CLIFFORD BRANCH DAM REMOVAL AND RESTORATION, FREDERICK COUNTY, MARYLAND: PROJECT SUMMARY AND DESIGN REPORT

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I. INTRODUCTION

The U.S. Fish and Wildlife Service (Service) - Chesapeake Bay Field Office, The Potomac Conservancy (Conservancy) and the Frederick County Division of Public Works (County) are involved in a collaborative effort to restore in-stream habitat and provide upstream brook trout passage in Clifford Branch, located in Frederick County, Maryland.

Clifford Branch is second order stream located in the Chesapeake Bay watershed of Maryland. It begins as a spring seep in the Frederick City Municipal Forest flowing for nearly 5 miles before reaching Tuscarora Creek. Tuscarora Creek then deposits directly into the Monocacy River which flows just outside the City of Frederick. After a short distance, the Monocacy empties in to the Potomac River and ultimately enters the Chesapeake Bay near Washington DC. Clifford Branch is one of the lesser known brook trout fisheries in Maryland, however, it sustains a healthy brook trout population due to the fact that most of its watershed is forested and much of its base flow is derived from cold water springs.

The goal of the restoration is to remove a dam on Clifford Branch to provide fish passage for Brook trout and open up an additional 3 miles of stream habitat. The dam is located just off of Hamburg Road, approximately 6 miles northwest of downtown Frederick, Maryland. It was constructed across the stream channel and was originally used to provide a source of drinking water for the City of Frederick. Since then, the facility on Clifford Branch has been decommissioned and is not expected to be used again. However, the inlet structure will be relocated and still provide the ability to withdrawal water, if ever needed, but still allow fish passage. The dam consists of a poured concrete headwall that is approximately 20 feet long, 3 feet wide at the base, and 6 feet high. The dam is currently intact and still constricts and alters water levels and fish passage. The restoration will involve removing of the dam, relocating the inlet structure and returning the adjacent stream channel to a stable, self-maintaining state. This will significantly increase the amount of available aquatic habitat and help promote sustainable populations of brook trout as well as other resident fish and aquatic species.

In addition to the dam removal, stream restoration will occur approximately 100 feet upstream and downstream of the dam's location to return the stream bed to its pre-existing slope and condition. In-stream grade control structures will be placed in the same general vicinity of the dam in order to stabilize the stream channel post dam removal. These structures will be installed using Natural Channel Design methodology and will promote stream stability, provide fish passage, and improve aquatic habitat.

Specifically, this report contains the methodologies used by the Service and follows criteria outlined in the Natural Channel Design Checklist (Harman & Starr, 2011); a brief watershed characterization; a brief stream characterization and stability condition description; the results of the stream assessment; and stream restoration design.

II. WATERSHED AND GEOMORPHIC ASSESSMENT

This section presents a brief summary of the methods used by the Service to conduct a limited watershed and stream assessment, develop restoration objectives, and conduct a restoration design.

A. Watershed Assessment

The limited watershed assessment involved two levels of assessment: stream-based assessment and land-based assessment. The stream-based assessment involved a visual assessment of stream character and stability condition upstream and downstream of the project area. The fluvial geomorphic conditions observed included channel dimensions, pattern, profile, and substrate material, vertical and lateral stability, sediment supply potential, Rosgen stream type, and channel evolution. The land-based assessment analyzed land use/land cover patterns, soils, geology, hydrology, valley type, existing water quality and biological data, and watershed development. The assessment was predominantly an office exercise with field verification.

1. Geology and Soils

The Clifford Branch watershed is located in the Blue Ridge province, which lies in between the Ridge and Valley and Piedmont Plateau provinces. The Blue Ridge province is underlain mainly by folded and faulted sedimentary rocks. The rocks of the Blue Ridge Province in western Frederick County are exposed in a large anticlinal fold whose limbs are represented by Catoctin Mountain and South Mountain. These two ridges are formed by Lower Cambrian quartzite, a rock which is very resistant to the attack of weathering and erosion. A broad valley floored by Precambrian gneiss and volcanic rock lies in the core of the anticline between the two ridges.

The Clifford Branch watershed contains two soil series (i.e., Airmont and Bagtown). The Airmont series consist of very deep, somewhat poorly drained soils formed in colluvial or debris flow materials from schist, quartzite and phyllite. They are located in mountain drainage ways and concave side slopes and back slopes of the Northern Blue Ridge. Permeability is slow to very slow throughout. Slopes range from 0 to 50 but are more commonly 3 to 25 percent. Mean annual precipitation is about 40 inches, and mean annual temperature is about 55 degrees F. The Bagtown series consists of very deep, well drained soils that have moderately slow or slow permeability. They have formed in colluvial materials on mountain back slopes, foot slopes, colluvial fans, and benches. Slopes range from 3 to 45 percent. Mean annual temperature ranges from 50 to 54 degrees F and annual precipitation ranges from 38 to 50 inches.

2. Land use/Land cover

The Service used aerial photographs and land use/land cover maps to estimate the land use/land cover percentages for the Clifford Branch watershed. The primary land uses in the watershed are Public/Quasi Public Park or Open Space and Natural Resources. Public/Quasi Public Park or Open Space represents 95 percent and Natural Resources represents 5 percent. Based on the 2010 Frederick County Comprehensive Land Use Plan, the land uses of this watershed will remain unchanged. Currently, the watershed consists of less than 1% impervious surface.

3. Hydrology

The Clifford Branch watershed is a sub-watershed of the Monocacy River, which is the largest Maryland tributary to the Potomac River. The Clifford Branch watershed is approximately 3.0 square miles (Figure 1) at the project location and is in the Blue Ridge hydrologic region. The valley type, as defined by Rosgen (1996) is a valley type II; a moderately steep, gentle sloping side slopes often in colluvial valleys.

Clifford Branch exhibits a flow regime typical of streams found in rural areas. Most runoff is absorbed into the soils, recharging the water table. Since Clifford Branch is predominantly spring fed, and there is little impervious surface, Clifford Branch does not exhibit “flashy” flows commonly found in urban settings. The Service did not conduct extensive hydrologic calculations since design criteria was derived from stable upstream and downstream conditions with good floodplain connectivity. The Service aims to increase the flood prone area within the project area and will make no significant bed elevation changes. Proposed cross sections were designed to accommodate bankfull flows that were determined by collected data and resistance equations.

