U.S. Fish & Wildlife Service

Natural Channel Design Protocols for Baltimore City, Maryland

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NATURAL CHANNEL DESIGN PROTOCOLS FOR BALTIMORE CITY, MARYLAND

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

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1.0 INTRODUCTION

This protocol outlines the components that are necessary to prepare a natural channel design for the City of Baltimore Department of Public Works (City). A stream restoration design team (Team) consists of the consultants and partners who will use this protocol to develop stream restoration design using natural channel design principles. Although the City is not identified in the Team, the Team will work closely with the City to develop the stream restoration design and the City will have the final decision making authority. This protocol does not promote any particular natural channel design methodology. However, for an example of a comprehensive design methodology, refer to Chapter 11 - *Rosgen Geomorphic Design in the National Engineering Handbook: Stream Restoration Design* (NRCS 2007).

This protocol assumes that a detailed stream and watershed assessment was conducted and has identified the stream as being unstable, possessing poor habitat, or otherwise requiring some level of rehabilitation. During the stream assessment, the Team should have used fluvial geomorphic assessment techniques to determine the stream's departure from its stable condition. From the watershed and stream assessments, the Team should have identified the causes of stream impairment, the processes responsible for stream impairment, and the future patterns of stream evolution.

The stream restoration design consists of several incremental stages, beginning with preliminary design planning and ending with a final restoration plan. As part of the preliminary design planning, the Team will prepare a scope of services that describes in detail the restoration design tasks, and identify quantifiable restoration objectives and measures to achieve the restoration objectives.

For the restoration design phase, the Team will conduct an alternatives analysis to select the most appropriate and effective restoration technique. During the restoration design phase, the Team will develop incremental plans that address the restoration objectives. At each stage, the Team further develops and refines the restoration design. Eventually, the Team develops a full set of construction plans and obtains permit approval for the proposed restoration plan.

The City encourages the Team to use innovative restoration techniques to resolve stream problems. The Team should not view this protocol as limiting their choice of restoration techniques or their ability to use innovative restoration approaches. As techniques and the understanding of stream and watershed relationships improve, the City may provide modifications to the protocol to improve the efficiency and effectiveness of assessments and designs.

This protocol provides a description of intermediate and final work products that a Team will prepare at each design stage. Appendix A contains a checklist of work products that the restoration designer will submit at each stage of project development.

2.0 ROLE OF STREAM AND WATERSHED ASSESSMENT(S)

The Team will complete the stream and watershed assessments prior to beginning the stream restoration design. The stream assessment will evaluate the current state of the stream and its departure from the potential stable state that is suitable for its watershed and valley conditions. In addition, the stream assessment will (at a minimum):

- Identify the type (e.g. vertical instability, lateral instability) of the stream impairment
- Identify the extent (e.g. localized or widespread) of the stream impairment
- Identify the cause(s) of the stream impairment
- Present the bankfull characteristics and discharge
- Discuss the bankfull determination and validation process and results

The stream assessment will have a thorough discussion of bankfull and its validation. The accurate identification of bankfull is critical to assessing a stream because it is used to classify the stream and evaluate its current condition and its departure from its potential stable state. The validation of bankfull is often a comparison to a regional bankfull and channel characteristic curve; however, a more intensive validation may be required for a more complex site. Examples of assessment forms used to summarize the site data are in Appendix B.

The watershed assessment will allow the Team to develop an understanding of how activities in the watershed (i.e. development and agricultural practices) influence stream stability and channel evolution. In addition, the watershed assessment will (at a minimum):

- Identify project drainage area
- Identify percent impervious cover
- Identify past, current, and planned land use(s) and land cover(s)
- Discuss land use and land cover trends
- Discuss the soils and geology of the watershed
- Discuss the climatic characteristics of the watershed
- Discuss the topography of the watershed (e.g. basin relief, basin shape, Rosgen valley type, etc.)
- Discuss the flow regime and drainage characteristics (e.g. drainage density, length of open stream channel and piping, etc.)

The watershed assessment may require hydrologic calculations (i.e. 2-, 5-, 10-, 25-, 50-, and 100-year discharge estimates) to quantify channel hydraulics and prepare floodplain studies. An extensive hydrologic evaluation may not be necessary for projects that have a gage station, an undeveloped (i.e. forest) landuse/cover, or access to a wide floodplain.

If there are missing components in the stream and/or watershed assessments, the Team will conduct the necessary work to complete the assessments. The Team will provide the missing information to the City as a supplemental report to the assessment reports.

3.0 DESIGN-PLANNING PHASE

The purpose of the design-planning phase is to present and discuss the restoration design process required by the City. During the design planning, the Team will also develop a scope of services that clearly defines project management and design expectations or limitations, and identifies the tasks necessary to complete the restoration design.

3.1 PRELIMINARY DESIGN MEETING

Prior to the preliminary design meeting, the Team will request a sample agenda and a list of attendees from the City. The Team will schedule a preliminary design meeting with the City to discuss project management and implementation, prior to preparing the scope of services. During this meeting, the City will provide the Team with the design standards and tolerances for using computer aided drafting design (CADD) and preparing the work plans. At the preliminary design meeting, the Team will discuss (at a minimum):

- Project management and implementation requirements
  - Project expectations
  - Project concerns and/or limitations
  - Project schedule and milestones
  - Project budget tracking and reporting
  - Quality control/quality assurance standards
- Restoration design methodology
- CADD and work plan design standards and tolerances
- Available and missing project data/information
- Scope of services

The outcome of this meeting will allow the Team to prepare a comprehensive and realistic scope of services and cost estimate table.

3.2 SCOPE OF SERVICES

Following the preliminary meeting, the Team will prepare a detailed scope of services that describes the steps necessary to develop the restoration design, including tasks necessary to obtain any missing information. The scope of services will include a cost estimate table that presents the level of effort (i.e. days) and cost for each of the restoration design steps (Appendix B). The scope of services will also include a project schedule that incorporates the City's project milestones. An example of a project schedule and a list of milestones will be provided by the City. For each project milestone, the Team will identify the critical path, the duration, and deliverables. The schedule will be realistic and incorporate the time necessary to obtain project permits and City and agency review. The Team will also list the resource allocation necessary to complete each milestone. In addition, the Team will (at a minimum):

- Summarize the preliminary design meeting discussion, including project management and implementation
- Describe in detail the restoration design methodology
- State any assumptions made in developing the work plans
- State the design standards and tolerances to be used in preparing the work plans
- State how quality control/quality assurance standards will be implemented for the project
- State the format and schedule for reporting project progress and expenditures (Format and schedule for reports will be provided by the City)

In addition to describing the type of work, the scope of services will specify the precision or level of effort for the proposed work, such as the precision of a topographic survey. When deciding on the precision or level of effort, the Team will evaluate the amount of detail required for each task to complete a successful restoration design and construction project. For example, a project with buried utilities and

other infrastructures will likely require a more detailed survey (i.e. more survey points and contours) to locate these potential site constraints, while a project without these constraints may require a less detailed survey. If the existing information (e.g. watershed and stream assessment, base map contours, etc.) is not sufficient for the required level of precision, the Team will conduct the necessary work to acquire the information.

4.0 DESIGN PHASE

Stream restoration plans generally follow the sequence of design steps listed in this protocol. However, adjustments to the protocols may be required for some projects because of project limitations, site-specific constraints or project objectives. Some projects may require fewer steps while others, depending on the situation, may require additional investigations, analyses and design plans.

The minimum data to be included with each phase of the stream restoration design is provided in a list under each design phase description. There may be situations where it is not possible to submit all the recommended data. In those situations, the Team will document that the submission is incomplete, provide reasons why the submission is incomplete, and what steps will be taken to rectify the situation. If changes to the protocol are required or desirable, the Team must justify and receive approval from the City for those changes prior to starting the work.

4.1 PRELIMINARY DESIGN

The first steps in the preliminary design phase are developing restoration objectives, followed by identifying and evaluating restoration alternatives.

4.1.1 Restoration Objectives

Using the information gathered during the assessments, the Team will develop restoration objectives that address the cause(s) of the stream impairment(s) and the restoration potential for the stream and watershed. The objectives will be well defined and have measurable performance criteria to evaluate their success. Examples of measurable performance criteria include eliminating bank erosion, providing fish passage, and reducing flood risks to infrastructures. The objectives will influence the scale of the restoration effort. Major restoration efforts involving adjustments to channel cross section, profile, or planform will focus on unstable streams. Minor restoration may include instream habitat or riparian buffer improvements to stable streams, or solutions to infrastructure conflicts. A list of typical restoration objectives are provided in Table 1.

Along with identifying and understanding the restoration objectives, the Team must also identify and understand any project limitations. Environmental project limitations may include poor water quality or lack of baseflow that might prevent establishment of suitable fish habitats. Physical project limitations, such as historical structure preservation, property access, or infrastructure conflicts can limit possibilities for horizontal or vertical stream adjustments. Other constraints may include limited funding or objective conflicts between project partners. The restoration design must address all these limitations.

4.1.2 Restoration Alternatives Analysis

The Team will identify restoration alternatives that address restoration objectives and project limitations. Initially, the focus will be on identifying the range of potential alternatives (including no action), rather than focusing on the feasibility of any single alternative.

Table 1. Examples of Restoration Objectives	
Hydrologic Objectives	
1.	Restore flood flows above the bankfull stage to an abandoned floodplain. Convert a terrace into an active floodplain by raising the channel bed and associated water table.
2.	Restore channel-forming flows to the appropriately sized channel based on Dominant Discharge Theory.
3.	Restore wetland and floodplain hydrology to meet the U.S. Army Corps of Engineers definition of a wetland.
4.	Dissipate flood energy by creating a meandering channel and new floodplain at the existing bankfull elevation. Partially restore lost floodplain and wetland functions.
5.	Dissipate flood energy by creating a step-pool channel and floodplain bench at the existing bankfull elevation. Restore floodprone area functions.
6.	For urban channels, restore bankfull discharge to pre-development levels by implementing watershed scale best management practices, providing grade control and/or recreating large floodplains.
7.	Create a riparian buffer to reduce flood velocities on the floodplain and encourage infiltration and sediment deposition.
Fluvial Geomorphologic Objectives	
1.	Create a stable channel that neither aggrades nor degrades over time.
2.	Create streambanks that do not erode at rates above natural levels for reference reach streams of the same stream type.
3.	For alluvial systems, restore a riffle-pool bedform sequence such that the pool to pool spacing and percent riffle-pool matches reference reach streams of the same stream type.
4.	For colluvial systems, restore a step-pool bedform sequence such that the pool to pool spacing matches reference reach streams of the same stream type.
Biological Objectives	
1.	Create coarse-grained riffles, via constructed riffles and proper profile design, to improve macroinvertebrate habitat and promote oxygenation of the water.
2.	Increase the amount and complexity of large woody debris to improve fish habitat.
3.	Create deep pools near cover structures (wood or rock) to improve fish habitat.
4.	Create holding areas in riffles for fish habitat and passage, i.e. provide a diversity of flow velocities within a cross section and reach.
5.	Create a riparian buffer using native plants to improve channel shade and terrestrial habitat.

The Team will prepare a description of each alternative that explains how the proposed alternative will address the restoration objective(s) and the conditions causing the problem(s). The Team will evaluate how successfully each alternative achieves the restoration objective(s). Based on all these factors in the alternatives analysis, the Team will recommend the best restoration alternative(s). The alternatives analysis will (at a minimum):

- Identify and discuss any project limitations, including structures or archeological sites with historical significance
- Describe how each alternative functions (i.e. hydraulics and geomorphologic principles)
- Discuss how each alternative will improve the hydraulics, hydrologics, and/or geomorphic stability of the stream
- Discuss how the alternatives will affect stream stability, infrastructure, stream habitat, water quality, private property, and other relevant factors
- Discuss any advantages and disadvantages of each alternative, specifically with regards towards the restoration objectives, construction feasibility, short and long term maintenance, and project success
- Prepare a cost estimate for each alternative
  - Estimate costs for the proposed time of construction
  - Consider potential factors that may influence material and construction costs
- Discuss the cost comparison

The Team may wish to summarize the alternatives analysis using a decision matrix table. Table 2 is a completed example of a decision matrix. The *Weighted Values* represent the relative importance of each restoration objective, using a ten-point scale with ten being the most important. For each restoration objective, the Team will assign a *Value* for each restoration alternative that will represent how successfully the alternative achieves the objective. A similar point scale is used for the restoration alternative *Value* as the restoration objective *Weighted Values*. The subtotal for each restoration objective is calculated by multiplying the *Weighted Value* with the restoration alternative *Value*. The subtotals for each restoration alternative are added up and the alternative with the highest total is the preferred restoration alternative for the project. Due to site constraints or limitations, there may be situations where another restoration alternative may be more appropriate for a section of stream. However, if the decision does not support the most appropriate restoration alternative, then it may be necessary to reevaluate the restoration objectives, the *Weighted Values* for the objective, and/or *Values* assigned to the alternatives.

4.1.3 Restoration Objectives and Alternatives Analysis Report

The Team will prepare a Restoration Objective and Alternatives Analysis Report that documents the restoration objectives and describes the method used to identify and evaluate the objectives. The Restoration Objective and Alternatives Analysis Report will also document and summarize the methods and findings of the alternatives analysis, and identify the preferred restoration alternative(s). The report will include written descriptions and examples (e.g. standard details, photographs, etc.) of the restoration alternatives.

The report will also reference previous watershed, stream, or field assessments and/or investigations and summarize the relevant information, especially hydraulic and hydrologic studies. If there are missing components in the watershed and stream assessments, the Team must provide the missing components in the Restoration Objective and Alternatives Analysis Report. The Team will provide sufficient information to allow the City to validate the alternatives analysis without having access to any of the original assessment or investigations, including aerial photos (Figure 1) and baseline maps with topographic contours, utilities, roads, trees, property boundaries, and other features that may influence the restoration design (Figure 2).

4.1.4 Alternatives Analysis Submission Package

The Team will submit two hard copies of the draft Restoration Objective and Alternatives Analysis Report to the City for their review. After receiving written comments from the City, the Team will address the City's comments and finalize the report. The Team will provide the City with two hardcopies and an Adobe Acrobat file of the final Restoration Objective and Alternatives Analysis Report to the City.

4.1.5 Alternatives Analysis Meeting

The Team will conduct a meeting with the City to review the alternatives analysis and the proposed restoration alternative(s). After the City provides the Team with their final restoration alternative decision, it is recommended that the City and the Team review the concept with the regulatory agencies to ensure that the general concept is permissible and feasible.

4.2 THIRTY (30) PERCENT (CONCEPTUAL) DESIGN

The next step in the design phase is to develop 30 percent design plans for the selected alternative and to prepare a Conceptual Design Report. The conceptual design will demonstrate that the selected stream restoration alternative(s) meets the restoration objectives and is feasible to implement at the project site.

Table 2. Example of Restoration Alternatives Selection Matrix

Criteria			Restoration Alternatives					
Description		Weighted Value	#1 - Soil Lifts		#2 - Structures		#3 - Soil Lifts & Structures	
			Value	Sub-Total	Value	Sub-Total	Value	Sub-Total
Design Objectives								
1.	Cost (linear feet)	8	10	80	8	64	6	48
2.	Channel stability (i.e. vertical, lateral, and sediment transport)							
a.	*Short-term channel stability*	10	8	80	9	90	10	100
b.	*Long-term channel stability*	10	9	90	10	100	10	100
3.	Restoration reliability							
a.	*Potential for success*	10	8	80	9	90	10	100
b.	*Adaptivity*	7	7	49	8	56	9	63
c.	*Establishment time*	5	10	50	8	40	9	45
d.	*Low maintenance*	8	9	72	9	72	7	56
4.	Ease of implementation							
a.	*Design complexity (e.g. installation)*	8	10	80	8	64	7	56
b.	*Site complexity (e.g. utilities)*	2	6	12	8	16	6	12
c.	*Natural resources impacts (e.g. trees)*	2	6	12	8	16	6	12
Baltimore City's Objectives								
5.	Instream habitat							
a.	*Diversity of velocity and depths*	9	7	63	10	90	10	90
b.	*Diversity and quality of cover*	9	6	54	9	81	9	81
c.	*Shading*	7	6	42	6	42	6	42
d.	*Spawning habitat*	5	8	40	10	50	10	50
6.	Riparian habitat (i.e. width, diversity, native planting, and establishment time)	8	8	64	8	64	8	64
7.	Water quality							
a.	*Sediment reduction*	10	10	100	9	90	9	90
b.	*Nutrient reduction*	6	9	54	9	54	9	54
Partner's Objectives								
8.	Channel stability (i.e. vertical, lateral, and sediment transport)							
a.	*Short-term channel stability*	10	8	80	9	90	10	100
b.	*Long-term channel stability*	10	9	90	10	100	10	100
9.	Restoration reliability	10	6	60	8	80	10	100
10.	Water quality (i.e. sediment reduction)	7	10	70	9	63	9	63
11.	Riparian habitat							
a.	*Aesthetics*	8	8	64	10	80	10	80
b.	*Low maintenance*	8	10	80	10	80	10	80
c.	*Wildlife habitat improvements*	5	8	40	8	40	8	40
d.	*Native planting*	6	9	54	9	54	9	54
			Total	**1560**	**Total**	**1666**	**Total**	**1680**

