 8, 10
Presence of anadromous fish above blockage	Presence	1, 3, 5, 8, 10
F-IBI	Improved over pre-construction conditions	1, 3, 5, 8, 10

PED=Preconstruction

5.3 Wetlands and Vegetation Monitoring

It is expected that the proposed project will be eligible to be considered under the general and regional terms and conditions of Nationwide Permit #27 (NW27), *Aquatic Habitat Restoration, Establishment, and Enhancement Activities*. The proposed project is focused on ecosystem restoration and providing a demonstrated functional lift to the targeted habitats. In the State of Maryland, MDE determined that NW27 is consistent with the State's Coastal Zone Management Program (Section 307 of the Coastal Zone Management Act of 1972, as amended) and issued Water Quality Certification (Section 401 of the Clean Water Act) for aquatic habitat restoration. Therefore, as long as the terms and conditions of the NW27 and MDE's permit requirements are met, no additional Clean Water Act Section 404(b)(1) analysis is required.

At one location at Site 11, temporary construction impacts to approximately 1 acre of wetlands will result (see Section 5 of the report for discussion of impacts). The existing wetlands at this location are infested with phragmites and are of poor quality. Project construction will result in an overall improvement to the wetlands and their sustainability, by replanting with native vegetation and increasing the streams connection with the floodplain. To ensure that these gains are realized, in addition to instream physical habitat monitoring for the project objectives, wetlands and vegetation monitoring will be performed. This monitoring is summarized in Table 7.

Table 7. Wetlands and Vegetation Monitoring Measurements and Criteria

Parameter	Measurement	Success Criteria	Monitoring Years
Floodplain connectivity	Bank height ratio	<1.2	AB, 5
Vegetative cover	% cover	>85% cover in LOD	1,3,5
Invasive species	% cover invasive species in LOD	Less than baseline	PED, 1, 3, 5
Wetlands	Delineation	Hydrology indicators present; hydric soils present; wetland vegetation dominance (greater than 50% are either	PED, 5

Parameter	Measurement	Success Criteria	Monitoring Years
		OBL, FACW, and/or FAC)	

AB=As-built, PED=Preconstruction

6. Adaptive Management

The technical team members include USACE- Baltimore District, Divisions of Planning and Engineering; Prince George's County Department of the Environment (PG DOE); Maryland Department of Natural Resources; and the Maryland-National Capital Park and Planning Commission. This same team will be used to organize and interpret the data collection to determine if adaptive management actions are needed. The technical team will recommend any adaptive management measures to an Executive Team. The Executive Team will consist of the Baltimore District Engineer, the Director of the Prince George's County Department of the Environment, and a representative from the Maryland Department of Natural Resources, or their designated alternates. The executive team's function will be to resolve disputes that the technical team cannot resolve at their level and to approve any adaptive management measures recommended by the technical team.

The technical team will meet in the fall (of those years when monitoring is conducted) to analyze monitoring data and develop recommendations for the project. This team will evaluate the data as it is developed annually to: determine if environmental benefits and impacts associated with the recommended plan are occurring as expected in the feasibility study; document the findings; and recommend adjustments to the project as necessary. These adjustments may include remedial measures needed to refine the recommended plan to further optimize aquatic ecosystem benefits, and to minimize any unanticipated adverse impacts associated with the recommended plan. This team will collect data or oversee its collection by others, ensure quality control over the data collection, analyze, and make recommendations based on the analysis. Routine technical matters will also be resolved by the technical team including: sampling gear changes, sampling protocol changes, reporting mechanisms, time of year changes, etc.

The technical team will communicate primarily by email and telephone. Meeting locations are anticipated to occur in either at Baltimore District Headquarters or at Prince George's County DoE offices. Video teleconferences (VTC) and telephonic conference calls may also be considered. The USACE will prepare an agenda for these meetings and will document the meeting with a memo for the record for each meeting.

After the planned ten years of post-construction monitoring has elapsed and all data collection and reporting has ceased, a final report will be generated by USACE.

6.1 Adaptive Management for Objective 1 - Physical Habitat

Recently completed projects have demonstrated that improvements in PHI are achievable with geomorphic stream restoration. Physical characteristics of the project such as the type of substrate, height of structures, presence of rootwads, and depth of riffle/runs can be controlled during construction, but colonization with epibenthics and embeddedness is much less certain.

Monitoring will determine if ecological success has been achieved, while adaptive management actions are the contingency plan that allow for post-construction adjustments.