4. Hydraulic Assessment

The Service used tractive force calculations as well as HEC-RAS to conduct a hydraulic assessment of this particular reach to assure the restoration design would not cause any unsafe rise in hydraulic forces within the channel. Thirteen separate cross sections were modeled to compare the existing and proposed conditions. The model was run using a bankfull flow of 210 cfs which was derived from Jarrets Equation using existing and design channel geometry. A Manning’s roughness coefficient of 0.10 was used for in-channel roughness which is common among high gradient mountain streams and provided similar results to those predicted by the Maryland Piedmont Regional Curve (McCandless and Everett 2002). The design used the existing channel and floodplain dimensions upstream and downstream of the reach since these conditions are stable. Therefore, the design objective is to have similar velocities, shear stress, and stream power in relation to stage and discharge, to the existing stable conditions. The results below represent the range of values found throughout the 13 existing and proposed cross sections. However, the tractive force calculation compared only the stable existing riffle cross section to the design riffle cross section. Detailed results can be found in **Appendix C**.

Table 1. Clifford Branch HEC-RAS Model Results

Bankfull Characteristics	Existing Conditions	Proposed Conditions
Tractive force in riffle (lbs/ft2)	5.59	5.24
Shear Stress (lbs/ft2)	1.08 - 12.70	1.46 - 12.71
Stream Power (lb/ft s)	2.52 - 90.73	4.02 - 90.82
Velocity (ft/s)	2.34 - 7.14	2.75 - 7.14

1. Results derived from multiple cross sections using a bankfull flow of 210 cfs and Manning's "n" of 0.10 for channel roughness

5. Riparian Vegetation

The right bank portion of the project area exists within a natural forested setting of mature hardwoods with little understory and a dense canopy. The buffer width ranges from approximately 10 to 100 feet consisting of native and non-native grasses, shrubs, understory trees, and mature canopy trees. However, the left bank portion of the project (**Figure 1**) exists within a maintained area with mowed edges and little to no canopy cover. There is also a concrete retaining wall directly upstream of the dam and intake structure.

Figure 1. Project area (Looking upstream from dam)

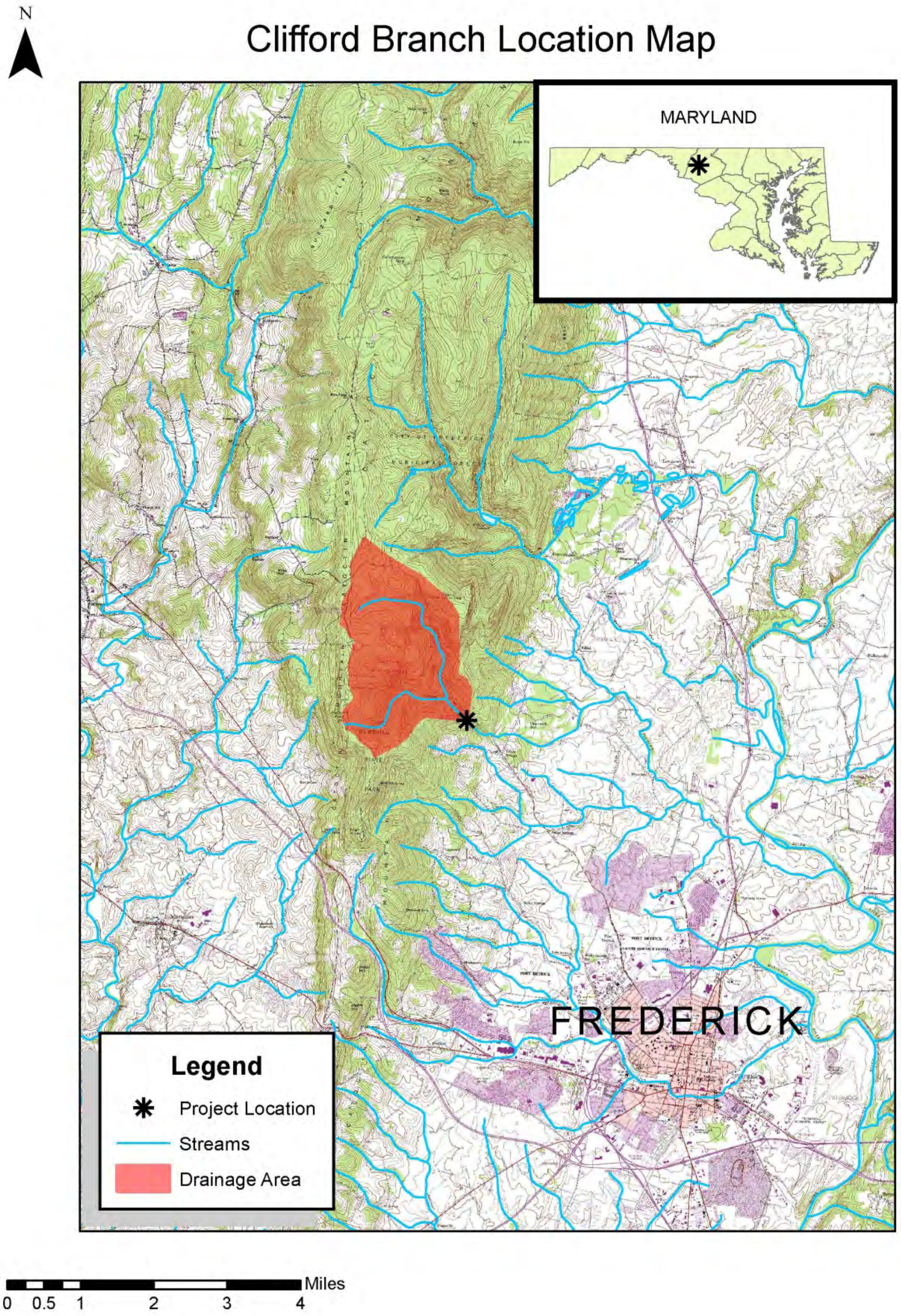
N
Clifford Branch Location Map
MARYLAND
FREDERICK
Legend
Project Location
Streams
Drainage Area
0 0.5 1 2 3 4
Miles

Figure 2

B. Base Mapping

The Service conducted a baseline survey and produced 1-foot ground survey information to accurately map (**Appendix A**) and represent the project area. This Service used this information to assess base line conditions and to develop and illustrate a restoration design plan. Plan form, longitudinal profile, and topographic information is represented.