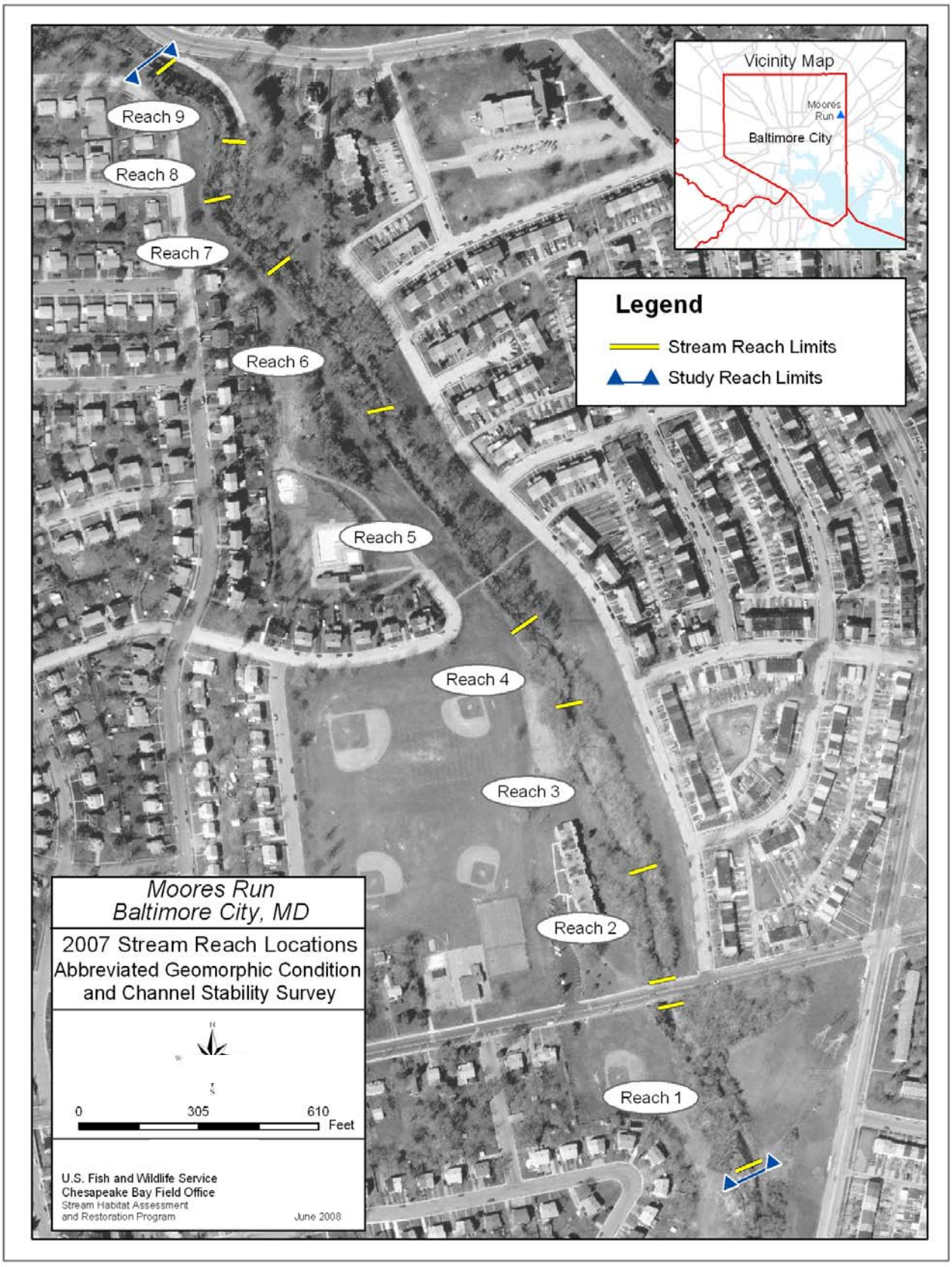


Figure 1. Example of aerial photograph with delineated study reaches

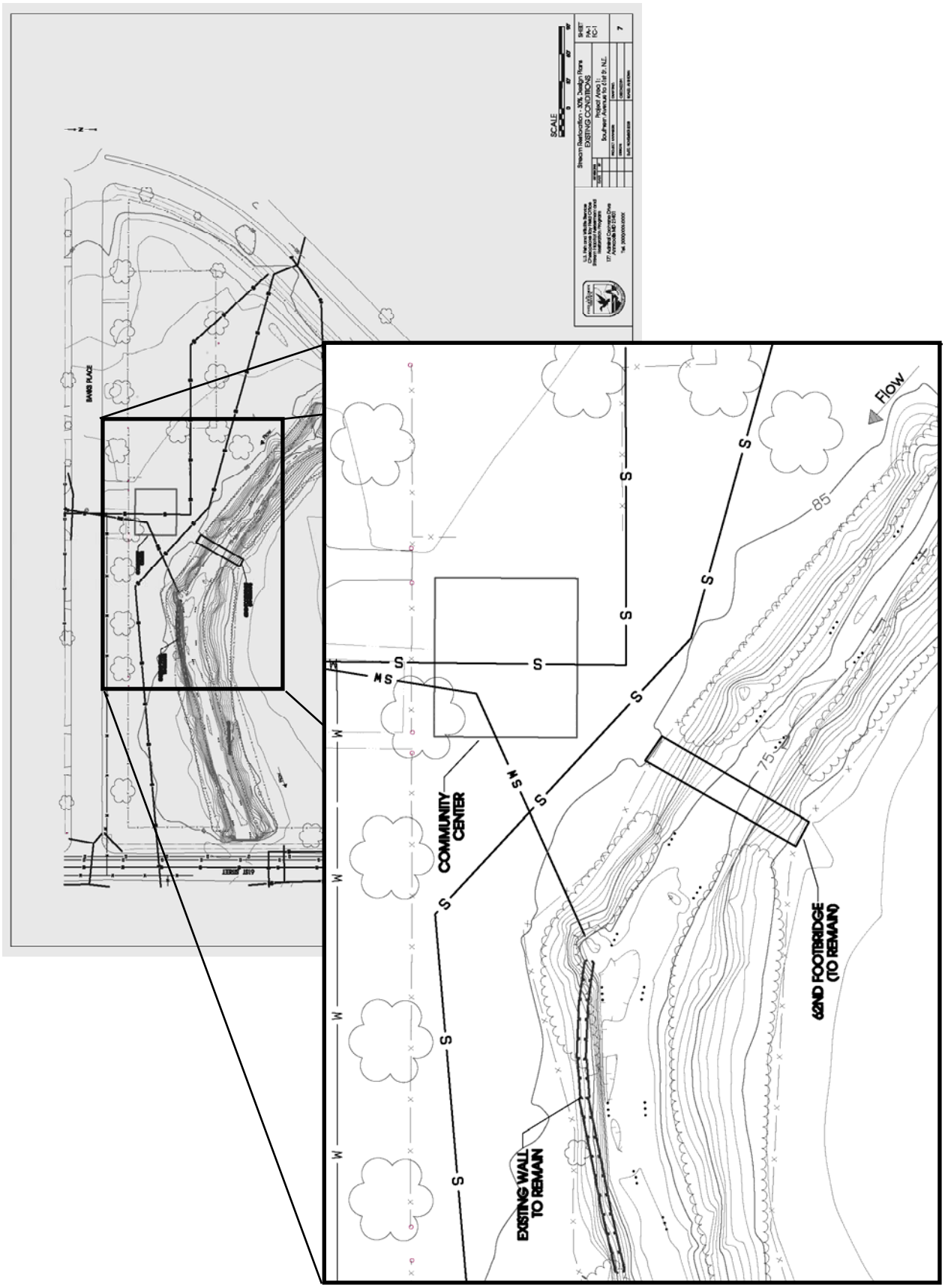


Figure 2. Example of existing conditions map and an enlargement of topographic survey with locations of utilities

4.2.1 Permit Preparation

In preparation for the project permit process, the Team will coordinate with the City to complete the following tasks:

- Identify and conduct any resource and/or historical inventory (e.g. wetland delineation, forest stand delineation, and historical structure assessment) necessary for the project permits
- Identify the required permits, appropriate regulatory agencies, and other project stakeholders
- Discuss any other special conditions that may influence permitting of the project
- Discuss any preliminary meetings that the Team/City has held with permitting agencies
- Prepare a schedule for the tasks necessary to acquire all the project permits

Depending on the complexity of the project, the Team will consider conducting a meeting with the City and regulatory agencies to discuss the necessary project permits, permit process, and permit schedule. If there is a potential for the project to have historical, archeological, and/or rare, threatened and endangered species issues, the Team will submit an information request letter to the appropriate regulatory agency. Sample information request letters for Maryland Historical Trust issues, and Rare, Threatened and Endangered Species are provided in Appendix C.

4.2.2 Conceptual Design Report

The report will provide a more detailed summary of the previous watershed, stream or field assessments and/or investigations than the Alternatives Analysis Report. The report will clearly identify existing stream problems, the processes causing existing stream problems, and explain how the selected restoration alternative(s) will address the causes of the stream problems.

The Conceptual Design Report will likely contain information previously provided in other reports. However, the Team will provide sufficient information to allow the City and permit regulators to conduct an accurate evaluation of the restoration design without having access to any of the original assessment or investigations. Specific items that will be included in the Conceptual Report are:

4.2.2.1 Site Information

- Provide a general site map showing stream location and upstream drainage basin and drainage area
- Provide a detailed, scaled site map showing limits of study area and major features (roadways, streams, building footprints, etc.)
- Describe the property ownership: provide ownership mapping if project extends onto property not owned by the City
- Describe the project area noting the presence of wetlands (e.g. type, quality, and location), riparian buffer and trees (e.g. type, condition, size), and presence of stream/infrastructure, etc.
- Provide a map of natural resources that includes forest resources, jurisdictional and non-jurisdictional wetlands, waters of the U.S., and other environmentally sensitive features
- Locate and describe any stormwater infrastructure within and/or near the project area. The 30 percent design plans will show the location of any outfalls, stormwater management facilities, inlets, etc.
- Locate and describe any overhead and buried utilities within and/or near the project area. The 30 percent design plans will show the locations of any utility within and/or near the project area.
- Locate and describe the benchmark controls for the restoration project

4.2.2.2 Stream and Watershed Assessments

- Provide a summary of the stream and watershed assessments, including (at a minimum):
  - Stream and watershed assessment methods
  - Assessment of Rosgen stream type (Figure 3) and Rosgen valley type
  - Existing bankfull channel dimensions
  - Existing planform and profile dimensions
  - Summary of departure from potential analysis
  - Listing of stream problems
  - Problem analysis identifying relationship between causes and effects

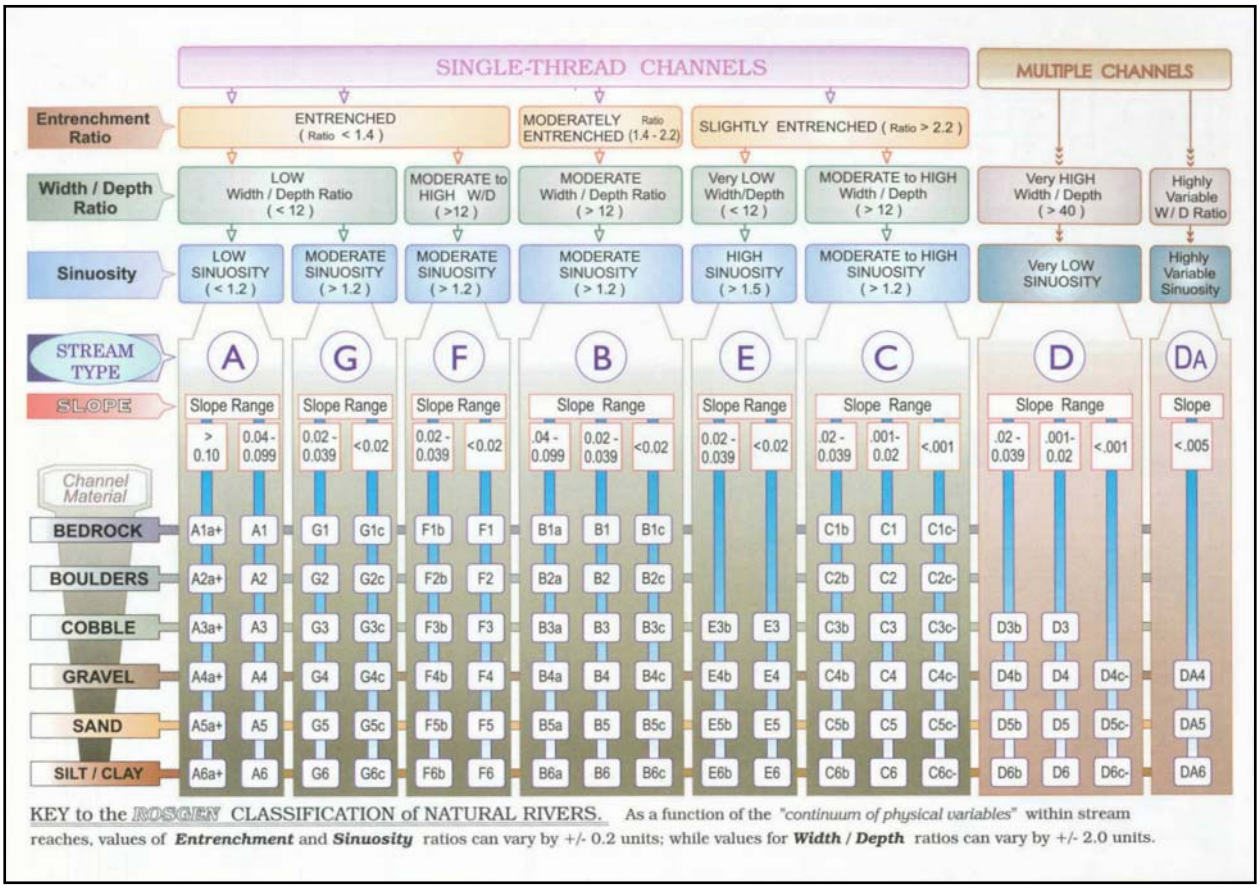


Figure 3. Rosgen stream type classification (Rosgen 1996)

- Provide stream assessment data, including (at a minimum):
  - Cross section plots (Figure 4)
  - Map of cross section locations (Figure 5)
  - Longitudinal profile of facet stream features for the existing channel bottom, water surface, bankfull elevation, and low top of bank (Figure 6)
  - Methods used to identify bankfull stage and bankfull stage indicators
  - Bankfull discharge including discussion on how the Team determined and validated the bankfull discharge

- Average surveyed water surface slope, estimated average bankfull water surface slope, and valley slope
- Summary of bed materials (substrate) and methods used to investigate bed materials

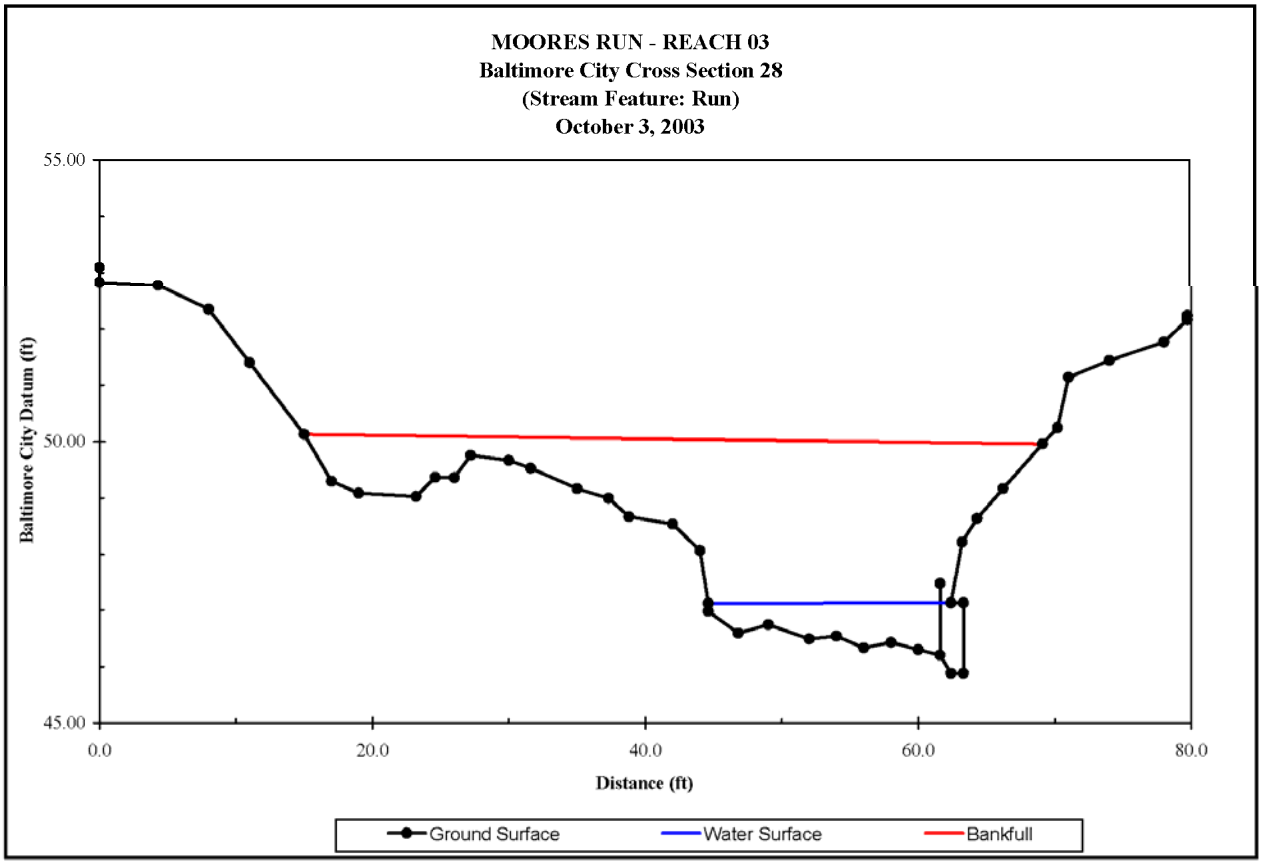


Figure 4. Example of cross section plot with monumented benchmarks and toe-pin

4.2.2.3 Alternatives Analysis

- List restoration objectives and project limitations
- Summarize the alternatives analysis including a no action alternative
  - Explain how the selected alternative addresses the restoration objectives and why it is superior to other alternatives including a no action alternative
  - Describe which stream functions (physical and/or biological) are being restored
  - Indicate and discuss the basic principles of stream hydraulics and geomorphology that underlie any proposed alterations to the channel and floodplain

4.2.2.4 Hydrologic and Hydraulic Analysis

An extensive hydrologic and hydraulic analysis may not be necessary in certain situations, such as a headwater stream or a stream with easy access to a broad floodplain. In these situations, the scope for the hydrologic and hydraulic analysis may be reduced; however, the Team will have to provide a justification for the change in scope.