It is anticipated that minimal adaptive management measures would need to be taken due to the type of structures within the design. The designs are intended to aid in the re-establishment of a new dynamic equilibrium for the stream, and not necessarily to lock the stream into its channel. Likely measures that may be needed are changes to elevation of structures or minor changes to structure locations. Most adaptive management actions that stem from normal conditions are anticipated to be minimal in effort; however, an unusually strong storm that occurs prior to establishment of vegetation and project features could cause damage to a project site that would need to be ameliorated. Following storm events, site visits will be performed by visual inspection to assess the stability and location of the structures.

Adaptive management activities may necessitate re-accessing the streams in order to adjust the lateral position or height of structures installed in streams to ensure proper hydrologic conditions. Similarly, if hydrologic profiles result in scouring, erosion, or sediment deposition that result in poor PHI scores or poor IBI scores structures, bank profiles, or other constructed features will require adjustment. Poor PHI scores and/or IBI scores will need to be evaluated on a case by case basis to determine what has influenced them and what actions will be required for a remedy.

For Objective 1, the triggers for adaptive management are defined by targets set for the metrics described in Section 5 and Tables 3 and 4. Adaptive management will be triggered based on the below; however, the technical team will be convened to discuss the necessity and type of actions. It is also possible that post-restoration adjustments made by the stream could result in temporary decreases in some metrics; therefore, individual metrics will need to be evaluated in total, and related to the calculation of the overall PHI score.

- Epibenthic substrate - Lack of cobble with gravel, productive surfaces uncommon.
- Instream habitat - Less than 30% of stable habitat.
- Numbers of woody debris or rootwads - Decrease in amount of woody debris and rootwads.
- Erosion extent or severity - Increased erosion extent and/or severity.
- Channel stability - Change in cross-sectional area, which would indicate erosion or aggradation.

Depending on a visual assessment of the integrity of in-stream structures, the scope of the adjustment or repair will be determined. Undesirable changes in the physical habitat metrics would likely result in a minor adjustment (shifting the location or height or height of parts of a structure) to induce favorable conditions. More substantial adjustments could be made if structures are undermined or the stream shows signs of instability. The designs are geared toward functional stream channel dimensions that do not promote excessive aggregation or degradation during normal and high flood flows, but allow sediment to accumulate where desired. The proposed in-stream structures will provide grade control (bed stability) and bank stability. Cross sectional measurements and evaluation of erosion extent and severity will indicate whether instability is present. If instability is present, adaptive management actions may be needed. This will be determined on a case by case by the technical team. Adaptive management actions could be necessitated by flooding during large storm events. Structures will be visually assessed following

extreme storm events. Storms have the potential to undermine structures by inducing scour around tie-in points with the bank, and by dislocating parts of the structure in the center of the channel. Furthermore, if there are significant problems with the performance and function of the project, the design would be revisited.

6.2 Adaptive Management for Objective 2

If desired fish species are not recorded above the corrected passage additional visual inspections would be undertaken to determine that no blockage still remains. These inspections could be undertaken in coordination with MWCOG's fisheries experts. If a constructed structure prevents fish movements, corrective action will be needed. The structure may need to be reset, stones or logs moved, a notch added, or other actions taken. These would constitute minor actions. Other factors, particularly regional population trends of the migratory species, may limit the numbers of fish migrating upstream, and will be considered. Water quality data would also be evaluated to determine if water quality conditions may be limiting fish usage in the opened stream reaches.

6.3 Adaptive Management for Wetlands and Vegetation

Monitoring for the reestablishment of wetlands at site 11 will include vegetation monitoring and wetland delineations and an assessment of hydrology, hydric soils, and vegetation. If one or more of these indicators are not present in areas where wetlands were expected to reestablish, the technical team will be convened to evaluate the potential reasons preventing these conditions. Should the technical team determine that hydrology or hydric soils are the limiting factor, adjustments to the project design, including adjustments to structures that control grade or retain or redirect water could be made. Vegetation monitoring, including monitoring for cover and invasive species at all disturbed locations, will indicate whether a desirable plant community is being maintained. Because of the prevalence of invasive species in the project areas, it will be necessary to actively manage the establishment of riparian vegetation, and potentially control invasive species. This will be done through the planting contract, which will include a warranty for plant growth and survival for a five year time period. Plants not in a live and healthy condition shall be replaced by the contractor during this period, and a prevalence of native plants will be ensured. An analysis of the source of plant mortality and stressors will be made. Different species could potentially be planted that have a better chance of survival based on cause of mortality. Measures to control invasive plant species will also be included in the planting contract as a potential adaptive management measure.