C. Project Reach Geomorphic Assessment

The Service conducted a visual Rosgen Level II assessment to assess the portion of Clifford Branch adjacent to the existing dam. The Rosgen Level II assessment describes the existing morphological character of the stream and classifies the stream using the Rosgen stream classification system (Rosgen 1994). The Rosgen stream classification system uses physical features of a stream such as width, depth, pattern, and bed material, to group streams into a "type" denoted by alphanumeric codes.

The Service found that the dam is a blockage to Brook trout passage on Clifford Branch (**Figure 2**). The dam is approximately 4 feet high and 20 feet wide and allows a small portion of water to flow over its crest into a plunge pool approximately 5 feet deep. Water continues to be redirected through the intake structure, which is piped downstream approximately 200 feet. During periods of low flow, all water moves through this intake and cuts off flowing water to a portion of Clifford Branch. During high flow events, the dam is still a complete fish blockage to Brook trout. Brook trout typically can only jump blockages with heights up to 4 - 5 times their body length if provided with an approach pool of 3 – 4 times their body length. However, blockages over 90cm prove impassable regardless of fish size, or pool depth (Kondratieff and Myrick 2005).

The areas directly upstream and downstream of the dam show indices of a stable Rosgen B3 channel with well-defined characteristics and only minimal and localized instability (**Figure 3**). The width-to-depth ratio and entrenchment ratio are within acceptable ranges for a Rosgen B channel and particle distributions are consistent with the Rosgen B3 channel type as well. Post dam removal the stream is expected to remain and function as a stable B3 channel due to the fact that the proposed design will mimic the stable channel geometry found upstream and downstream of the project area. Any further assessment was unnecessary due to the limited complexity and extent of the restoration design.

Figure 2. Clifford Branch Dam

Figure 3. Stable downstream conditions

D. Bankfull Verification

Bankfull discharge characterizes the range of discharges that is effective in shaping and maintaining a stream. Over time, geomorphic processes adjust the stream capacity and shape to accommodate the bankfull discharge within the stream. Bankfull discharge is strongly correlated to many important stream morphological features (*e.g.*, bankfull width, drainage area, etc.) and is the critical parameter used by the Service in assessing Mossy Creek. Bankfull discharge is also used in natural channel design procedures as a scale factor to convert morphological parameters from a stable reach of one size to a disturbed reach of another size.

During the Clifford Branch assessment, the Service identified bankfull stage using physical indicators of bankfull stage described by McCandless and Everett (2002). **Figure 4** depicts significant geomorphic indicators typically found in the Mid-Atlantic. Based on these indicators, the Service identified a consistent geomorphic feature at Clifford Branch. This geomorphic indicator was typically a significant slope break or back of bench found throughout the project area.

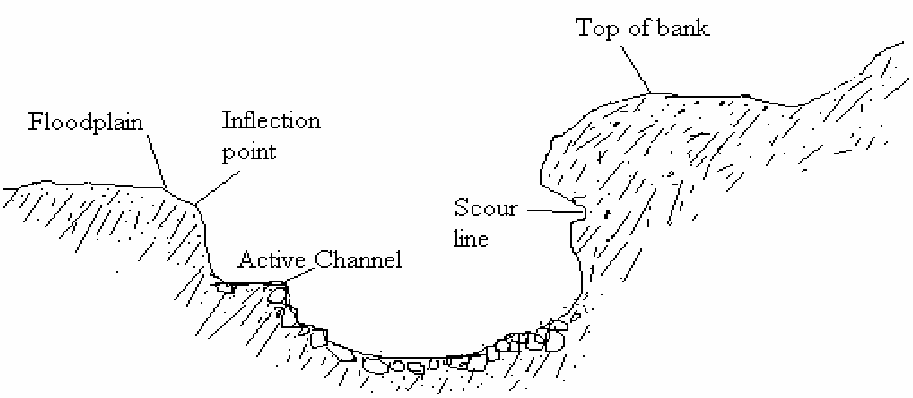

Figure 4: Typical Bankfull Indicators (McCandless and Everett 2002)

The Service compared representative cross section dimension to the regional relationships of the same parameters developed for the Maryland Piedmont (McCandless and Everett 2002) physiographic regions for verification (**Table 2**). The representative cross section dimensions were collected approximately 100 feet upstream of the project area. The Service determined that the existing condition measurements were supported by the regional curve date and were sufficient and could be utilized to develop design criteria from.

Table 2. Clifford Branch and Regional Curve Bankfull Characteristics

Bankfull Characteristics	Existing Representative Cross Section	Design Cross Section	Maryland Piedmont Regional Curve
Area (ft^2)	48.58	42.00	31.50
Width (ft)	21.71	20.00	22.00
Depth (ft)	2.24	2.10	1.40
Velocity (ft/s)	4.33	4.10	
Discharge (cfs)	210.23	172.01	194.88

1. Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Piedmont Hydrologic Region (McCandless and Everett 2002)

III. PRELIMINARY DESIGN

This section presents the project goals, design criteria, and conceptual design parameters involved in the Clifford Branch Dam Removal and Restoration.