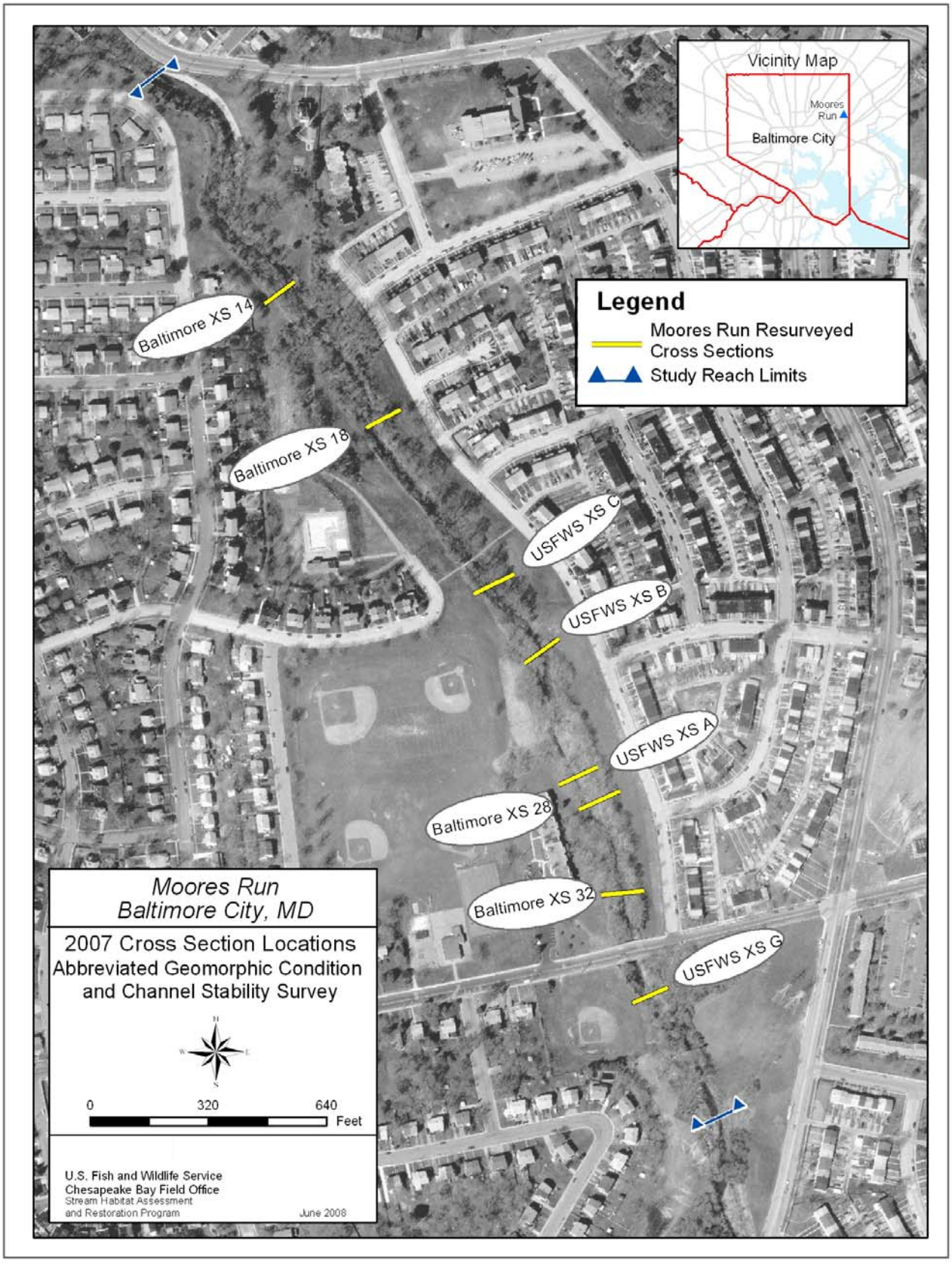


Figure 5. Example of aerial photograph with cross section locations

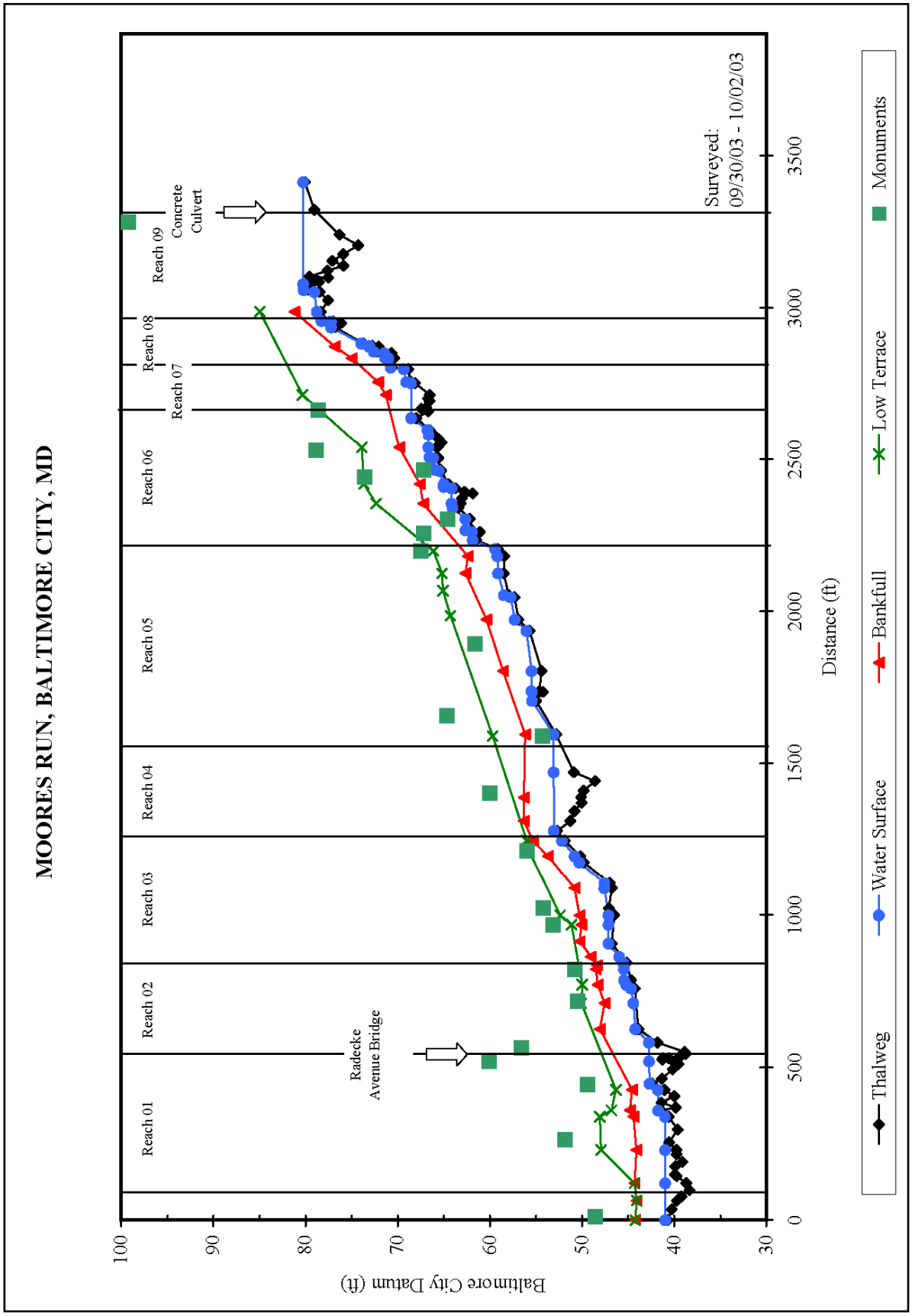


Figure 6. Example of Longitudinal profile survey plot with facet stream features for the existing channel bottom, water surface, bankfull elevation, and low top of bank

- The hydrologic analysis may include:
  - Existing FEMA 2-, 5-, 10-, 50-, 100-year return period discharges (Table 3)
  - If the current FEMA discharges are unrealistic, revised FEMA 2-, 5-, 10-, 50-, 100-year return period discharges and summary of analysis used to develop revised discharges
  - Discussion of hydrologic modeling methods used and model calibration

Table 3. Exerpt of FEMA 10-, 50-, 100-, and 500-Year Return Period Discharge

Flooding Source and Location	Drainage Area (sq. miles)	Peak Discharges (cfs)			
		10-Year	50-Year	100-Year	500-Year
Gwynns Falls					
At confluence of Middle Branch Patapsco River	66.07	8,257	18,960	26,470	47,000
Upstream of confluence of Gwynns Run	58.27	6,920	14,500	20,200	33,000
Upstream of confluence of Dead Run	42.43	4,200	9,040	12,200	21,000
Jones Falls					
At confluence with Northwest Harbor	56.94	13,680	17,300	20,600	42,000
Upstream of confluence of Stony Run	51.70	9,950	14,600	19,050	42,000
Upstream of confluence of Western Run	41.40	9,150	13,900	18,450	37,500

- The hydraulic analysis may include:
  - Summary of any floodplain studies including FEMA mapping and modeling
  - FEMA existing water surface profiles (Figure 7) and mapping (Figure 8)
  - Discussion of FEMA mapping accuracy and the potential need for revisions
  - Review of floodplain limits and adjacent properties
  - Identification of structures/infrastructures that are subject to flooding

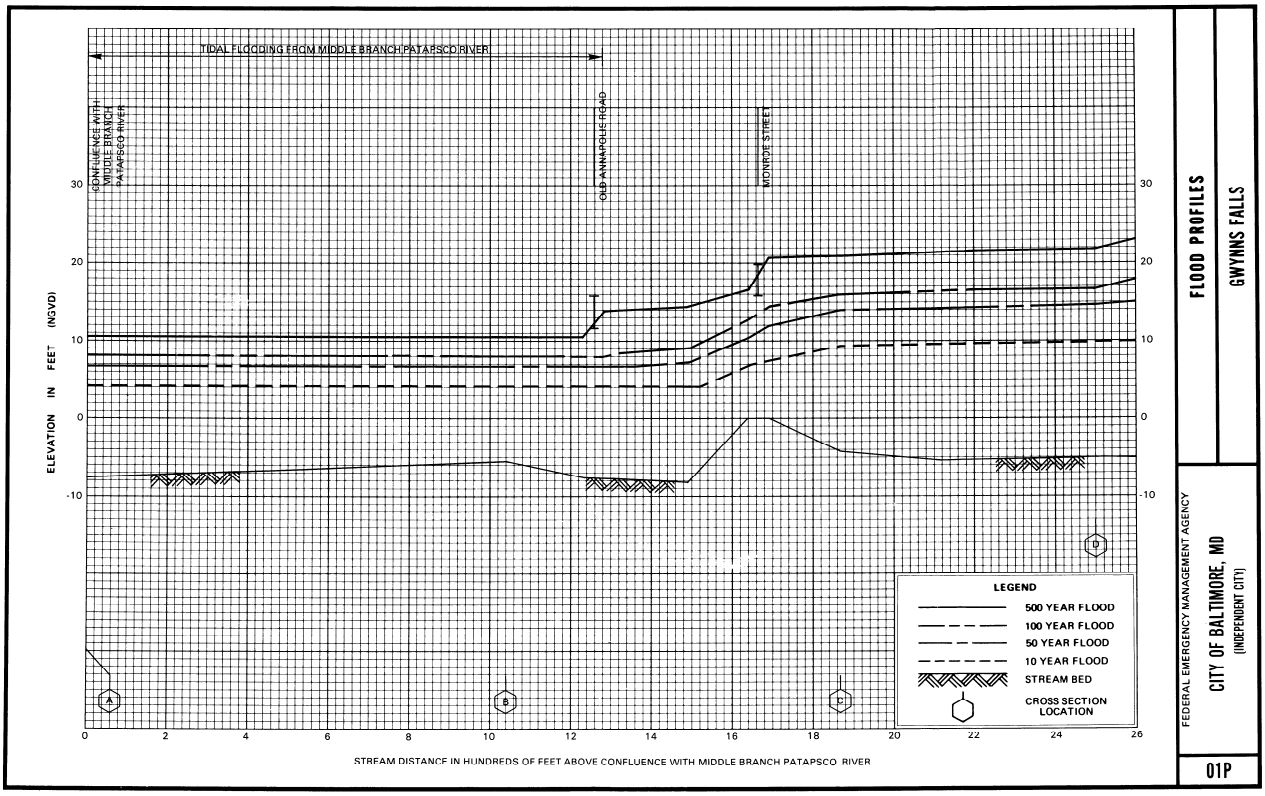


Figure 7. Example of existing FEMA water surface profiles

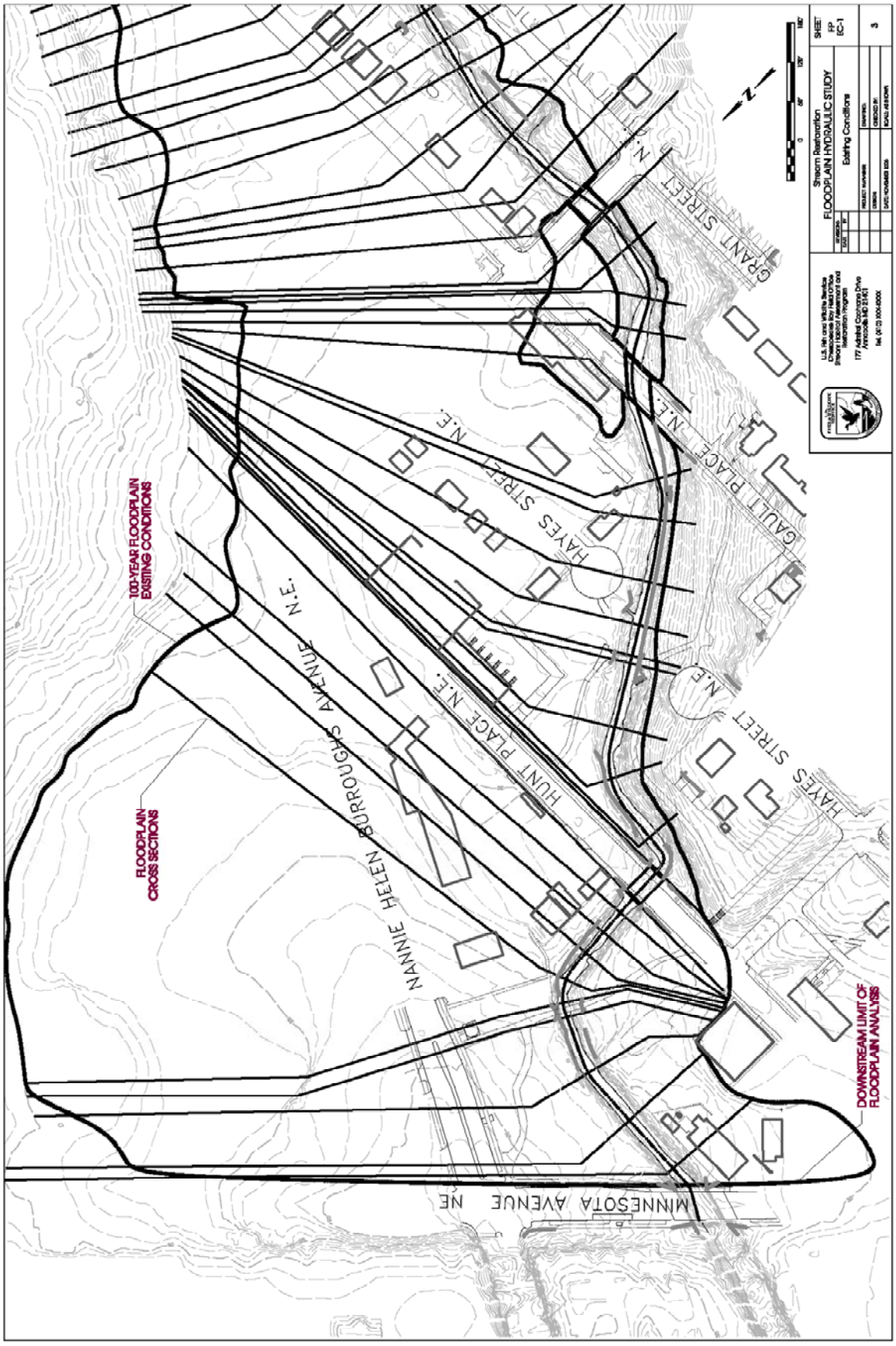


Figure 8. Example of existing FEMA 100-year floodplain map with floodplain boundary and cross sections

4.2.2.5 Reference Data and Design Criteria

The report must present and discuss the development of design criteria from reference data. The collection of reference data and the subsequent development of design criteria are critical to the natural channel design process because the criteria are used as a template to design the restored channel dimensions, pattern, and longitudinal profile. The Team will present the reference reach data and design criteria dimensionless ratios used to develop the restoration design (Table 4). The reference data and design criteria will be presented in a tabular format (Appendix B)

Table 4. Select Design Criteria Dimensionless Ratios for the Piedmont Region of North Carolina*

Parameters	C4/E4	Parameters	C4/E4
Width to Depth Ratio	10-14	Riffle Slope Ratio	1.5-2
Max. Riffle Depth Ratio	1.1-1.3	Run Slope Ratio	0.5-0.8
Bank Height Ratio	1-1.1	Glide Slope Ratio	0.3-0.5
Meander Length Ratio	7-12	Pool Slope Ratio	0-0.2
Meander Width Ratio	3.5-8	Max. Pool Depth Ratio	2-3.5
Radius of Curvature Ratio	2-3	Pool Width Ratio	1.3-1.7
Sinuosity	1.2-1.6	Pool to Pool Spacing Ratio	4-7

(*) Reference data collected by Baker Engineering NY, Inc.