7. Cost

The costs associated with implementing the monitoring and adaptive management plans are estimated based on currently available data. Given refinements that will be made in advancing the engineering designs from feasibility level (35%), the costs for adaptive management may need to be adjusted in the preconstruction, engineering, and design phase.

Per Memorandum on Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007, Monitoring for Ecosystem Restoration (USACE 2007), the estimated cost of the proposed monitoring program will be included in the project cost estimate and cost

shared accordingly. Cost shared monitoring can (but is not required to) continue for a period of up to 10 years. For estimation of the biological monitoring costs for this project, monitoring costs for the baseline sampling conducted by Tetra Tech in 2015 for this project were evaluated. Other costs were established in consultation with the appropriate disciplines of the project delivery team. A breakdown of monitoring costs are shown in Tables 8, 9, and 10, with total costs provided in Table 12. Monitoring is planned for a 10 year period following project construction, with monitoring occurring in years 1, 3, 5, 8, and 10. The total cost for monitoring is $570,000. In addition, given the current stage of planning, contingency is included on the Total Project Cost Summary (Appendix E).

Table 8. Monitoring Cost Breakdown for Physical Habitat and Biological Sampling

Task	**Cost**
Study Mobilization	$3,000
Field Sampling	$30,000
Laboratory Processing (Sorting and Taxonomy)	$10,000
Data Entry/Management/Analysis	$11,000
Report	$14,000
ESTIMATED PER YEAR OF MONITORING	**$68,000**
TOTAL COST FOR 5 ROUNDS OF MONITORING	**$340,000**

Table 9. Monitoring Cost Breakdown for Stream Stability Surveys

Task	**Cost**
Establish vertical control benchmark on-site* (2 cross sections per stream for six streams)	$23,000*
Survey cross sections in field (2 cross sections per stream for six streams)	$17,000
Office work to generate cross sections	$17,000
Generate Report	$3,000
ESTIMATED FIRST YEAR OF MONITORING	$60,000
ESTIMATED SUBSEQUENT YEAR OF MONITORING	$37,000
TOTAL COST FOR 5 ROUNDS OF MONITORINNG	**$208,000**
*required only for first year of monitoring	

Table 10. Monitoring Cost Breakdown for Wetland and Vegetation Monitoring

Task	**Cost**
Bank height ratio (in conjunction with surveys)	NA
Vegetative cover and invasive species assessment (2 people for two days in years 1 and 3; year 5*)	$10,000
Wetland Delineation - labor and post-processing (2 people for one week in year 5)	$12,000
TOTAL COST	**$22,000**
*cost included with wetlands delineation for year 5	

As described in Section 6, contingency measures (adaptive management) will be implemented if the monitoring program (or any other documented observations by qualified personnel) indicates performance targets are not being met and cannot be explained by extraneous variables. Metrics would then be evaluated to determine corrective actions to address the problem. Adaptive management activities in this plan will be refined in the preconstruction, engineering, and design phase.

As discussed previously, minimal adaptive management is expected, but given the uncertainty associated with the settling of structures, reestablishment of wetlands, or the potential for large storm events, contingency has been estimated for adaptive management actions that include adjustment of 100 tons of rock over 500 feet of stream per site (Table 11). Adaptive management actions will likely require contracting actions and re-disturbance of the original site access routes. Adjustments to structures will be made with small vehicles (e.g., bobcats) and will need to be surveyed or profiled. Plantings will be needed to restore site access sites and to manage invasive species. Total adaptive management costs are estimated at $328,000. In addition, given the current stage of planning, contingency is included on the Total Project Cost Summary (Appendix E). These costs are included into project first costs and are cost shared with the non-federal sponsor. The total cost of monitoring and adaptive management are shown in Table 12.

Table 11. Contingency (Adaptive Management) Costs for Minor and Major Actions

Task	Cost
Vane, j-hook adjustment/repairs, including 100 tons of rock Stabilization measures for in stream structures (wooden logs), 500 linear feet Site protection and erosion control measures (construction and silt fencing)	$328,000 (total for all sites)
Replanting and/or invasive species management	**
TOTAL FOR ALL SITES	$328,000
**To be covered under planting contract	

Table 12. Monitoring and Contingency Costs

Task	Cost
Total Monitoring	$570,000
Total Contingency (Adaptive Management)	$328,000
TOTAL Monitoring and Adaptive Management	**$898,000**

8. References

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