A. Restoration Goals and Objectives

The Service generated objectives based on Service and Potomac Conservancy missions. These goals focused on improving stream function by developing quantifiable objectives. This goal setting method follows guidelines developed by the Service in the Stream Function Framework Pyramid document. Goal setting is critical to the success of a project because it communicates why the project is being done and sets expectations on how success will be measured (Harman, et al. 2011). These goals and objectives are focused on level's 2 & 3 of the pyramid. They were then discussed and combined into one list and include the following:

Table 3. Clifford Branch - Goals and Objectives. *The underlined words under the objectives are parameters or measurement methods from the* ***Stream Functions Pyramid*** *(Harman, et al. 2011.)*

Goals	Objectives
Provide fish passage for Brook Trout	1. Demolish dam
Maintain water intake capability	1. Install sediment sluice to ensure water can be diverted if needed
Improve Brook Trout habitat (*i.e.*, diversity and quality)	1. Provide ability to withdraw water while maintaining in-channel flow 2. Provide pool depths greater than 30" for fish passage 3. Plant riparian vegetation to match species diversity and composition of upstream and downstream conditions. 4. Incorporate large woody debris structure within vanes to provide habitat for trout and benthic organisms

B. Design Criteria

Design criteria was compiled by standardizing existing channel plan, profile, and dimension of stable stream reaches directly upstream of the project area.

Table 4. Clifford Branch Design Criteria

Variable	Upstream Cross Section	Design Criteria
Stream Type	B3	B3
Drainage Area (mi. ^{2})	3.0	3.0
Riffle Bankfull Mean Depth (ft.)	1.76	1.56 – 2.44
Riffle Bankfull Width (ft.)	21.10	20.00 – 25.00
Width/Depth Ratio	14.26	12.00 – 18.00
Riffle Bankfull Cross Sectional Area (ft. ^{2})	42.47	36.35 – 48.58
Riffle Bankfull Maximum Depth (ft.)	2.44	2.10 – 2.56
Max. Riffle Depth / Mean Riffle Depth	1.39	0.70 – 1.40
Pool Max. Depth	4.5	3.0 – 5.0
Pool Max. Width	28	27 – 35
Mean Pool Depth	2.31	3.5 – 5.3
Mean Pool Depth / Mean Riffle Depth	1.31	2.0 – 3.0
Width of Flood Prone Area (ft.)	55.87	>35
Entrenchment Ratio	2.23	1.4 – 2.2
Pool-to-Pool Spacing	50.93	42 - 63
Riffle Slope (water surface facet slope)	0.08	0.06 – 0.12
Riffle Slope to Average Channel Slope	2.0	1.50 – 3.00
Pool Slope (water surface facet slope)	0.01	0.00 – 0.02
Pool Slope / Average Water Surface Slope	0.22	0.00 – 0.38
Glide Slope (water surface facet slop)	0.01	0.00 – 0.02

Table 4. Clifford Branch Design Criteria Continued

Variable	Upstream Cross Section	Design Criteria
Average Water Surface Slope (ft/ft)	0.04	0.04

C. Conceptual Design

A conceptual design was completed and submitted to project partners prior to the creation of this document. This document focuses on the final restoration design criteria and plans.

IV. FINAL DESIGN

A. Natural Channel Design

The Service developed stream restoration designs based on the restoration objectives and the stability problems identified during the watershed and stream assessment. The Service only considered restoration practices based on natural channel design (NCD) principles.

The Natural Channel Design methodology incorporates a combination of analog, empirical, and analytical methods for assessment and design. Because all rivers within a wide range of valley types do not exhibit similar morphological, sedimentological, hydraulic, or biological characteristics, it is necessary to group rivers of similar characteristics into discreet stream types. Such characteristics are obtained from stable reference reach locations by discreet valley types, and then are converted to dimensionless ratios for extrapolation to disturbed stream reaches of various sizes. (USDA 2007)

The results of the watershed and stream assessment showed that both the upstream and downstream portions of Clifford Branch directly adjacent to the dam are stable. Currently, the dam is providing grade control and the removal of the dam will increase the likelihood of a headcut developing in the system. A headcut could form due to the streambed elevation difference between the upstream and downstream portions of Clifford Branch. With the dam removed, facet slopes would increase to unstable levels causing the bed to effectively downcut and begin to migrate upstream. Therefore, the restoration design (**Appendix B**) proposes the installation of (3) grade control structures and channel dimension and profile modifications. The Service intends to remove the dam and allow Clifford Branch to flow uninhibited as it once did. This approach will allow Brook Trout to pass upstream and provide stable geometry to the system. These modifications will reflect the stable upstream and downstream conditions and maintain floodplain connectivity in the system.

B. Sediment Transport

The Service did not conduct a sediment transport study of this particular reach due to the low complexity of the restoration design. The design used the existing channel and floodplain dimensions upstream and downstream of the reach and these conditions are stable. Therefore, competence and capacities will not change as a result of the restoration design.

C. In-Stream Structures

Rock and log structures are in stream structures, made of natural materials, used to divert erosive stream flows away from stream banks and maintain streambed elevations. The most typical rock and log structures used from stream restoration are cross-vanes and j-hooks. The rock and log structures provide streambed bank stability and allow the streambed to naturally armor and the riparian vegetation to establish.

The Service has determined that a step pool system consisting of (3) Rock Cross-Vanes with steps will be most suited to address any concern of instability post dam removal. The locations of these structures were determined by matching the naturally occurring pool-to-pool spacing. Channel slope was also matched to existing channel slope, and no vertical drops were introduced that would hinder Brook trout passage.