The Team will explain why the reference site/data is a reference condition and why the data are applicable to the restoration site. The Team will discuss how the design criteria (e.g. dimensionless ratios) were developed from the reference data. There are many methods for developing design criteria including analytical models, regime equations, and empirical relationships. When appropriate, the Team will compare and discuss how the natural channel design criteria compare to these or other design methods. Projects that are more complex may require multiple methods to develop the design criteria. In those situations, a more detailed discussion of the design criteria development will be required by the City. The reference data and design criteria discussion will (at a minimum):

- Provide reference reach data for proposed stream alterations with the same type and level of detail as the existing conditions
- Discuss the suitability of the reference reach as a template for the restored reach
- Identify any limitations to reference reach data and discuss how the restoration design addresses these limitations
- Develop and document proposed design criteria of bankfull channel, planform, profile dimensions, and substrate

4.2.2.6 Stream Velocity and Sediment Transport Analysis

- Provide a conceptual level stream flow analysis of stream velocity (an example of a velocity calculation form is provided in Appendix B)
  - Evaluate existing and proposed stream velocities at bankfull
  - Provide a justification for the method used to estimate stream velocity
- Provide a conceptual level analysis of sediment transport issues (an example of an entrainment calculation form is provided in Appendix B)
  - Identify the status of existing sediment supply, if the stream is aggrading or degrading, and existing sediment competency

- Verify that the proposed design would result in a stable channel and address any degradation or aggradation issues

4.2.3 Conceptual Design Plans

The Team will prepare a set of conceptual design plans prepared in accordance with the CADD standards of the City. The plans will include:

- A general location map showing the restoration location and adjacent roadways that will be used to access the site during construction
- Scale map(s) of the restoration reach showing existing conditions, utilities, delineated wetlands, existing 100-year FEMA floodplain boundary (may be provided in the hydrologic and hydraulic analysis), waters of the U.S., and major topographic features such as roads, buildings, etc.
- Scale map(s) of the restoration reach showing proposed conditions including the stream alignment, proposed bankfull width, and type and location of instream structures
- Longitudinal profile of existing and proposed conditions showing channel thalweg and bankfull stage
- Typical design cross sections (Figure 9)

The scaled map(s) will be developed from a topographic basemap, usually with one-foot contours. However, complex projects (e.g. projects with buried utilities) may require basemapping with more detailed contours. Basemapping should be tied into a real world coordinate system (e.g. state plane), especially for complex urban projects.

4.2.4 Conceptual Construction Cost Estimate

The conceptual construction cost estimates will be for the proposed time of construction and consider potential factors that may influence the cost of materials and construction. During subsequent design phases, the Team will refine the construction cost estimate. The accuracy of the cost estimate will be within 35 percent of the actual construction cost. Any significant cost changes in subsequent design phases will require a written justification submitted to the City. The Team will prepare a conceptual level construction cost estimate that will provide an estimate of material quantities and unit price costs (Table 5 and Appendix B).

4.2.5 Conceptual Design Submission Package

The Team will submit two hard copies of the draft Concept Design Report and two full-sized (i.e. 24 x 36 inches) hardcopies of the conceptual design plans to the City for their review. After receiving written comments from the City, the Team will address the City's comments and finalize the report. The Team will provide the City with two hardcopies and an Adobe Acrobat file of the final Conceptual Design Report to the City.

After receiving written comments and/or mark-ups of the conceptual design plans from the City, the Team will provide a written response to the City discussing how the Team will address the comments on the conceptual design plans and incorporate the conceptual design comments/revisions into the 60 percent design plans.

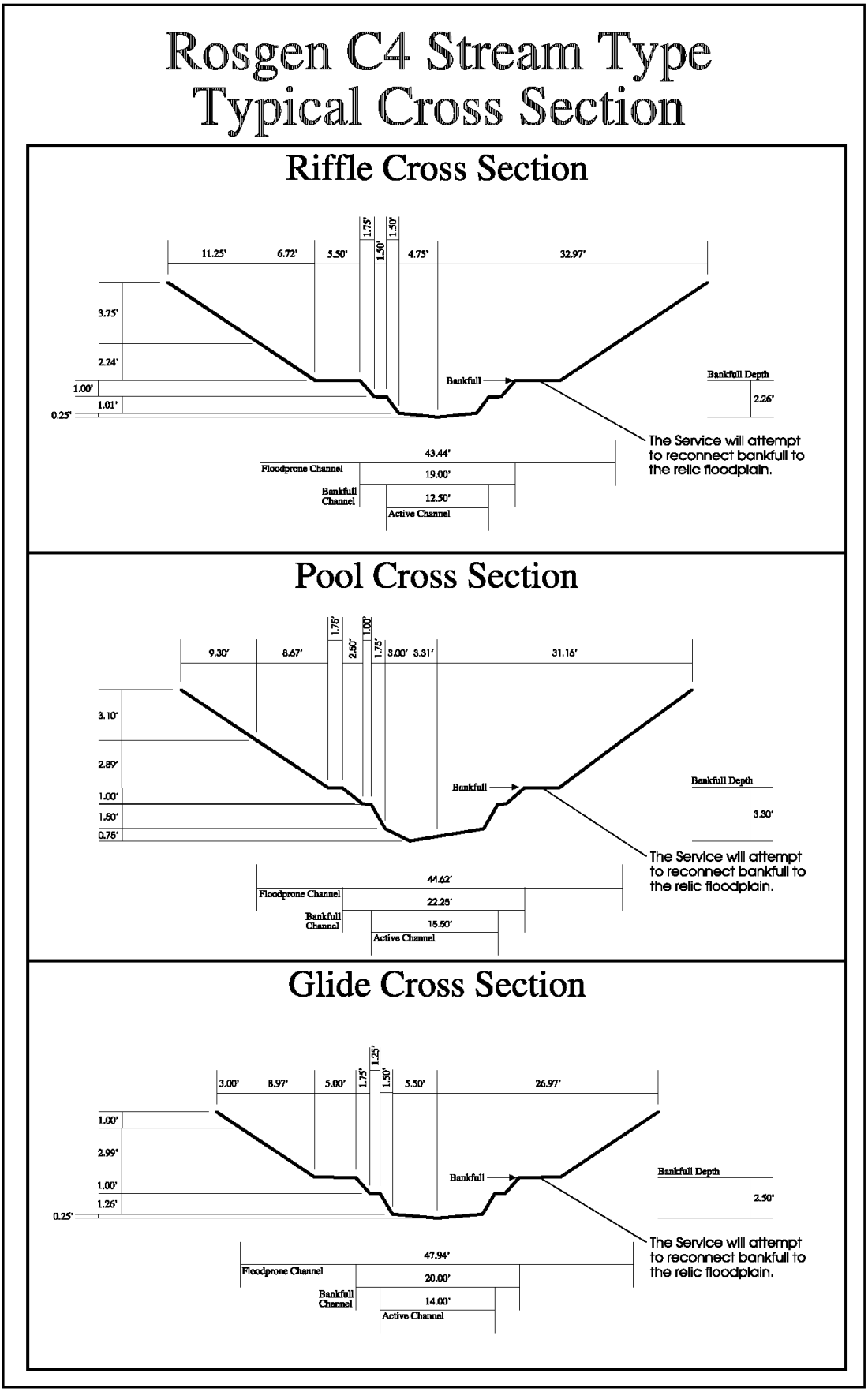


Figure 9. Example of typical design cross sections

Table 5. Example of Conceptual Level Construction Cost Estimate

Bid Item Number	Commodity	Unit of Measure*	Estimated Quantity°	Unit Price	Total Cost
1	Mobilization	LS	1	$6,000	$6,000.00
2	Construction Stakeout	LS	1	$5,000	$5,000.00
3	Load Protection Mats	SY	13	$40	$520.00
4	Sediment and Erosion Control	LS	1	$3,000	$3,000.00
5	Silt Fence	LF	435	Included in the Erosion and Sediment Control	
6	Blaze Orange Fence	LF	240		
7	Clearing and Grubbing	LS	1	$1,000	$1,000.00
8	Temporary Stream Diversion	LS	1	$2,500	$2,500.00
9	Channel Excavation	CY	1,050	$12	$12,600.00
10	Select Borrow	CY	0	$40	$0.00
11	Soil Stabilization Matting	SY	1,345	$6	$8,069.17
12	Soil Lifts	LF	1,210	$27	$32,670.00
13	Cobble-Gravel Mix	CY	68	$125	$8,541.67
14	Topsoil	CY	0	$1	$0.00
15	Rock Cross Vane	LF	195	$80	$15,623.20
16	Log Vane	LF	138	$80	$11,040.00
17	Log/Rock J-Hook				
	Log Portion	LF	85	$80	$6,800.00
	Rock Portion	LF	91	$80	$7,280.00
18	Rip Rap Bridge Protection	CY	25	$120	$3,022.22
19	Rock Sills	LF	45	$16	$720.00
20	Temporary Seeding	SY	6,700	$0.40	$2,680.00
21	Riparian Seeding	SY	1,360	$0.55	$748.00
22	Upland Seeding	SY	5,340	$0.70	$3,738.00
				Total Cost Estimate	**$131,552.26**

(*) LS = Lump Sum, SY = Square Yard, LF = Linear Feet, CY = Cubic Yard

(°) Contingent commodities (i.e. commodities that may ***not*** be necessary during construction) should have an estimated quantity of zero.

4.4 SIXTY (60) PERCENT DESIGN

The purpose of the 60 percent design plans is to update design plans to address conceptual design comments provided by the City. The 60 percent design plans will build on the conceptual designs and include the alignment geometry, proposed grading, revised longitudinal profile, detailed cross sections (i.e. cut sheets), structure details, erosion and sediment control plan, and planting plan.

The 60 percent design submission will include the Hydrologic and Hydraulic Study Report with the results of the flood modeling and sediment transport analysis, the construction specifications, the revised cost estimates, and the 60 percent design plans.

4.4.1 Permit Preparation

Prior to the 60 percent design, the Team will complete any necessary resource and/or historical inventory (e.g. wetland delineation, forest stand delineation, and historical structure assessment). During the 60 percent design, the Team will coordinate with regulatory agencies to ensure that all necessary regulatory reviews (e.g. jurisdictional determination) are completed for the resource and/or historical inventories.

To facilitate the permit review process, the Team ***will*** schedule a pre-application meeting with the regulatory agencies to review the 60 percent design plans.

The Team will submit written responses to the regulatory agencies' comments/revisions to the 60 percent design plans. The Team will also submit the written responses and documentations of any plan changes to the City.

4.4.2 Hydrologic and Hydraulic Analysis Report

The Team will include a Hydrologic and Hydraulic Analysis Report with the 60 percent design submission. The hydrologic and hydraulic analysis will evaluate flood stages, stream velocity, shear stress, and stream power, and compare existing and proposed flood conditions. The analysis will also evaluate and compare existing and proposed sediment transport, both competency (i.e. size) and capacity (i.e. load). The *Watershed Assessment of River Stability and Sediment Supply* (Rosgen 2006) provides a good overview of sediment transport. There are many methods for analyzing sediment transport and the Team must state which method they used and why they selected that particular method. In addition, the hydrologic and hydraulic analysis will (at a minimum):

- Review existing FEMA floodplain studies and include a discussion of existing floodplain model and discharges used to develop existing floodplain limits
- Document the development of a revised existing floodplain model and any revised discharges, if the existing FEMA floodplain delineation is inaccurate
- Document the proposed floodplain model
- Prepare water surface profiles for the existing floodplain model, revised existing floodplain model, and proposed floodplain model
    - Profiles and data will be consistent with floodplain management requirements (Requirements to be provided by the City)
    - Profiles will be included in the hydrologic and hydraulic analysis or on the 60 percent design plans (if a hydrologic and hydraulic analysis is not done)
- Discuss any changes in floodplain limits
    - If limits of flooding increase, document height of the increase and areas that are affected by the increased flood elevations
    - If there are changes to the 100-year floodplain boundary, the Team will coordinate with FEMA to document and obtain approval of the changes (FEMA contacts and procedures to be provided by the City)
- Prepare a tractive force analysis that evaluates boundary shear stress for existing and proposed conditions
    - Compare existing and proposed shear stress
    - Compare existing and proposed stream power and stage or discharge
    - Determine the appropriate sediment transport capacity and competence for the stream
    - Document that the proposed design will provide the correct sediment transport capacity and competence

4.4.3 Sixty (60) Percent Design Plans

The 60 percent design plans are a refinement of the 30 percent design plans. The 60 percent design plans will include:

- Revised scale map of the restoration reach showing existing conditions, utilities, property ownership, delineated wetlands, waters of the U.S., existing FEMA 100-year floodplain boundary (may be provided in the hydrologic and hydraulic analysis), and other major topographic features such as roads, buildings, etc.
- Revised scale map of the restoration reach showing proposed conditions including stream alignment, proposed bankfull width, detailed grading, type and location of instream structures, location of existing and proposed FEMA 100-year floodplain boundaries (may be provided in the hydrologic and hydraulic analysis) (Figure 10)
- Revised longitudinal profile of existing and proposed conditions showing channel thalweg, bankfull stage, utility , bridge low cord, and instream structure locations (Figure 11)
- Alignment geometry with stakeout chart (Figure 12)
- Typical design cross sections
- Design cross sections with existing topography and proposed grading (Figure 13)
- Standard structure details
- Sequence of construction

4.4.4 Erosion and Sediment Control

The erosion and sediment control (ESC) plans are not a separate set of plans and will be included in the restoration design plans. Depending on the complexity of the project, it may be beneficial to prepare the ESC plan as part of 60 percent design. The advantage of including ESC plans in 60 percent design is that it may reduce overall time required by the regulatory agencies to review the restoration project and issue the permit. Another advantage is that the Team will be able to address regulatory agency comments/ revisions earlier in the design phase and avoid missing any important components of the ESC plans or having to make significant changes to the ESC plans later in the design phase. The disadvantage is that the ESC plan may require significant revisions if the regulatory agency requires significant changes to the restoration design (e.g. changes to the proposed stream alignment).

If the ESC plans are not included in the 60 percent design plans, the Team will include them in the 90 percent design plans. When making the decision to include ESC in the 60 percent design plans or 90 percent design plans, the Team will consider the potential for changes in overall design plans and previous coordination with permit agencies. The ESC plans will include (at a minimum):

- ESC cover sheet providing standard Maryland Department of the Environment (MDE) language and legend
- ESC plan views for each phase of construction
- ESC standard details taken from MDE guidelines
- Detailed narrative describing sequence of construction

If the Team decides to include the ESC plans in the 60 percent design, it is suggested that the Team completes the ESC plans prior to the pre-application meeting with the regulatory agencies, because the meeting is an excellent opportunity to ask or respond to specific questions and obtain immediate feedback.

4.4.5 Construction Cost Estimate

The Team will update the construction cost estimate and provide written justifications for any significant changes to the cost estimate provided in the 30 percent design submission.

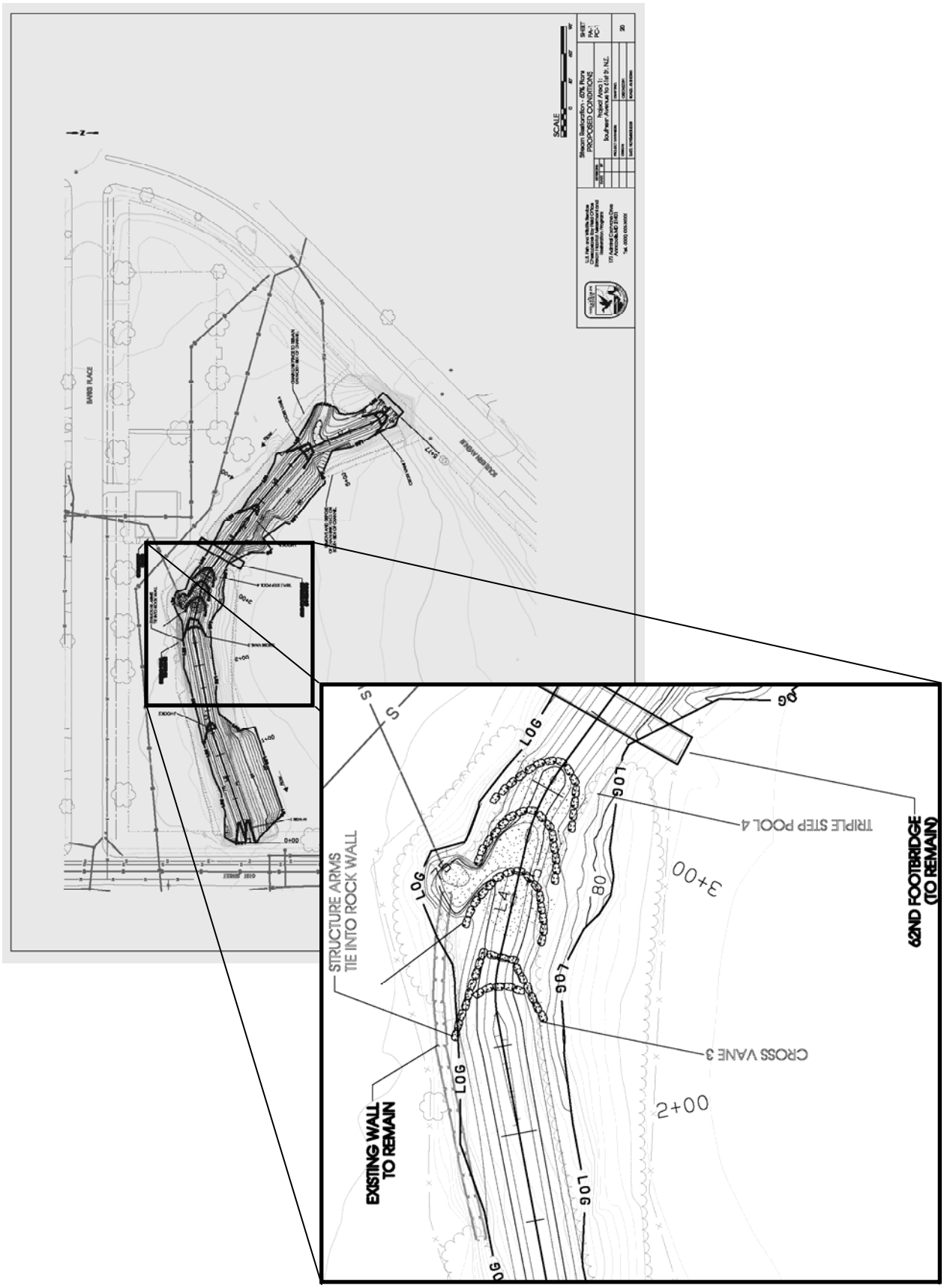


Figure 10. Example of proposed conditions map and an enlargement with the proposed grading and instream structures