1. Cross-Vane

The Cross-Vane (**Figure 5**) will establish grade control, reduce bank erosion, create a stable width/depth ratio, maintain channel capacity, while maintaining sediment transport capacity, and sediment competence. The Cross-Vane also provides for the proper natural conditions of secondary circulation patterns commensurate with channel pattern, but with high velocity gradients and boundary stress shifted from the near-bank region. The Cross-Vane is also a stream habitat improvement structure due to: 1) an increase in bank cover as a result to a differential raise of the ater surface in the bank region; 2) the creation of holding and refuge cover during both high and low flow periods in the deep pool; 3) the development of feeding lanes in the flow separation zones (the interface between fast and slow water) due to the strong down welling and upwelling forces in the center of the channel; and 4) the creation of spawning habitat in the tail-out or glide portion of the pool. (Rosgen, 2010)

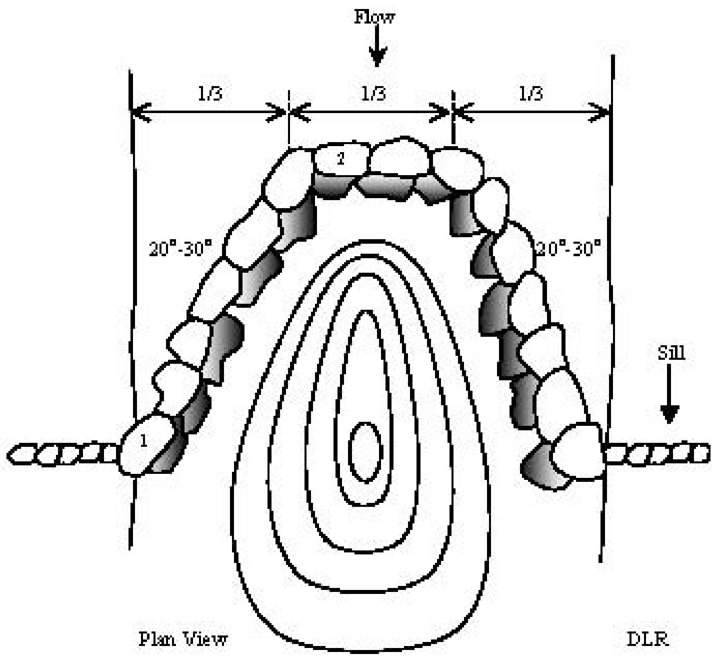

Figure 5. Cross-Vane in Plan View

D. Vegetation Design

The riparian buffer is an integral part of the stream ecosystem, providing bank stability and nutrient uptake, serving as a food source for aquatic organisms, and providing terrestrial habitat and migration corridors for various types of wildlife, including migratory neotropical songbirds. Shading from the buffer moderates stream temperature and prevents excessive algal growth. Large woody debris derived from the buffer is an important component of aquatic habitat.

The Service developed stream restoration planting plan that utilizes native plant and shrub species in both the riparian and upland corridors. The only areas that will be targeted for post-construction planting will be those areas that are disturbed during the implementation process. The species selected are consistent with native species found in the Great Valley physiographic province of Maryland.

V. MAINTENANCE AND MONITORING PLANS

A. Maintenance Plan

The Service will collaborate with Potomac Conservancy, The County and The City to develop a maintenance plan that will ensure the success of the restoration objectives and goals. Plan duration and responsible parties will also be determined at that time.

B. Monitoring Plan

The Service will produce an As-Built survey directly following completion of the restoration. This survey will be used to confirm that the project was built to design standards and will serve as baseline data for future monitoring. The Service will compare this data to the design criteria and produce a brief report summarizing any implementation adjustments or discrepancies.

A well-developed post-restoration monitoring plan will allow the partners to determine the success of the project, and address any problems that may arise. The Service, Potomac Conservancy and The County have developed a monitoring plan based on the restoration goals and objectives outlined in section 3A, to evaluate the performance of the stream restoration project. This will take place after the successful completion of the Clifford Branch Restoration.

In cooperation with the Service - CBFO, the Service, Maryland Fishery Resources Office (MFRO) will conduct pre- and post- dam removal biological monitoring for brook trout and other fish species. Two sites below the dam and two sites above the dam will be sampled using backpack electrofishing. The four sites will be sampled to collect baseline data prior to dam removal. Post project monitoring will be conducted one year after dam removal and again 3 years after dam removal. A backpack electrofishing unit will be used to conduct depletion sampling in order to assess the species assemblage and obtain a brook trout population estimate.

A Rapid Monitoring Protocol (RMP), developed by the Service - CBFO, will be used to monitor the physical characteristics of the restoration projects. The RMP is a tiered approach for rapid restoration assessment that visually evaluates the stability and qualitative functional success of the restoration project. If there are indications of potential failure, the methodology requires that the project evaluators conduct a more intensive monitoring survey, which is the second tier survey. However, if a severe problem is identified (*e.g.* complete structure failure, excessive bank erosion, vertical incision > 1.3) the second tier may be skipped to go directly to the third tier – remediation/repair. During the second tier survey, project evaluators take measurements of the existing stream conditions and compare them to the proposed design criteria and reference data, to determine if remediation is required. If remediation/repair is required, the evaluators will perform a third tier survey that includes restoration design and implementation. The success of the riparian buffer plantings will also be monitored by visually quantifying bare areas, invasive species distribution, native recruitment and survivability of planted species. The Service will monitor the stream for three years and provide a brief monitoring summary report for each year of monitoring.