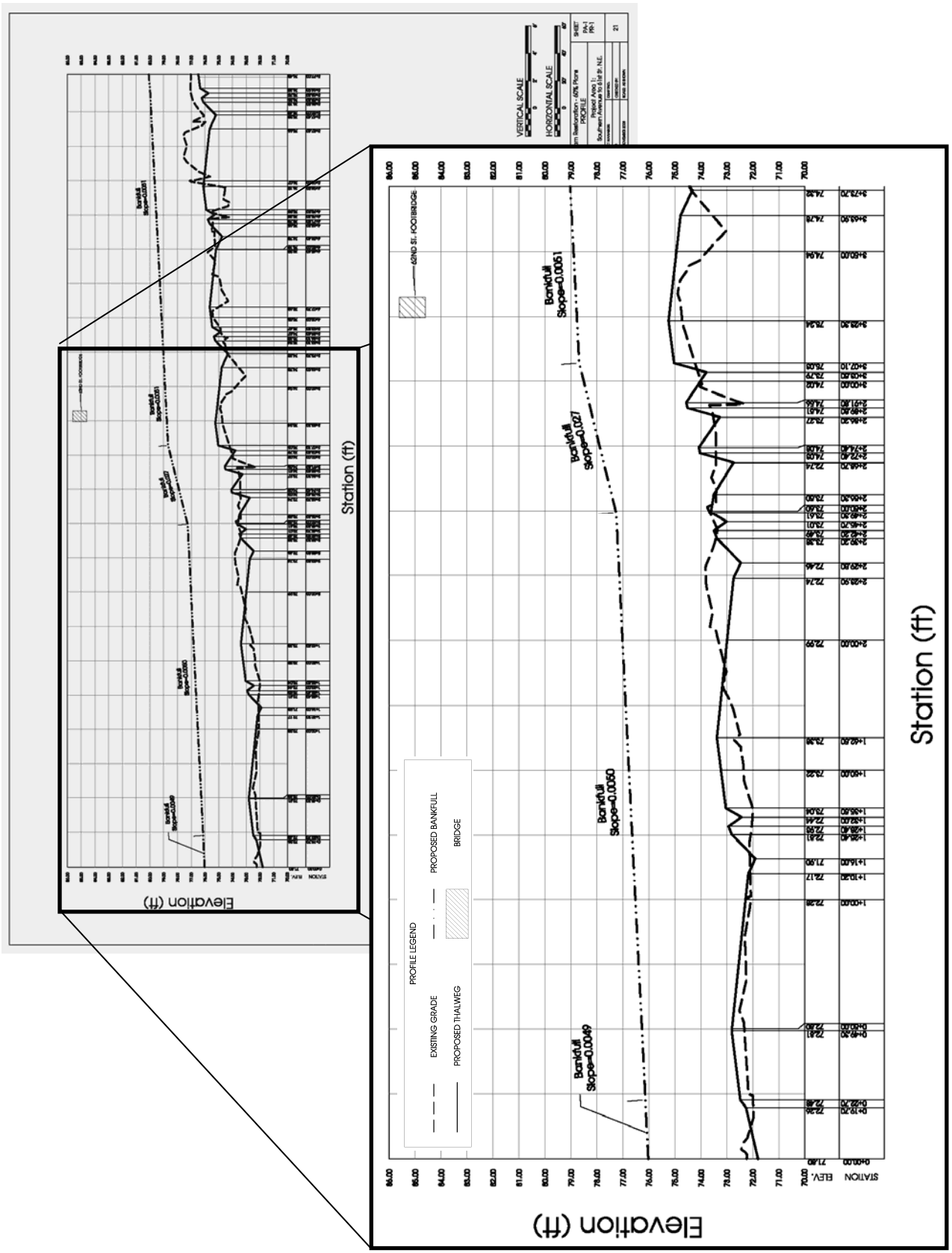


Figure 11. Proposed longitudinal profile with existing topography and bridge low cord (profile should show the location of any utilities)

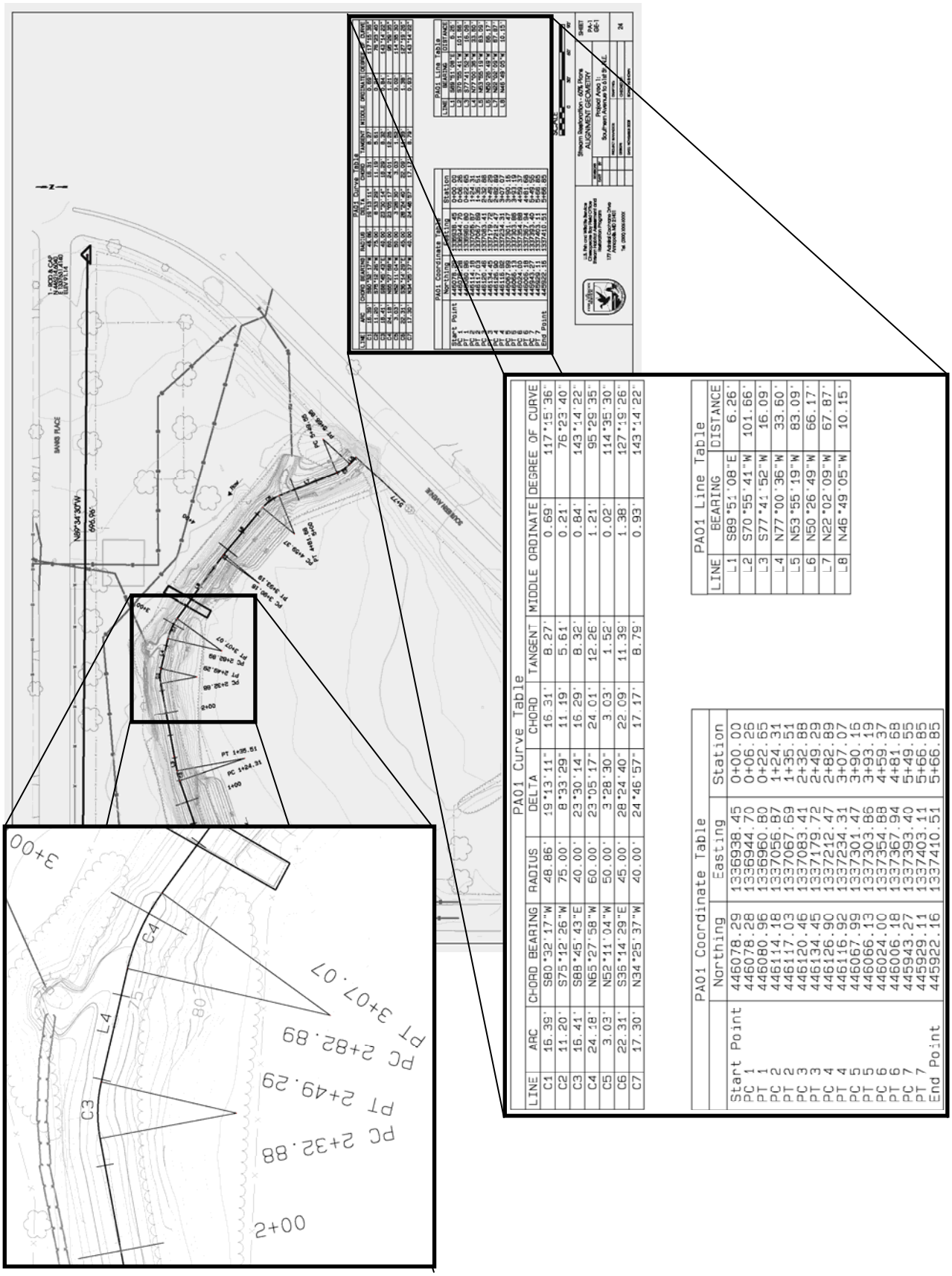


Figure 12. Example of alignment geometry with enlargements of the alignment layout and stakeout chart

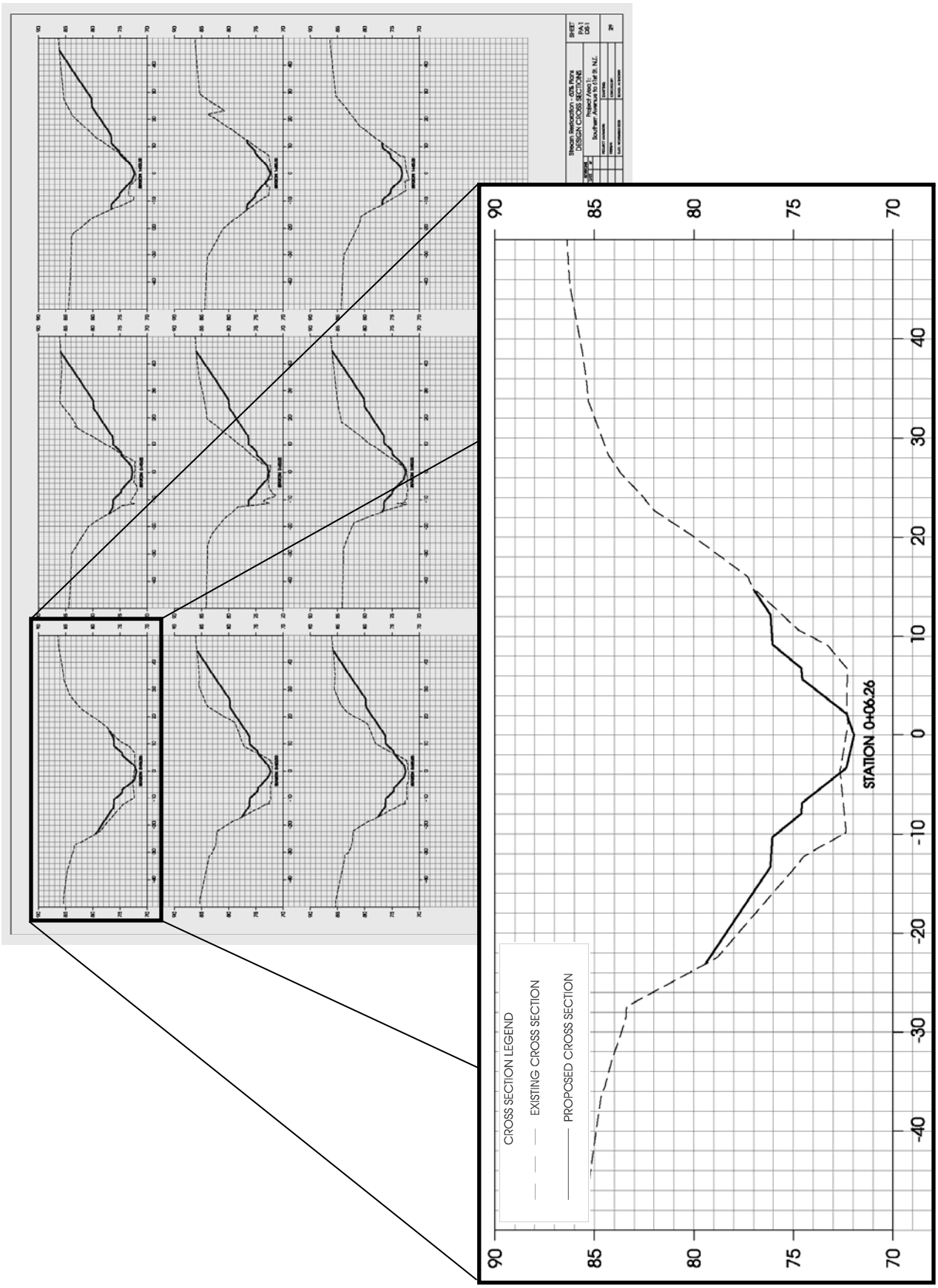


Figure 13. Example of design cross sections with existing topography and proposed grading

4.4.6 Construction Specifications

The Team will submit draft construction specifications with the 60 percent design plans. An example of construction specifications is located in Appendix D. The City will provide the Team with the specification standards and guidelines necessary to prepare the construction specifications.

4.4.7 Sixty (60) Percent Design Submission Package

The Team will submit two hard copies of the draft Hydrologic and Hydraulic Analysis Report, draft specifications, revised cost estimates, and two full-sized (i.e. 24 x 36 inches) hardcopies of the 60 percent design plans to the City for their review. After receiving written comments from the City, the Team will address the City's comments and finalize the report. The Team will provide the City with two hardcopies and Adobe Acrobat files of the final Hydrologic and Hydraulic Analysis Report, draft specifications, and revised cost estimates to the City.

After receiving written comments and/or mark-ups of the 60 percent design plans from the City, the Team will provide a written response to the City discussing how the Team will address the comments on the 60 percent design plans and incorporate the 60 percent design comments/revisions into the 90 percent design plans.

4.5 NINETY (90) PERCENT DESIGN

The purpose of the 90 percent design plans is to update the 60 percent design plans to address agency comments and to submit ESC plans for permitting, if one was not already submitted to the regulatory agency. The 90 percent design submission will include the revised construction specifications, the revised cost estimate, and the 90 percent design plans.

4.5.1 Permit Preparation

To facilitate the permit review process, the Team will consider scheduling another pre-application meeting with the regulatory agencies to review the 90 percent design plans, especially if the ESC plans were not include in the 60 percent design plans.

If another pre-application meeting occurs, the Team will submit written responses to the regulatory agencies' comments/revisions to the 90 percent design plans. The Team will also submit the written responses and documentations of any plan changes to the City.

4.5.2 Ninety (90) Percent Design Plans

The 90 percent design plans are a refinement of the 60 percent design plans. The 90 percent design plans will include:

- Itemized time schedule for construction (e.g. mobilization, ESC installation, etc.)
- Revised scale map of restoration reach showing existing conditions, utilities, property ownership, delineated wetlands, waters of the U.S., existing FEMA 100-year floodplain boundary (may be provided in the hydrologic and hydraulic analysis), and other major topographic features such as roads, buildings, etc.
- Revised scale map of restoration reach showing proposed conditions including stream alignment, proposed bankfull width, detailed grading, type and location of instream structures, and location

of existing and proposed FEMA 100-year floodplain boundaries (may be provided in the hydrologic and hydraulic analysis)
- Revised longitudinal profile of existing and proposed conditions showing channel thalweg, bankfull stage, utility, bridge low cord, and instream structure locations
- Longitudinal profile summary table with relevant cross section channel elevations (e.g. active channel toe, bankfull, top of bank, etc.) (Figure 14)
- Revised alignment geometry with stakeout table
- Revised design cross sections with existing topography and proposed grading
- Revised ESC plans
- Structure (e.g. cross vane, step-pool, etc.) tables with relevant structure elevations (Figure 15)
- Planting plan (Figure 16)
  - Planting zones
  - Upland, riparian, and temporary seed mix
  - Planting standard details
  - Plant species, size and quantity chart

4.5.3 Construction Specifications and Construction Cost Estimate

The Team will update the construction specifications and construction cost estimate, and provide written justifications for any significant changes to the cost estimate provided in the 60 percent design submission.

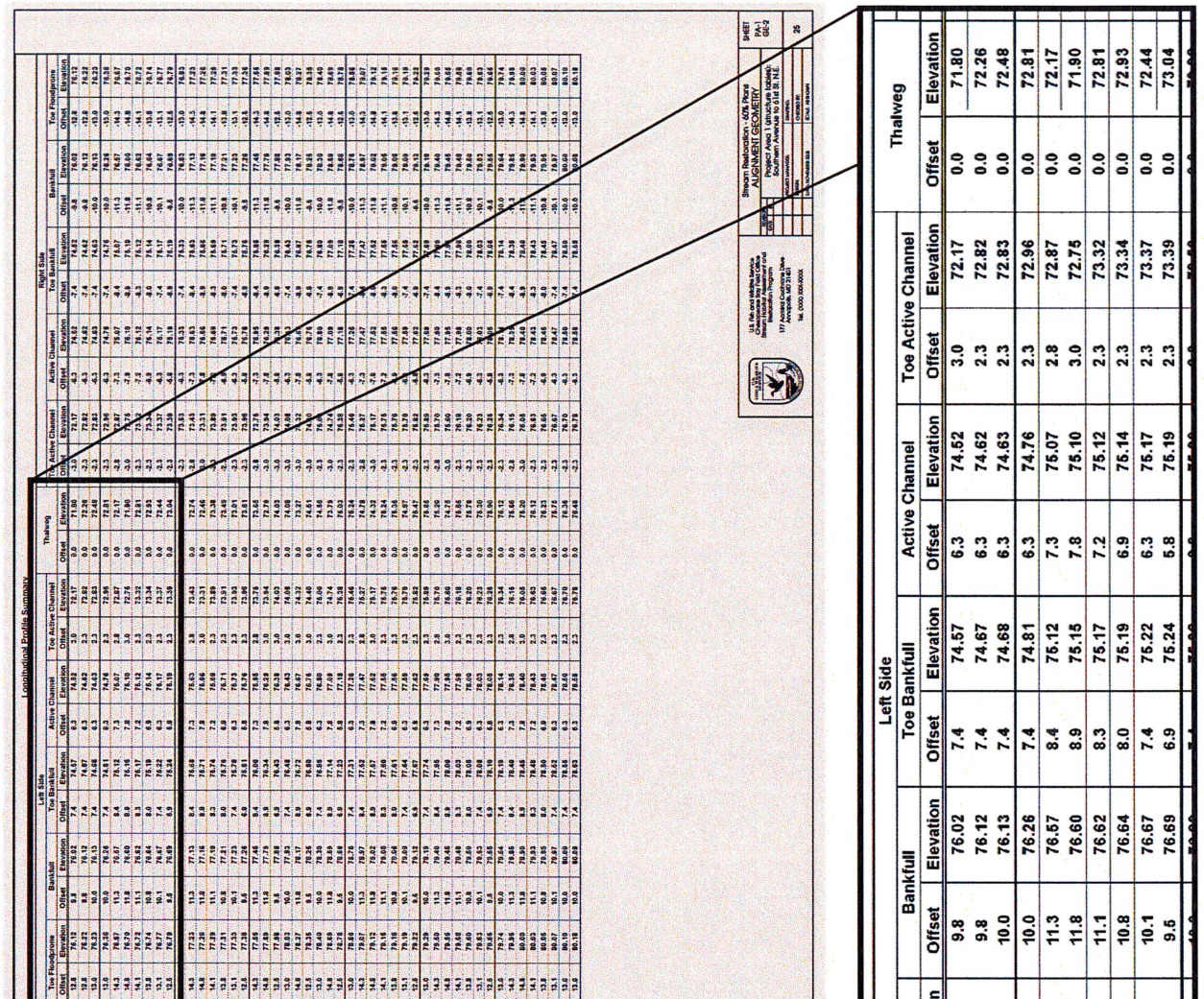
4.5.4 Ninety (90) Percent Design Submission Package

The Team will submit two copies of the revised construction specifications and revised cost estimates, and two full-sized (i.e. 24 x 36 inches) hardcopies of the 90 percent design plans to the City for their review. After receiving written comments from the City, the Team will address the City's comments and finalize the revised specifications and revised cost estimates. The Team will provide the City with two hardcopies and Adobe Acrobat files of the final revised specifications and revised cost estimates to the City.