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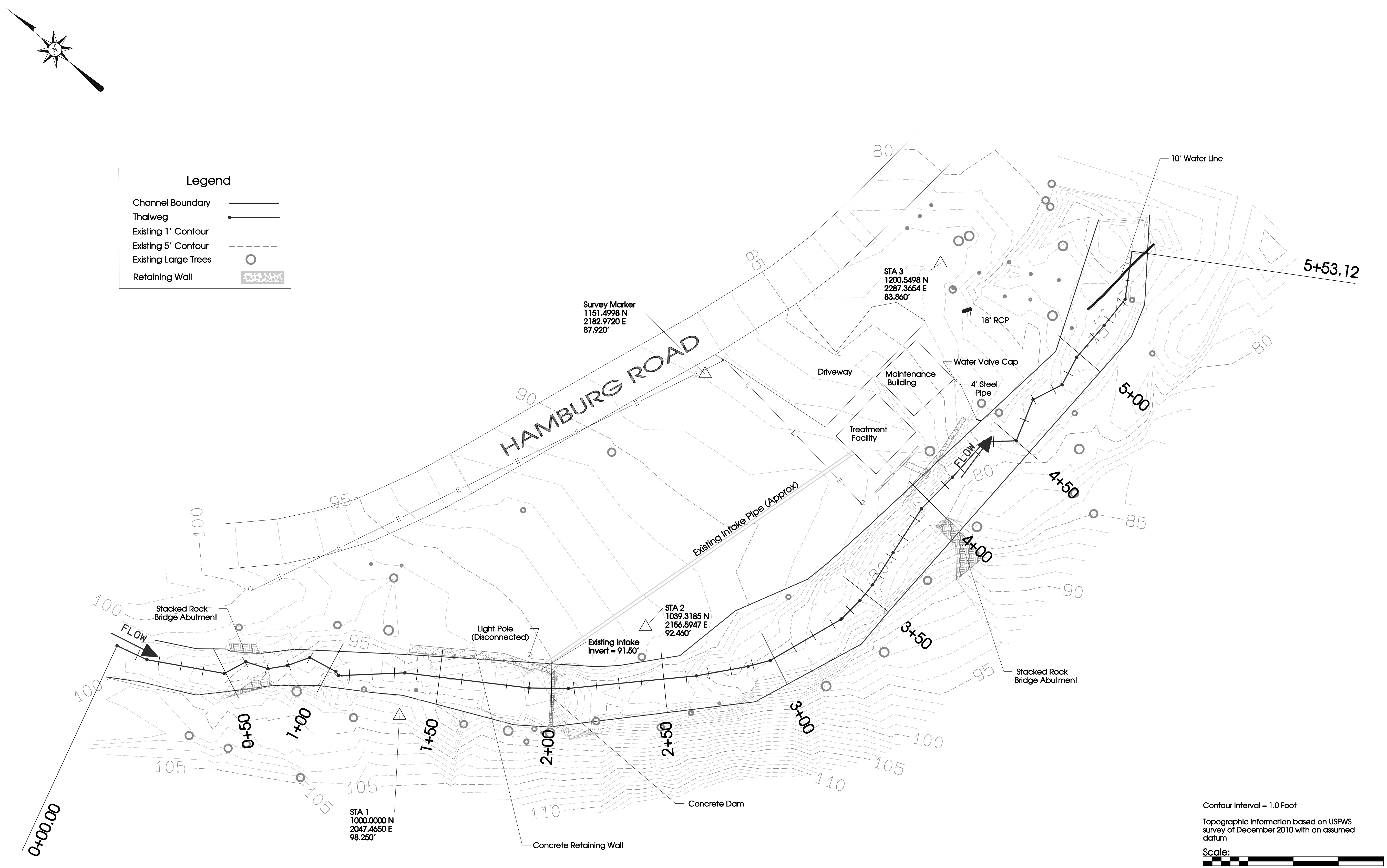
APPENDIX A



Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License No. 20945, Expiration Date: 08-23-2013.

(Signature) (Date)

U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Stream Habitat Assessment and Restoration Program

177 Admiral Cochrane Drive
Annapolis, MD 21401

Tel. (410) 573-4583

Clifford Branch
Frederick County, MD

100% Design
Existing Conditions

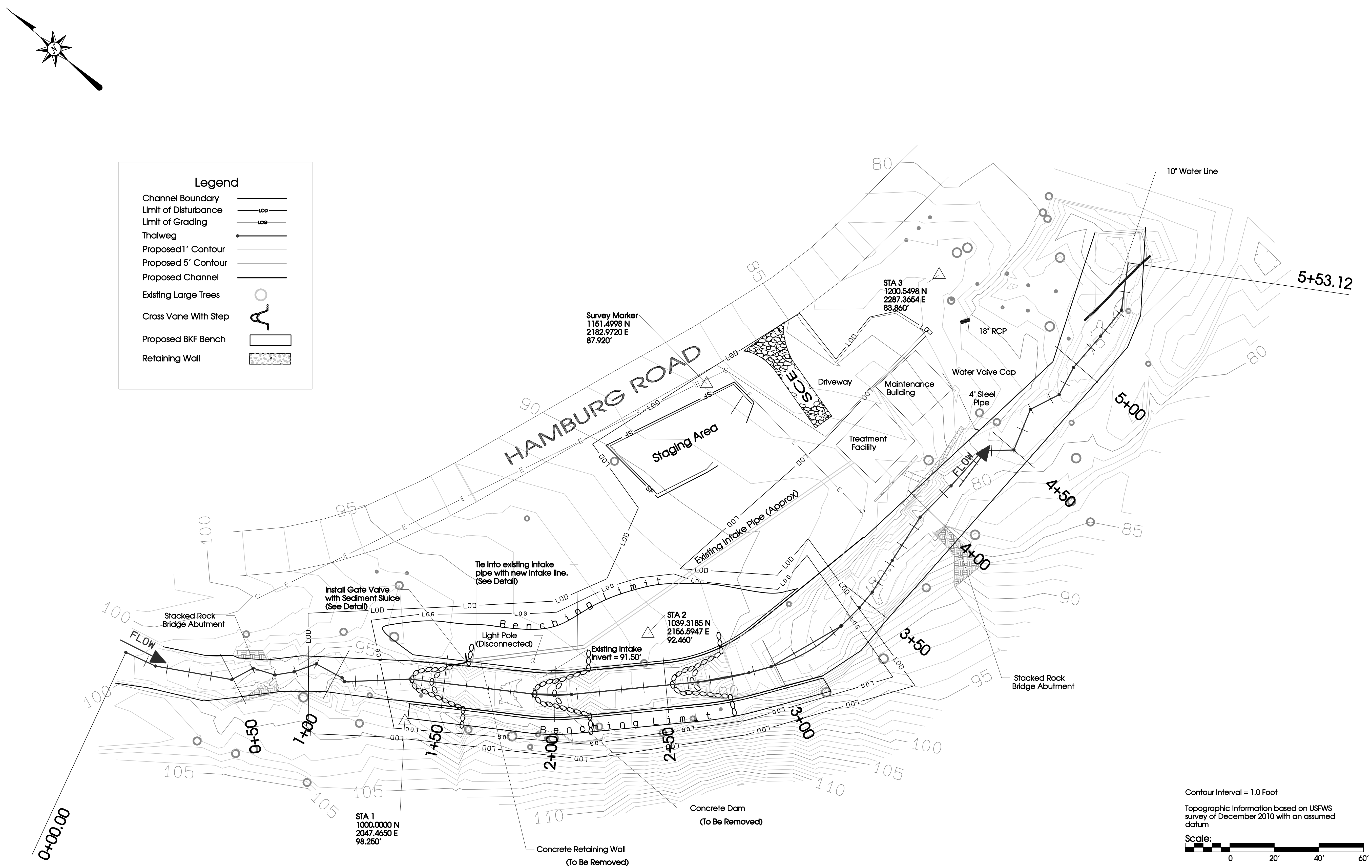
REVISIONS	
DATE	BY

PROJECT MANAGER: BH	DRAFTING: BH
DESIGN: BH	CHECKED BY: MAS
DATE: June 29, 2011	SCALE: AS SHOWN

SHEET
2

EC-1

APPENDIX B



Professional Certification. I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland, License No. 20945, Expiration Date: 08-23-2013.

(Signature) (Date)

U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Stream Habitat Assessment and Restoration Program

177 Admiral Cochrane Drive
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Clifford Branch Frederick County, MD		SHEET 3
REVISIONS DATE BY	100% Design Proposed Conditions	
PROJECT MANAGER: BH	DRAFTING: BH	PC-1
DESIGN: BH	CHECKED BY: MAS	
DATE: June 29, 2011	SCALE: AS SHOWN	

APPENDIX C

Reach	*River Station	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)
1	550	PF 1	Proposed	210	98.26	100.2		100.5	0.048518	4.39	48.43	35.4	0.61	4.71	20.71
1	550	PF 1	Existing	210	98.26	100.2		100.5	0.048665	4.4	48.37	35.33	0.61	4.72	20.77
1	500	PF 1	Proposed	210	94.98	98.33		98.61	0.030225	4.27	50.69	27.54	0.5	4.01	17.13
1	500	PF 1	Existing	210	94.98	98.34		98.62	0.029973	4.26	50.85	27.59	0.49	3.99	16.97
1	450	PF 1	Proposed	210	93.6	96.89		97.16	0.027752	4.17	50.67	23.19	0.48	3.78	15.76
1	450	PF 1	Existing	210	93.6	97.22		97.43	0.018672	3.62	58.94	26.84	0.4	2.78	10.06
1	400	PF 1	Proposed	210	89.9	95.84	94.37	95.99	0.018917	3.37	73.12	53.26	0.37	2.5	8.42
1	400	PF 1	Existing	210	92.89	96.39	95.62	96.5	0.017477	3.05	88.86	83.06	0.38	2.11	6.43
1	360	PF 1	Proposed	210	91.74	93.52	93.52	94.31	0.139093	7.14	29.43	19.93	1	12.71	90.82
1	360	PF 1	Existing	210	92.37	94.53	94.53	95.04	0.108554	5.98	40.01	42.32	0.86	9.15	54.75
1	340	PF 1	Proposed	210	87.7	92.69		92.8	0.007515	2.75	76.91	24.52	0.25	1.46	4.02
1	340	PF 1	Existing	210	86.44	91.14		91.22	0.005811	2.34	89.73	27.03	0.23	1.08	2.52
1	300	PF 1	Proposed	210	89.42	91.7	91.65	92.08	0.078598	5.38	48.29	56.44	0.76	7.21	38.83
1	300	PF 1	Existing	210	87.54	90.33		90.69	0.046378	4.79	43.83	22.75	0.61	5.3	25.41
1	250	PF 1	Proposed	210	83.33	86.13	86.13	86.92	0.138631	7.14	29.39	18.9	1.01	12.7	90.73
1	250	PF 1	Existing	210	83.33	86.13	86.13	86.92	0.138631	7.14	29.39	18.9	1.01	12.7	90.73
1	200	PF 1	Proposed	210	80.75	84.12		84.29	0.018914	3.35	62.66	27.45	0.39	2.48	8.31
1	200	PF 1	Existing	210	80.75	84.12		84.29	0.018914	3.35	62.66	27.45	0.39	2.48	8.31
1	150	PF 1	Proposed	210	78.99	82.47		82.87	0.045799	5.04	41.64	17.63	0.58	5.71	28.8
1	150	PF 1	Existing	210	78.99	82.47		82.87	0.045799	5.04	41.64	17.63	0.58	5.71	28.8
1	100	PF 1	Proposed	210	77.76	80.34		80.63	0.04253	4.38	49.74	35.27	0.58	4.53	19.84
1	100	PF 1	Existing	210	77.76	80.34		80.63	0.04253	4.38	49.74	35.27	0.58	4.53	19.84
1	50	PF 1	Proposed	210	75.13	77.96		78.32	0.050378	4.84	44.23	28.82	0.63	5.5	26.66
1	50	PF 1	Existing	210	75.13	77.96		78.32	0.050378	4.84	44.23	28.82	0.63	5.5	26.66
1	0	PF 1	Proposed	210	73.18	75.79	75.12	76.06	0.040012	4.17	50.64	32.32	0.56	4.16	17.34
1	0	PF 1	Existing	210	73.18	75.79	75.12	76.06	0.040012	4.17	50.64	32.32	0.56	4.16	17.34