After receiving written comments and/or mark-ups of the 90 percent design plans from the City, the Team will provide a written response to the City discussing how the Team will address the comments on the 90 percent design plans and incorporate the 90 percent design comments/revisions into the 100 percent design plans.

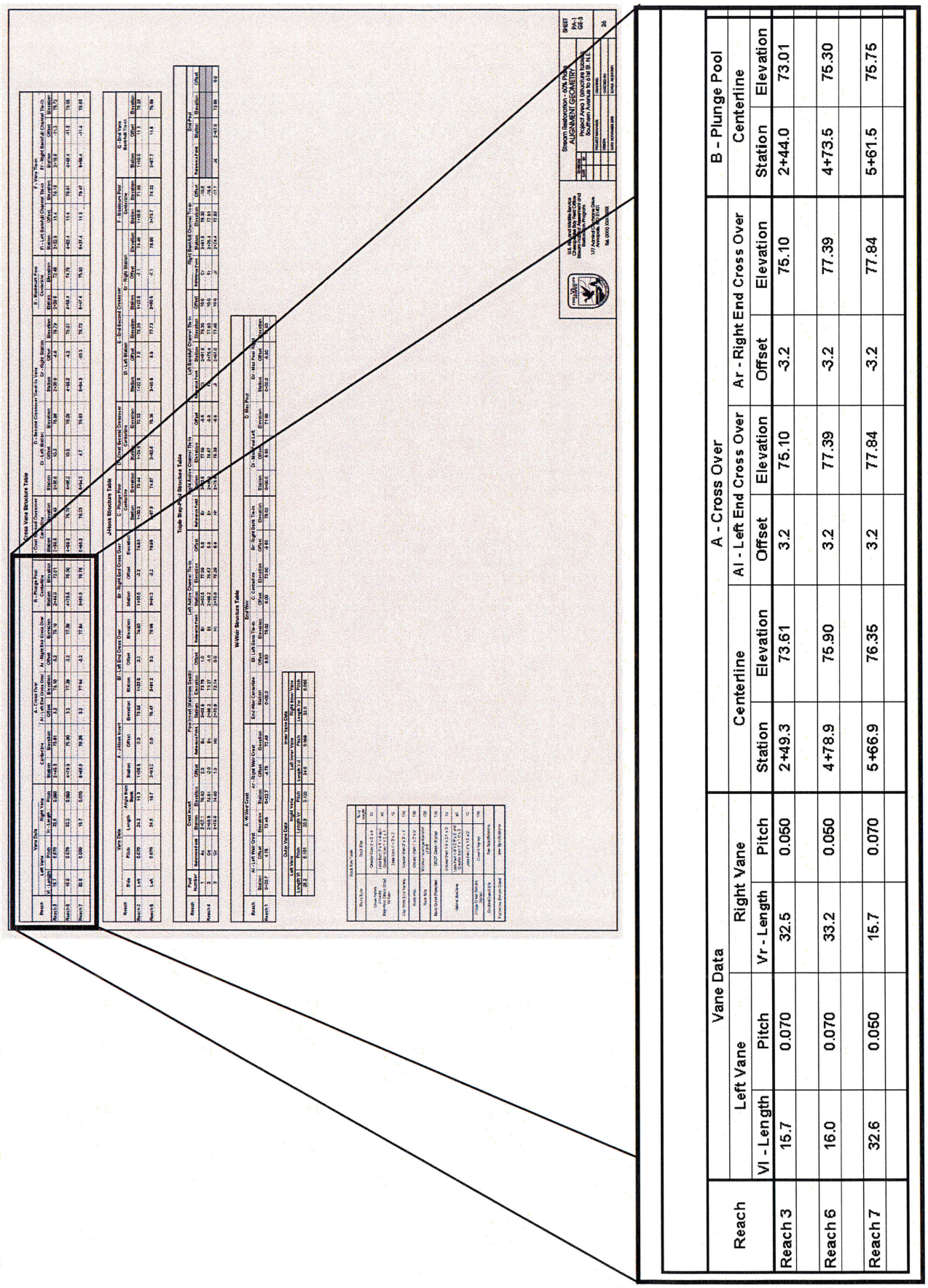
4.6 ONE HUNDRED (100) PERCENT DESIGN

The 100 percent design plans are a refinement of the 90 percent design plans. The Team should be aware that the Team might be required to make additional revisions to the 100 percent design plans and supporting documents by the regulatory and City agencies during their project review. The 100 percent design plans will require the signature and stamp of a professional engineer or licensed landscape architect prior to the joint Federal/State permit application and 100 percent design submission to the City.



Reach Number	Structure Type	Feature	Station	Left Side										Thalweg	
				Toe Floodprone		Bankfull		Toe Bankfull		Active Channel		Toe Active Channel			
				Offset	Elevation	Offset	Elevation	Offset	Elevation	Offset	Elevation	Offset	Elevation	Offset	Elevation
Reach 1	W-Weir	End Reach	0+00.0	12.8	76.12	9.8	76.02	7.4	74.57	6.3	74.52	3.0	72.17	0.0	71.80
		Run	0+19.7	12.8	76.22	9.8	76.12	7.4	74.67	6.3	74.62	2.3	72.82	0.0	72.26
		Top Step	0+22.7	13.0	76.23	10.0	76.13	7.4	74.68	6.3	74.63	2.3	72.83	0.0	72.48
Reach 2	J-Hook Left	End Glide	0+49.3	13.0	76.36	10.0	76.26	7.4	74.81	6.3	74.76	2.3	72.96	0.0	72.81
		End Pool	1+10.2	14.3	76.67	11.3	76.57	8.4	75.12	7.3	75.07	2.8	72.87	0.0	72.17
		Max-Pool	1+16.0	14.8	76.70	11.8	76.60	8.9	75.15	7.8	75.10	3.0	72.75	0.0	71.90
		End Run	1+21.9	14.1	76.72	11.1	76.62	8.3	75.17	7.2	75.12	2.3	73.32	0.0	72.81
		Second Step	1+24.9	13.8	76.74	10.8	76.64	8.0	75.19	6.9	75.14	2.3	73.34	0.0	72.93
		Plunge Pool	1+30.2	13.1	76.77	10.1	76.67	7.4	75.22	6.3	75.17	2.3	73.37	0.0	72.44
		Start Reach	1+35.6	12.5	76.79	9.5	76.69	6.9	75.24	5.8	75.19	2.3	73.39	0.0	73.04
		End Glide													

Figure 14. Example of longitudinal profile summary table with enlargement of relevant cross section channel elevations



Reach	Vane Data				A - Cross Over				B - Plunge Pool	
	Left Vane		Right Vane		Centerline		Al - Left End Cross Over		Ar - Right End Cross Over		Centerline	
	Vl - Length	Pitch	Vr - Length	Pitch	Station	Elevation	Offset	Elevation	Offset	Elevation	Station	Elevation
Reach 3	15.7	0.070	32.5	0.050	2+49.3	73.61	3.2	75.10	-3.2	75.10	2+44.0	73.01
Reach 6	16.0	0.070	33.2	0.050	4+78.9	75.90	3.2	77.39	-3.2	77.39	4+73.5	75.30
Reach 7	32.6	0.050	15.7	0.070	5+66.9	76.35	3.2	77.84	-3.2	77.84	5+61.5	75.75

Figure 15. Example of structure (e.g. cross vane, step-pools, etc.) tables with relevant structure elevations

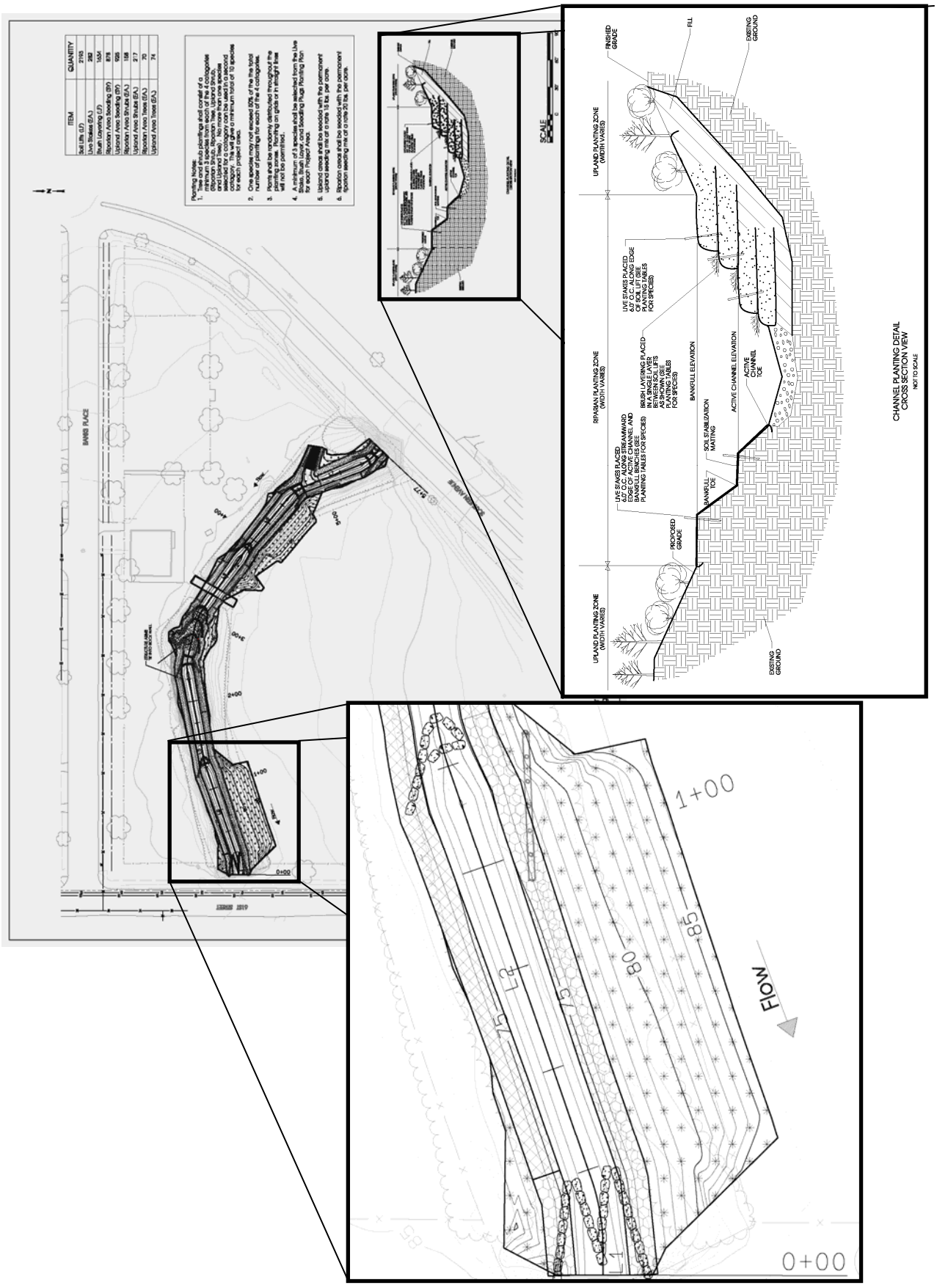


Figure 16. Example of planting plan with enlargements of cross sectional planting detail and planting zones

4.6.1 Permit Application(s)

Prior to submitting the joint Federal/State permit (joint permit) application, the Team will obtain any necessary approvals for the resource inventories conducted during the restoration project from the regulatory agencies (e.g. wetland jurisdictional determination for the wetland delineation). For complex projects, the Team will consider scheduling a permit application meeting with the regulatory agencies to review the joint permit application and 100 percent design plans. If a permit meeting occurs, the Team will submit written responses to the regulatory agencies' comments/revisions to the 100 percent design plans. The Team will also submit the written responses and documentations of any plan changes to the City.

The Team will prepare and submit the joint permit application on behalf of the City. The Team will submit five copies of the cover letter, joint permit application, full-sized (i.e. 24 x 36 inches) hardcopies of the 100 percent design plans, and any other relevant supporting documentation to the Maryland Department of the Environment – Water Management Administration. A copy of the joint permit application and instructions are provided in Appendix C. The City will identify all the relevant permits for the restoration project. The Team will also prepare and submit any other relevant permits on behalf of the City.

If there are regulatory agencies' comments/revisions following the submission of the permit application(s), the Team will submit written responses to the regulatory agencies' comments/revisions to the permit application(s) and 100 percent design plans. The Team will also submit the written responses and documentations of any plan changes to the City.

4.6.2 One Hundred (100) Percent Design Plans

If there are substantial comments on the 90 percent design plans, the Team may want to submit two pre-final proof sets of the 100 percent design plans as a final check before submitting final plans. Any changes that occur because of comments on 90 percent design plans will be discussed with the City prior to submission of 100 percent design plans.

4.6.3 Construction Specifications and Construction Cost Estimate

The Team will update the construction specifications and construction cost estimate, and provide written justifications for any significant changes to the cost estimate provided in the 60 percent design submission.

4.6.4 One Hundred (100) Percent Design Submission Package

The Team will submit two copies and Adobe Acrobat files of final construction specifications and final cost estimates, and two full-sized (i.e. 24 x 36 inches) hardcopies and one set of mylars of the 100 percent design plans that are signed and stamped by a professional engineer or licensed landscape architect to the City. The page size for the 100 percent design plans Adobe Acrobat file(s) will be 24 x 36 inches.

REFERENCES

1. Federal Emergency Management Agency. 1988. *Flood Insurance Study City of Baltimore, Maryland Independent City,* Community Number 240087, September 30, 1988.
2. McCandless, T.L. and R.A. Everett. 2002. *Maryland Stream Survey: Bankfull Discharge and Channel Characteristics in the Piedmont Hydrologic Region*. U.S. Fish and Wildlife Service, Annapolis, MD. CBFO-S02-02.
3. McCandless, T.L. 2003a. *Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Allegheny Plateau and the Valley and Ridge Hydrologic Region*. U.S. Fish and Wildlife Service, Annapolis, MD, CBFO-S03-01.
4. McCandless, T.L. 2003b. *Maryland Stream Survey: Bankfull Discharge and Channel Characteristics of Streams in the Coastal Plain Hydrologic Region*. U.S. Fish and Wildlife Service, Annapolis, MD, CBFO-S03-02.
5. Rosgen, D. R. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.
6. Rosgen, D. R. 2006. *Watershed Assessment of River Stability and Sediment Supply (WARSSS).* Wildland Hydrology, Pagosa Springs, CO.
7. U.S. Department of Agriculture – Natural Resources Conservation Service. 2007. *Part 654 National Engineering Handbook: Stream Restoration Design.* Washington, D.C.