* River Stations in HEC-RAS are reversed from stationing used on plan set

APPENDIX D

Natural Channel Design Review Checklist

Project Design Checklist

Reviewer: ______________________
Date: ______________________

Project: Clifford Branch Dam Removal
Engineer: Ben Hutzell

Item	Submitted (Y/N)	Acceptable (Y/N)	Page #	Comments
1.0 Watershed and Geomorphic Assessment				
1.1 Watershed Assessment				
1.1a Was the watershed assessment methodology described?	Yes		2	
1.1b Was the project drainage area provided?	Yes		2	
1.1c Was the percent impervious cover for the watershed provided?	Yes		2	
1.1d Was the current land use described along with future conditions?	Yes		2	
1.1e Were watershed hydrology calculations performed?	No			
1.2 Basemapping				
1.2a Does the project include basemapping?	Yes		Appendix A	
1.3 Hydraulic Assessment				
1.3a Was a hydraulic assessment completed?	No		3	Ther Service did not complete a hydraulic assessment of this particular reach due to the low complexity of the restoration design.
1.3b Was stream velocity, shear stress and stream power shown in relation to stage and discharge?	No		3	Ther Service did not complete a hydraulic assessment of this particular reach due to the low complexity of the restoration design.
1.4 Bankfull Verification				
1.4a Were bankfull verification analyses completed?	Yes		7	
1.4b Were USGS gages or regional curves used to validate bankfull discharge and area?	No		8	The respresentative cross section dimensions were higher than the Regional Curve data due to the fact that Mossy Creek is charged more so by its strong spring source than run-off
1.4c If a regional curve was used, were the curve data representative of the project data?	Yes		8	
1.4d If gages or regional curves were not available, were other methods, such as hydrology and hydraulic models used?	No			Ther Service did not complete a hydraulic assessment of this particular reach due to the low complexity of the restoration design.
1.5 Project Reach Geomorphic Assessment				
1.5a Was the geomorphic assessment methodology described?	Yes		5	
1.5b Were vertical and lateral stability analyses completed?	Yes		5	
1.5c Was it shown whether the instability was localized or system-wide?	Yes		6	
1.5d Was the cause-and-effect relationship of the instability identified?	Yes		6	
1.5e Was the channel evolution predicted?	Yes		6	
1.5f Were constraints identified that would inhibit restoration?	Yes		6	
1.5g Should this stream reach be a restoration project?				
1.5h Overall Geomorphic Assessment Comment(s)				

Natural Channel Design Review Checklist

Project Design Checklist

Reviewer: ______________________
Date: ______________________

Project: Clifford Branch Dam Removal
Engineer: Ben Hutzell

Item	Submitted (Y/N)	Acceptable (Y/N)	Page #	Comments
2.0 Preliminary Design				
2.1 Goals and Restoration Potential				
2.1a Does the project have clear goals and objectives?	Yes		9	
2.1b Was the restoration potential based on the assessment data provided?	Yes		11	
2.1c Was a restoration strategy developed and explained based on the restoration potential?	Yes		12-Oct	
2.2 Design Criteria				
2.2a Were design criteria provided and explained?	Yes		10	
2.2b Were multiple methods used to prepare design criteria?	No		10	The Service only considered restoration practives based on Natural Channel Design principles
2.2c Are the design criteria appropriate given the site conditions and restoration potential?	Yes		10	
2.3 Conceptual Design				
2.3a Was the conceptual channel alignment provided and developed within the design criteria?	No		10	Final design provided
2.3b Were typical bankfull cross sections provided and developed within the design criteria?	Yes		Plan Set	
2.3c Were typical drawings of in-stream structures provided and their use and location explained?	Yes		12	
2.3d Was a draft planting plan provided?	No		12	
2.3e Overall Conceptual Design Comment(s)				
3.0 Final Design				
3.1 Natural Channel Design				
3.1a Was a proposed channel alignment provided and developed within the design criteria?	Yes		Plan Set	
3.1b Were proposed channel dimensions provided and developed within the design criteria?	Yes		Plan Set	
3.1c Do the proposed channel dimensions show the adjacent floodplain or flood prone area?	Yes		Plan Set	
3.1d Was a proposed channel profile provided and developed within the design criteria?	Yes		Plan Set	
3.1e Were specifications for materials and construction procedures provided and explained for the project (i.e., in-stream structures and erosion control measures)?	Yes		Plan Set	

Natural Channel Design Review Checklist

Project Design Checklist

Reviewer: ____________________
Date: ____________________

Project: Clifford Branch Dam Removal
Engineer: Ben Hutzell

Item	Submitted (Y/N)	Acceptable (Y/N)	Page #	Comments
3.2 Sediment Transport				
3.2a Was a sediment transport analysis necessary?	No		11	
3.2b If necessary, was the type of sediment transport analysis explained?	N/A		11	
3.2c Were graphs or relationships created that show shear stress, velocity and stream power as a function of stage or discharge?	N/A		11	
3.2d Did sediment transport capacity analysis show that the stream bed would not aggrade or degrade over time?	N/A		11	
3.2e Did sediment transport competency analysis show what particle sizes would be transported with a bankfull discharge?	N/A		11	
3.2f For gravel/cobble bed streams, does the proposed design move particles that are larger than the D100 of the stream bed?	N/A		11	
3.3 In-Stream Structures				
3.3a Based on the assessment and design, were in-stream structures necessary for lateral stability?	Yes		11	
3.3b Based on the assessment and design, were in-stream structures needed for vertical stability?	Yes		11	
3.3c If needed, was the reason for their location and use explained?	Yes		11	
3.3d Will the in-stream structures provide the intended stability?	Yes		11	
3.3e Were detail drawings provided for each type of in-stream structure?	Yes		Plan Set	
3.4 Vegetation Design				
3.4a Was a vegetation design provided?	Yes		Plan Set	
3.4b Does the design address the use of permanent vegetation for long term stability?	Yes		12	
3.4c Overall Final Design Comment(s)				

Natural Channel Design Review Checklist

Project Design Checklist **Reviewer:** ______________________
Date: ______________________

Project: Clifford Branch Dam Removal
Engineer: Ben Hutzell

Item	Submitted (Y/N)	Acceptable (Y/N)	Page #	Comments
4.0 Maintenance and Monitoring Plans				
4.1 Maintenance Plan				
4.1a Was a maintenance plan provided?	No		13	
4.1b Does it clearly state when maintenance will be required and if so, is it quantifiable?	N/A			
4.1c Does it clearly state how erosion will be addressed and by whom?	N/A			
4.2 Monitoring Plan				
4.2a Was a monitoring plan provided?	Yes		12	
4.2b Does it state who is required to conduct the monitoring?	Yes		12	
4.2c Does it have measurable performance standards?	Yes		12	
4.2d Is monitoring required for at least 3 years?	Yes		12	
5.0 Overall Design Review				
5.0a Does the design address the project goals and objectives?				
5.0b Are there any design components that are missing or could adversely affect the success of the project?				
5.0c Does the project have a high potential for success?				