APPENDIX A
NATURAL CHANNEL DESIGN METHODOLOGY CHECKLIST FOR PROJECT SUBMISSIONS

City of Baltimore, Department of Public Works, Bureau of Water and Wastewater			
Natural Channel Design Methodology **Checklist for Project Submissions**	**Reviewer:** **Date:**		
Project:			
Engineer:			
Item	**Completed (Y/N)**	**Acceptable (Y/N)**	**Comments**
I. PRELIMINARY DESIGN MEETING			
A. Discussion of project management			
B. Discussion of project implementation			
C. Discussion of project expectations			
D. Discussion of project concerns and limitations			
E. Discussion of project schedule and milestones			
F. Discussion of design methodology			
G. CADD and work plan design standards and tolerances			
H. Discussion of project budget tracking and reporting			
I. Discussion of quality control/quality assurance standards			
J. Discussion of available and missing project data/information			
K. Discussion of scope of services			
II. SCOPE OF SERVICES			
A. Summarize preliminary design meeting discussion			
B. Description of design methodology			
C. List and description of work products			
D. Work schedule			
E. Time (i.e., hours) and cost estimates by task			
F. Design assumptions			
G. Design standards and tolerances			
H. Quality control and assurance standards			
I. Format and schedule for reporting project progress and expenditures			
III. RESTORATION OBJECTIVES			
A. Hydrologic objectives			
B. Fluvial geomorphological objectives			
C. Biological objectives			
D. Project limitations			
IV. ALTERNATIVES ANALYSIS			
A. Alternatives analysis			
1. Project limitations evaluation			
2. Alternative description and discussion			
i. Functions (i.e., hydraulics and geomorphologic principles)			
ii. Improvements to hydraulics, hydrologics, and/or geomorphic stability of the stream			
iii. Effects on stream stability, infrastructure, stream habitat, water quality, private property, and other relevant factors			
3. Advantages and disadvantages of alternatives			
4. Alternative cost estimates and comparison			
B. Alternatives Analysis Report			
1. Project description and summary			
2. Aerial photograph(s)			
3. Baseline map(s)			
4. Summary of existing assessment reports			
i. Type, extent, and cause of stream impairment			
ii. Bankfull determination and validation			
iii. Bankfull characteristics and discharge			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
iv. Drainage area			
v. Percent impervious cover			
vi. Current and planned landuse(s)			
5. Summary of hydraulic and hydrologic studies			
6. Summary of restoration objectives			
7. Summary of alternative analysis			
i. Alternative evaluation			
ii. Alternative selection			
C. Alternatives analysis submission package			
1. Draft alternatives analysis report (2 copies)			
2. Final alternatives analysis report (2 copies)			
D. Alternative analysis meeting			
V. 30 PERCENT DESIGN - CONCEPTUAL PLANS			
A. Permit preparation			
i. Identify any resource and/or historical inventories (e.g., wetland delineation, forest stand delineation, and historical structure assessment) necessary for the project permits			
ii. Conduct any resource and/or historical inventories necessary for the project permits			
iii. Identify the required permits, appropriate regulatory agencies, and other project stakeholders			
iv. Discuss any other special conditions that may influence permitting of the project			
v. Discuss any preliminary meetings that the Team/City has held with permitting agencies			
vi. Prepare a schedule for the tasks necessary to acquire all the project permits			
B. Conceptual report			
1. Site information			
i. General site map showing stream location and upstream drainage basin and drainage area			
ii. Detailed, scaled site map showing limits of study area and major features (roadways, streams, building footprints, etc.)			
iii. Description of property ownership: provide ownership mapping if project extends onto property not owned by the City			
iv. Description of project area noting the presence of wetlands (e.g., type, quality, and location), riparian buffer and trees (e.g., type, condition, size), and presence of stream/infrastructure, etc.			
v. Map of natural resources that includes forest resources, jurisdictional and non-jurisdictional wetlands, waters of the U.S., and other environmentally sensitive features			
vi. Location and description of any stormwater infrastructure within and/or near the project area. The 30 percent design plans will show the location of any outfalls, stormwater management facilities, inlets, etc.			
vii. Location and description of any overhead and buried utilities within and/or near the project area. The 30 percent design plans will show the locations of any utility within and/or near the project area			
viii. Location and description of benchmark controls for the restoration project			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
2. Summary of stream and watershed assessment			
i. Stream and watershed assessment methods			
ii. Assessment of Rosgen stream type and Rosgen valley type			
iii. Existing bankfull channel dimensions			
iv. Existing planform and profile dimensions			
v. Summary of departure from potential analysis			
vi. Listing of stream problems			
vii. Problem analysis identifying relationship between causes and effects			
3. Summary of sream assessment data			
i. Cross section plots			
ii. Map of cross section locations			
iii. Longitudinal profile of facet stream features for the existing channel bottom, water surface, bankfull elevation, and low top of bank			
iv. Methods used to identify bankfull stage and bankfull stage indicators			
v. Bankfull discharge including discussion on how the Team determined and validated the bankfull discharge			
vi. Average surveyed water surface slope, estimated average bankfull water surface slope, and valley slope			
vii. Summary of bed materials (substrate) and methods used to investigate bed materials			
4. Summary of alternative analysis			
i. List restoration objectives and project limitation			
ii. Summarize the alternatives analysis including a no-action alternative			
iii. Explain how the selected alternative addresses the restoration objectives and why it is superior to other alternatives including a no-action alternative			
iv. Describe which stream functions (physical and/or biological) are being restored			
v. Indicate and discuss the basic principles of stream hydraulics and geomorphology that underlie any proposed alterations to the channel and floodplain			
5. Summary of hydrologic analysis			
i. Existing FEMA 2-, 5-, 10-, 50-, 100-year return period discharges			
ii. If the current FEMA discharges are unrealistic, revised FEMA 2-, 5-, 10-, 50-, 100-year return period discharges and summary of analysis used to develop revised discharges			
iii. Discussion of hydrologic modeling methods used and model calibration			
6. Summary of hydraulic analysis			
i. Summary of any floodplain studies including FEMA mapping and modeling			
ii. FEMA existing water surface profiles and mapping			
iii. Discussion of FEMA mapping accuracy and the potential need for revisions			
iv. Review of floodplain limits and adjacent properties			
v. Identification of structures/infrastructures that are subject to flooding			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
7. Reference data and design criteria			
i. Provide reference reach data for proposed stream alterations with the same type and level of detail as the existing conditions			
ii. Discuss the suitability of the reference reach as a template for the restored reach			
iii. Identify any limitations to reference reach data and discuss how the restoration design addresses these limitations			
iv. Develop and document proposed design criteria of bankfull channel, planform, profile dimensions, and substrate			
8. Stream velocity and sediment transport analysis			
i. Provide a conceptual level stream flow analysis of stream velocity			
ii. Evaluate existing and proposed stream velocities at bankfull			
iii. Provide a justification for the method used to estimate stream velocity			
iv. Provide a concept level analysis of sediment transport issues			
v. Identify the status of existing sediment supply, if the stream is aggrading or degrading, and existing sediment competency			
vi. Verify that the proposed design would result in a stable channel and address any degradation or aggradation issues			
C. Conceptual design plans			
1. General location map showing the restoration location and adjacent roadways that will be used to access the site during construction			
2. Scale map(s) of the restoration reach showing existing conditions, utilities, delineated wetlands, existing 100-year FEMA floodplain boundary (may be provided in the hydrologic and hydraulic analysis), waters of the U.S., and major topographic features such as roads, buildings, etc.			
3. Scale map(s) of the restoration reach showing proposed conditions including the stream alignment, proposed bankfull width, and type and location of instream structures			
4. Longitudinal profile of existing and proposed conditions showing channel thalweg and bankfull stage			
5. Typical design cross sections			
D. Conceptual construction cost estimate			
1. Provide an estimate of material quantities and unit price costs			
2. Prepare a conceptual level construction cost estimate			
E. Conceptual design submission package			
1. Draft conceptual design report (2 copies)			
2. Draft conceptual design plans (2 copies)			
3. Comment response letter(s)			
4. Final conceptual design report (2 copies)			
5. Final conceptual design report Adobe Acrobat file (2 copies)			
VI. 60 PERCENT DESIGN PLANS			
A. Permit preparations			
1. Resource and historical inventory coordination			
2. Joint permit pre-application meeting			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
3. Other relevant permit pre-application(s) meeting(s)			
4. Comment response letter(s)			
B. Hydrologic and hydraulic analysis report			
1. Review existing FEMA floodplain studies and include a discussion of existing floodplain model and discharges used to develop existing floodplain limits			
2. Document development of a revised existing floodplain model and any revised discharges, if the existing FEMA floodplain delineation is inaccurate			
3. Document the proposed floodplain model			
4. Prepare water surface profiles for the existing floodplain model, revised existing floodplain model, and proposed floodplain model			
5. Prepare profiles and data so that they are consistent with floodplain management requirements			
6. Include the profiles in the hydrologic and hydraulic analysis or on the 60 percent design plans (if a hydrologic and hydraulic analysis is not done)			
7. Discuss any changes in floodplain limits			
8. If limits of flooding increase, document height of the increase and areas that are affected by the increased flood elevations			
9. If there are changes to the 100-year floodplain boundary, coordinate with FEMA to document and obtain approval of the changes			
10. Prepare a tractive force analysis that evaluates boundary shear stress for existing and proposed conditions			
11. Prepare a stream flow analysis that evaluates existing and proposed velocity conditions			
12. Prepare a tractive force analysis that evaluates boundary shear stress for existing and proposed conditions			
13. Compare existing and proposed shear stress			
14. Compare existing and proposed stream power and stage or discharge			
15. Determine the appropriate sediment transport capacity and competence for the stream			
16. Document that the proposed design will provide the correct sediment transport capacity and competence			
C. 60 percent design plans			
1. Revised scale map of the restoration reach showing existing conditions, utilities, property ownership, delineated wetlands, waters of the U.S., existing FEMA 100-year floodplain boundary (may be provided in the hydrologic and hydraulic analysis), and other major topographic features such as roads, buildings, etc.			
2. Revised scale map of the restoration reach showing proposed conditions including stream alignment, proposed bankfull width, detailed grading, type and location of instream structures, location of existing and proposed FEMA 100-year floodplain boundaries (may be provided in the hydrologic and hydraulic analysis)			
3. Revised longitudinal profile of existing and proposed conditions showing channel thalweg, bankfull stage, utility, bridge low cord, and instream structure locations			
4. Alignment geometry with stakeout chart			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
5. Typical design cross sections			
6. Design cross sections with existing topography and proposed grading			
7. Standard structure details			
8. Sequence of construction			
D. Erosion and sediment control			
1. ESC cover sheet providing standard MDE language and legend			
2. ESC plan views for each phase of construction			
3. ESC standard details taken from MDE guidelines			
4. Detailed narrative describing sequence of construction			
E. Construction cost estimate			
F. Construction specifications			
G. 60 percent design submission package			
1. Draft hydrologic and hydraulic analysis report (2 copies)			
2. Draft 60 percent design plans (2 copies)			
3. Comment response letter(s)			
4. Final hydrologic and hydraulic analysis report (2 copies)			
5. Final hydrologic and hydraulic analysis report Adobe Acrobat file (2 copies)			
VII. 90 PERCENT DESIGN PLANS			
A. Permit preparations			
1. Joint permit pre-application meeting			
2. Other relevant permit pre-application(s) meeting(s)			
3. Comment response letter(s)			
B. 90 percent design plans			
1. Itemized time schedule for construction (e.g., mobilization, ESC installation, etc.)			
2. Revised scale map of restoration reach showing existing conditions, utilities, property ownership, delineated wetlands, waters of the U.S., existing FEMA 100-year floodplain boundary (may be provided in the hydrologic and hydraulic analysis), and other major topographic features such as roads, buildings, etc.			
3. Revised scale map of restoration reach showing proposed conditions including stream alignment, proposed bankfull width, detailed grading, type and location of instream structures, and location of existing and proposed FEMA 100-year floodplain boundaries (may be provided in the hydrologic and hydraulic analysis)			
4. Revised longitudinal profile of existing and proposed conditions showing channel thalweg, bankfull stage, utility, bridge low cord, and instream structure locations			
5. Longitudinal profile summary table with relevant cross section channel elevations (e.g., active channel toe, bankfull, top of bank, etc.)			
6. Revised alignment geometry with stakeout table			
7. Revised design cross sections with existing topography and proposed grading			
8. Revised ESC plans			
9. Structure (e.g., cross vane, step-pool, etc.) tables with relevant structure elevations			
10. Planting plan			
11. Planting zones			

Item	Completed (Y/N)	Acceptable (Y/N)	Comments
12. Planting standard details			
13. Plant species, size and quantity chart			
14. Upland, riparian, and temporary seed mix			
C. Construction cost estimate			
D. Construction specifications			
E. 90 percent design submission package			
1. Draft 90 percent design plans (2 copies)			
2. Draft construction specifications (2 copies)			
3. Draft revised cost estimates (2 copies)			
4. Comment response letter(s)			
VIII. 100 PERCENT DESIGN PLANS			
A. Permit applications			
1. Resource inventory approval(s)			
2. Joint permit application (5 copies of application, plans, and other supporting documents)			
3. Other relevant permit application(s)			
4. Permit submissions(s)			
5. Comment response letter(s)			
6. Permit application meeting			
B. 100 percent design plans			
C. Construction cost estimate			
D. Construction specifications			
E. 100 percent design submission package			
1. Pre-final 100 percent design plans (2 copies)			
2. Draft construction specifications (2 copies)			
3. Draft revised cost estimates (2 copies)			
4. Comment response letter(s)			
5. Final 100 percent design plans (2 copies)			
6. Final construction specifications (2 copies)			
7. Final cost estimate (2 copies)			
8. Final 100 percent design plans mylars (2 copies)			
9. Final 100 percent design plans Adobe Acrobat file (2 copies)			

APPENDIX B
STANDARD FORMS AND SPREADSHEETS

TABLE OF CONTENTS

EXAMPLE OF COST ESTIMATE TABLE

DESIGN COST ESTIMATE TABLE

Project Name:	
Project Location:	
Project Description:	
Project Length (ft):	

Task	Days	Cost	Comments
I. DESIGN-PLANNING PHASE			
A. Preliminary Design Meeting			
B. Scope of Service Preparation			
II. DESIGN PHASE			
A. Preliminary Design			
1. Restoration Objective(s)			
2. Restoration Alternative Anaylsis			
3. Restoration Objective and Alternative Analysis Report			
4. Alternative Analysis Submission Package			
5. Alternative Analysis Meeting			
B. 30 Percent (Conceptual) Design			
1. Permit Preparation			
2. Conceptual Design Report			
i. Summary of Existing Information			
ii. Hydrologic and Hydraulic Analysis			
iii. Reference Data and Design Criteria			
• Reference Reach Search			
• Reference Reach Survey			
• Reference Reach Analysis			
• Design Criteria Preparation			
iv. Stream Velocity and Sediment Transport Analysis			
3. Conceptual Design Plans			
• Topographic Survey			
4. Conceptual Construction Cost Estimate			
5. Conceptual Design Submission Package			
C. 60 Percent Design Plans			
1. Permit Preparation			
2. Hydrologic and Hydraulic Report			
3. 60 Percent Design Plans			
4. Erosion and Sediment Control			
5. Construction Cost Estimate			
6. Construction Specifications			
7. 60 Percent Design Submission Package			
D. 90 Percent Design Plans			
1. Permit Preparation			
2. 90 Percent Design Plans			
3. Construction Cost Estimate			
4. Construction Specifications			
5. 90 Percent Design Submission Package			
E. 100 Percent Design Plans			
1. Permit Application(s)			
2. 100 Percent Design Plans			
3. Construction Cost Estimate			
4. Construction Specifications			
5. 100 Percent Design Submission Package			
Total	$0.00	$0.00	

EXAMPLE OF REFERENCE REACH DATA TABLE

Reference Reach Data							
No.	**Variable**	**Symbol**	**Units**		**Existing Conditions**	**Reference Conditions**	**Design Criteria**
1	Stream type						
2	Drainage area		mi^2				
3	Riffle bankfull width	W_{bkf}	feet	Mean			
				Min			
				Max			
4	Riffle bankfull mean depth	d_{bkf}	feet	Mean			
				Min			
				Max			
5	Width depth ratio	W/d		Mean			
				Min			
				Max			
6	Riffle bankfull cross sectional area	A_{bkf}	ft_2	Mean			
				Min			
				Max			
7	Pool bankfull cross sectional area	A_{pool}	ft_2	Mean			
				Min			
				Max			
8	Maximum riffle bankfull depth	d_{max}	feet	Mean			
				Min			
				Max			
9	Max. riffle depth to Mean riffle depth	d_{riff}/d_{bkf}		Mean			
				Min			
				Max			
10	Low bank height to Max. riffle depth	LBH/d_{riff}		Mean			
				Min			
				Max			
11	Width of flood prone area	W_{fpa}	feet	Mean			
				Min			
				Max			
12	Entrenchment ratio	W_{fpa}/W_{bkf}		Mean			
				Min			
				Max			
13	Meander length	L_m	feet	Mean			
				Min			
				Max			
14	Ratio of meander length to Bankfull width	L_m/W_{bkf}		Mean			
				Min			
				Max			
15	Radius of curvature	R_c	feet	Mean			
				Min			
				Max			

Reference Reach Data							
No.	**Variable**	**Symbol**	**Units**		**Existing Conditions**	**Reference Conditions**	**Design Criteria**
16	Radius of curvature to Bankfull width	R_c/W_{bkf}		Mean			
				Min			
				Max			
17	Belt width	W_{blt}	feet	Mean			
				Min			
				Max			
18	Meander width ratio	W_{blt}/W_{bkf}		Mean			
				Min			
				Max			
19	Sinuosity	K					
20	Valley slope	S_{val}	ft/ft				
21	Average water surface slope	S_{avg}	ft/ft				
22	Pool water surface slope	S_{pool}	ft/ft	Mean			
				Min			
				Max			
23	Pool WS slope to Average WS slope	S_{pool}/S_{avg}		Mean			
				Min			
				Max			
24	Riffle water surface slope	Sriff	ft/ft	Mean			
				Min			
				Max			
25	Riffle WS slope to Average WS slope	S_{rifF}/S_{avg}		Mean			
				Min			
				Max			
26	Run water surface slope	S_{run}/S_{avg}	ft/ft	Mean			
				Min			
				Max			
27	Run WS slope to Average WS slope	S_{run}/S_{avg}		Mean			
				Min			
				Max			
28	Glide water surface slope	S_{glide}	ft/ft	Mean			
				Min			
				Max			
29	Glide WS slope / Average WS slope	S_{glide}/S_{avg}		Mean			
				Min			
				Max			
30	Maximum pool bankfull depth	d_{pool}	feet	Mean			
				Min			
				Max			
31	Max. pool depth to Average bankfull depth	d_{pool}/d_{bkf}		Mean			
				Min			
				Max			

Reference Reach Data							
No.	**Variable**	**Symbol**	**Units**		**Existing Conditions**	**Reference Conditions**	**Design Criteria**
32	Maximum run bankfull depth	d_{run}	feet	Mean			
				Min			
				Max			
33	Max. run depth to Average bankfull depth	d_{run}/d_{bkf}		Mean			
				Min			
				Max			
34	Maximum glide bankfull depth	d_{glide}	feet	Mean			
				Min			
				Max			
35	Max. glide depth to Average bankfull depth	d_{glide}/d_{bkf}		Mean			
				Min			
				Max			
36	Pool length	L_{pool}	feet	Mean			
				Min			
				Max			
37	Ratio of pool length to Bankfull width	L_{pool}/W_{bkf}		Mean			
				Min			
				Max			
38	Pool width	W_{pool}	feet	Mean			
				Min			
				Max			
39	Pool width to Bankfull width	W_{pool}/W_{bkf}		Mean			
				Min			
				Max			
40	Pool area to Bankfull area	A_{pool}/A_{bkf}		Mean			
				Min			
				Max			
41	Point bar slope	S_{pb}	ft/ft	Mean			
				Min			
				Max			
42	Pool to pool spacing	p-p	feet	Mean			
				Min			
				Max			
43	Pool to pool spacing to Bankfull width	$p\text{-}p/W_{bkf}$		Mean			
				Min			
				Max			
Materials							
44	Particle size distribution (Channel)	D_{16}	mm				
		D_{35}	mm				
		D_{50}	mm				
		D_{84}	mm				
		D_{95}	mm				

Reference Reach Data						
No.	**Variable**	**Symbol**	**Units**	**Existing Conditions**	**Reference Conditions**	**Design Criteria**
45	Particle size distribution (Riffle)	D_{16}	mm			
		D_{35}	mm			
		D_{50}	mm			
		D_{84}	mm			
		D_{95}	mm			
46	Particle size distribution (Bar)	D_{16}	mm			
		D_{35}	mm			
		D_{50}	mm			
		D_{84}	mm			
		D_{95}	mm			
47	Largest particle size		mm			

EXAMPLE OF VELOCITY CALCULATION FORM

VELOCITY CALCULATION FORM

Stream:	
Reach:	
Location:	
Date:	
Observer(s):	
Comments:	

Existing Conditions					
	A_{BKF}	**Bankfull Cross-Sectional Area (ft^2)**		D_{84}	**Riffle D_{84} (ft)**
	W_{BKF}	**Bankfull Width (ft)**		S	**Water Surface Slope**
	D_{BKF}	**Bankfull Mean Depth (ft)**		R/D_{84}	**R/D_{84} (ft/ft)**
	WP	**Wetted Perimeter (ft)**	32.20	g	**Gravitational Acceleration (ft/s^2)**
	R	**Hydraulic Radius (ft)**		DA	**Drainage Area (mi^2)**
	D_{84}	**Riffle D_{84} (mm)**			

R/D84, u/u*, Mannings "n" Relative Roughness vs. Resistance Relationship Graphs	
u/u* (using R/D_{84}: see *Watershed Assessment of River Stability and Sediment Supply* (Rosgen 2006), pg. 5-22)	ft/s/
Manning's "n" (see *Watershed Assessment of River Stability and Sediment Supply* (Rosgen 2006), pg. 5-24)	
Velocity (using Manning's equation: $u=1.49R^{(2/3)}S^{(1/2)}/n$)	ft/s
Discharge (using $Q=A_{BKF}u$)	cfs

Resistance as a function of Relative Roughness (Leopold 1994) $u/u^* = 2.83+5.7\log(R/D84)$	
u*: (using $u^*=(gRS)^{0.5}$)	ft/s
Velocity (using $u=u^*(2.83+5.7\log(R/D_{84}))$	ft/s
Discharge (using $Q=A_{BKF}u$)	cfs

Manning's "n" by Stream Type	
Stream Type	
Manning's "n" (see *Applied river Morphology* (Rosgen 1996), pg. 8-3)	
Velocity (using Manning's equation: $u=1.49R^{(2/3)}S^{(1/2)}/n$)	ft/s
Discharge (using $Q=A_{BKF}u$)	cfs

Limerinos Equation (1970)	
Manning's "n" (using $"n"=(R^{(1/6)}0.0926)/(1.16+2\log(R/D84))$	
Velocity (using Manning's equation: $u=1.49R^{(2/3)}S^{(1/2)}/n$)	ft/s
Discharge (using $Q=A_{BKF}u$)	cfs

Jarretts Equation for Estimating Manning's n	
$n = 0.39\ S^{0.38}\ R^{-0.16}$	
Velocity (using Manning's equation: $u=1.49R^{(2/3)}S^{(1/2)}/n$)	ft/s
Discharge (using $Q=A_{BKF}u$)	cfs

Continuity Equation	
Q_{BKF} (from Maryland - Allegheny Plateau/Valley and Ridge Regional Curve (McCandless 2003a))	cfs
Q_{BKF} (from Maryland - Piedmont Regional Curve (McCandless and Everett 2002))	cfs
Q_{BKF} (from Maryland - Western Coastal Plain Regional Curve (McCandless 2003b))	cfs
Q_{BKF} (from Maryland - Eastern Coastal Plain Regional Curve (McCandless 2003b))	cfs

EXAMPLE OF ENTRAINMENT CALCULATION FORM

ENTRAINMENT CALCULATION FORM

Stream:	
Reach:	
Location:	
Date:	
Observer(s):	
Comments:	

Existing Conditions				
	D_{50} **Riffle Bed Material (mm)**		S_e	**Existing Bankfull Water Surface Slope**
	$D^{\wedge}_{50}$ **Bar Material (mm)**		d_e	**Existing Bankfull Mean Depth (ft)**
	Di **Largest Particle from Bar Sample (ft)**		R	**Hydraulic Radius (ft)**
	Di **Largest Particle from Bar Sample (mm)**	**1.65**	γ_s	**Submerged Specific Weight of Sediment (may change with substrate (i.e. basalt))**

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress			
$\tau^*_{ci} = 0.0834\ (D_{50} / D^{\wedge}_{50})^{-0.872}$		$\tau^*_{ci} = 0.0384\ (D_i / D_{50})^{-0.887}$	
	$D_{50} / D^{\wedge}_{50}$ **(Range 3.0 - 7.0)**		D_i / D_{50} **(Range 1.3 - 3.0)**
	τ^*_{ci} **Critical Dimensionless Shear Stress**		τ^*_{ci} **Critical Dimensionless Shear Stress**

Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample			
Required Bankfull Mean Depth (ft)		**Required Bankfull Mean Depth (ft)**	
	$d_r = (\tau^*_{ci}\ \gamma_s\ D_i) / S_e$		$d_r = (\tau^*_{ci}\ \gamma_s\ D_i) / S_e$
	Stability Condition (d_e / d_r)		**Stability Condition** (d_e / d_r)

Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample			
Required Water Surface Slope (ft)		**Required Water Surface Slope (ft)**	
	$S_r = (\tau^*_{ci}\ \gamma_s\ D_i) / d_e$		$S_r = (\tau^*_{ci}\ \gamma_s\ D_i) / d_e$
	Stability Condition (S_e / S_r)		**Stability Condition** (S_e / S_r)

Validate Sediment Transport		
	$\tau_c = \gamma\ R\ S_e$ **Bankfull Shear Stress (lb/ft^2)**	
	Best-Fit	**Movable particle size (mm) at bankfull shear stress (predicted by the Shields Diagram: The River Field Book, pg. 238 or the Reference Reach Field Book, pg. 190.**
	High Outlier	
	Best-Fit	**Shear stress required to initiate movement of Di (mm) (predicted by the Shields Diagram: The River Field Book, pg. 238 or the Reference Reach Field Book, pg. 190.**
	High Outlier	

1) **If the predicted shear stress can entrain the largest particle in the bar sample (Di) the stream is degrading. If the predicted shear stress can not entrain the Di, check the required depth and slope to validate aggradation. An aggrading stream may not be able to entrain the Di at bankfull.**

2) **To evaluate aggradation for high W/D streams (W/D>100) calculate entrainment for the study reach at a stable or higher transport reach)**

EXAMPLE OF COST ESTIMATE TABLE

CONSTRUCTION COST ESTIMATE TABLE

Project Name:	
Project Location:	
Project Description:	
Project Length (ft):	

Bid Item Number	Commodity	Unit of Measure*	Estimated Quantity°	Unit Price	Total Price
				Total	**$0.00**

(*) LS = Lump Sum, SY = Square Yard, LF = Linear Feet, CY = Cubic Yard

(°) Contingent commodities (i.e. commodities that may ***not*** be necessary during construction) should have an estimated quantity of zero

APPENDIX C
PROJECT PERMITTING

TABLE OF CONTENTS

MARYLAND HISTORICAL TRUST
SAMPLE INFORMATION REQUEST LETTER

[Date]

Ms. Elizabeth J. Cole [*confirm Contact Name*]
Administrator
Maryland Historical Trust
100 Community Place
Crownsville, Maryland 21032

RE: Information Request: [*Project Name*], Baltimore City, Maryland

Dear Ms. Cole:

I am writing on behalf of Baltimore City to request information from your office pertaining to the presence of, or potential for, historical and archaeological features and resources located on the above-referenced stream restoration project located in Baltimore City, Maryland. The stream restoration design will consist of [*description of design concept (e.g. restoring a meandering stream channel)*] located on [*description of property (e.g. Baltimore City property)*].

The project site is approximately [*project acreage*] acres and is located [*specific description of project location (e.g. east of Interstate 301 between Main Street and Oak Drive)*]. Historically, the landuse of the project site was [*description of historical landuse(s)*]. The current landuse of the project site is [*description of current landuse(s)*]. The current landcover and natural resources at the project site consists of [*description of current landcover and natural resource inventory*].

The following items have been enclosed to assist you with this request:

- Vicinity map for the property
- USGS quadrangle graphic that shows the project boundaries
- Aerial photo of the project site

If you require any additional information in order to process this request, please do not hesitate to contact [*Contact Name*] at [*contact phone number*] or [*contact email address*]. Thank you for your assistance with this matter.

Sincerely,
[*Company Name*]

[*Contact Name*]
[*Contact Title*]

enclosures: as noted above

RARE, THREATENDED, AND ENDANGERED RESOURCES
SAMPLE INFORMATION REQUEST LETTER

[*Date*]

Mr. Devin Ray [*confirm Contact Name*]
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
177 Admiral Cochrane Drive
Annapolis, Maryland 21401

RE: Information Request: [*Project Name*], Baltimore City, Maryland

Dear Mr. Ray:

I am writing on behalf of Baltimore City (City) to request information from your office pertaining to the presence of, or potential for, federally listed threatened or endangered plant and animal species located on or near the above-referenced stream restoration project located in Baltimore City, Maryland. The stream restoration design will consist of [*description of design concept (e.g. restoring a meandering stream channel)*] located on [*description of property (e.g. Baltimore City property)*].

The project site is approximately [*project acreage*] acres and is located [*specific description of project location (e.g. east of Interstate 301 between Main Street and Oak Drive)*]. The current landuse of the project site is [*description of current landuse(s)*]. The current landcover and natural resources at the project site consists of [*description of current landcover and natural resource inventory*]. The restoration project may potentially result in [*description of environmental impacts (e.g. 2,500 square feet of temporary impacts to the stream*)]. The City will restore the impact areas to their original site condition.

The following items have been enclosed to assist you with this request:

- Vicinity map for the property
- USGS quadrangle graphic that shows the project boundaries
- Aerial photo of the project site

If you require any additional information in order to process this request, please do not hesitate to contact [*Contact Name*] at [*contact phone number*] or [*contact email address*]. Thank you for your assistance with this matter.

Sincerely,
[*Company Name*]

[*Contact Name*]
[*Contact Title*]

enclosures: as noted above

JOINT FEDERAL/STATE APPLICATION FOR THE ALTERATION OF ANY FLOODPLAIN, WATERWAY, TIDAL OR NONTIDAL WETLAND IN MARYLAND

FOR AGENCY USE ONLY

Application Number _____ **Date Determined Complete** _____
Date Received by State _____ **Date(s) Returned** _____
Date Received by Corps _____ _____
Type of State permit needed _____ **Date of Field Review** _____
Type of Corps permit needed _____ **Agency Performed Field Review** _____

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- Please submit 1 original and 4 copies of this form, required maps and plans to the Wetlands and Waterways Program as noted on the last page of this form.
- Any application which is not completed in full or is accompanied by poor quality drawings may be considered incomplete and result in a time delay to the applicant.

Please check one of the following:

RESUBMITTAL: ____ **APPLICATION AMENDMENT:** ____ **MODIFICATION TO AN EXISTING PERMIT:** ____
JURISDICTIONAL DETERMINATION ONLY ____ **APPLYING FOR AUTHORIZATION** ____
PREVIOUSLY ASSIGNED NUMBER (RESUBMITTALS AND AMENDMENTS) _____
DATE _____

1. APPLICANT INFORMATION:

APPLICANT NAME:

A. Name: _____ B. Daytime Telephone: _____
C. Company: _____
D. Address: _____
E. City: _____ State: _____ Zip: _____

AGENT/ENGINEER INFORMATION:

A. Name: _____ B. Telephone: _____
C. Company: _____
D. Address: _____
E. City: _____ State: _____ Zip: _____

ENVIRONMENTAL CONSULTANT:

A. Name: _____ B. Telephone: _____
C. Company: _____
D. Address: _____
E. City: _____ State: _____ Zip: _____

CONTRACTOR (If known): _____

A. Name: _____ B. Telephone: _____
C. Company: _____
D. Address: _____
E. City: _____ State: _____ Zip: _____

PRINCIPAL CONTACT:

A. Name: _____ B. Telephone: _____
C. Company: _____
D. Address: _____
E. City: _____ State: _____ Zip: _____

2. PROJECT DESCRIPTION

a. GIVE WRITTEN DESCRIPTION OF PROJECT:

Has any portion of the project been completed? _____ Yes _____ No If yes, explain _____

Is this a residential subdivision or commercial development? _____ Yes _____ No
If yes, total number of acres on property _____ acres

b. ACTIVITY: Check all activities that are proposed in the wetland, waterway, floodplain, and nontidal wetland buffer as appropriate.

A. _____ filling
B. _____ dredging
C. _____ excavating
D. _____ flooding or impounding water
E. _____ draining
F. _____ grading
G. _____ removing or destroying vegetation
H. _____ building structures

Area for item(s) checked: Wetland _____ (sq. ft.) Buffer (Nontidal Wetland Only) _____ (sq. ft.)
Expanded Buffer (Nontidal Wetland Only) _____ (sq. ft.)
Area of stream impact _____ (sq. ft.)
Length of stream affected _____ (linear feet)

c. TYPE OF PROJECTS: Project Dimensions

For each activity, give overall length and width (in feet), in columns 1 and 2. For multiple activities, give total area of disturbance in square feet in column 3. For activities in tidal waters, give maximum distance channelward (in feet) in column 4. For dam or small ponds, give average depth (in feet) for the completed project in column 5. Give the volume of fill or dredged material in column 6.

		Lengt (Ft.) 1	Width (Ft.) 2	Area Sq. Ft. 3	Maximum/Average Channelward Encroachment 4		Pond Depth 5	Volume of fill/dredge material (cubic yards) below MHW or OHW 6
A. _____	Bulkhead							
B. _____	Revetment							
C. _____	Vegetative Stabilization							
D. _____	Gabions							
E. _____	Groins							
F. _____	Jetties							
G. _____	Boat Ramp							
H. _____	Pier							
I. _____	Breakwater							
J. _____	Repair & Maintenance							
K. _____	Road Crossing							
L. _____	Utility Line							
M. _____	Outfall Construction							
N. _____	Small Pond							
O. _____	Dam							
P. _____	Lot Fill							
Q. _____	Building Structures							
R. _____	Culvert							
S. _____	Bridge							
T. _____	Stream Channelization							
U. _____	Parking Area							
V. _____	Dredging							

1. _____ New 2. _____ Maintenance 3. _____ Hydraulic 4. _____ Mechanical
W. _____ Other (explain) _____

d. PROJECT PURPOSE: Give brief written description of the project purpose:

3. PROJECT LOCATION:

a. LOCATION INFORMATION:

A. County: _____ B. City: _____ C. Name of waterway or closest waterway _____

D. State stream use class designation: _____

E. Site Address or Location: _____

F. Directions from nearest intersection of two state roads: _____

G. Is your project located in the Chesapeake Bay Critical Area (generally within 1,000 feet of tidal waters or tidal wetlands)?:
_____ Yes _____ No

H. County Book Map Coordinates (Alexandria Drafting Co.); Excluding Garrett and Somerset Counties:
Map: _____ Letter: _____ Number: _____ (to the nearest tenth)

I. FEMA Floodplain Map Panel Number (if known): _____

J. 1. _____ latitude 2. _____ longitude

b. ACTIVITY LOCATION: Check one or more of the following as appropriate for the type of wetland/waterway where you are proposing an activity:

A. _____ Tidal Waters
B. _____ Tidal Wetlands
C. _____ Special Aquatic Site (e.g., mudflat, vegetated shallows)
D. _____ Nontidal Wetland
E. _____ 25-foot buffer (nontidal wetlands only)
F. _____ 100-foot buffer (nontidal wetland of special State concern)
G. _____ In stream channel
1. _____ Tidal 2. _____ Nontidal
H. _____ 100-year floodplain (outside stream channel)
I. _____ River, lake, pond
J. _____ Other (Explain)

c. LAND USE:

A. Current Use of Parcel Is: 1. _____ Agriculture: Has SCS designated project site as a prior converted cropland?
_____ Yes _____ No 2. _____ Wooded 3. _____ Marsh/Swamp 4. _____ Developed
5. _____ Other _____

B. Present Zoning Is: 1. ____ Residential 2. ____ Commercial/Industrial 3. _____ Agriculture 4. _____ Marina 5. _____ Other

C. Project complies with current zoning _____ Yes _____ No

THE FOLLOWING INFORMATION IS REQUIRED BY THE STATE (blocks 4-7):

4. REDUCTION OF IMPACTS: Explain measures taken or considered to avoid or minimize wetland losses in F. Also check Items A-E if any of these apply to your project.

A. _____ Reduced the area of disturbance
B. _____ Reduced size/scope of project
C. _____ Relocated structures
D. _____ Redesigned project

E. _____ Other _____

F. Explanation _____

Describe reasons why impacts were not avoided or reduced in Q. Also check Items G-P that apply to your project.

G. _____ Cost
H. _____ Extensive wetlands on site
I. _____ Engineering/design constraints
J. _____ Other natural features
K. _____ Parcel size
L. _____ Other regulatory requirement
M. _____ Failure to accomplish project purpose
N. _____ Safety/public welfare issue
O. _____ Inadequate zoning
P. _____ Other _____

Q. Description _____

5. LETTER OF EXEMPTION: If you are applying for a letter of exemption for activities in nontidal wetlands and/or their buffers, explain why the project qualifies:

A. _____ No significant plant or wildlife value and wetland impact
1. _____ Less than 5,000 square feet
2. _____ In an isolated nontidal wetland less than 1 acre in size
B. _____ Repair existing structure/fill
C. _____ Mitigation Project
D. _____ Utility Line
1. _____ Overhead
2. _____ Underground
E. Other (explain) _____

F. _____ Check here if you are **not** applying for a letter of exemption.

IF YOU ARE APPLYING FOR A LETTER OF EXEMPTION, PROCEED TO BLOCK 11

6. ALTERNATIVE SITE ANALYSIS: Explain why other sites that were considered for this project were rejected in M. Also check any items in D-L if they apply to your project. **(If you are applying for a letter of exemption, do not complete this block):**

A. _____ 1 site
B. _____ 2 - 4 sites
C. _____ 5 or more sites

Alternative sites were rejected/not considered for the following reason(s):

D. _____ Cost
E. _____ Lack of availability
F. _____ Failure to meet project purpose
G. _____ Located outside general/market area
H. _____ Greater wetlands impact
I. _____ Water dependency
J. _____ Inadequate zoning
K. _____ Engineering/design constraints
L. _____ Other _____

M. Explanation: _____

7. PUBLIC NEED: Describe the public need or benefits that the project will provide in F. Also check Items in A-E that apply to your project. **(If you are applying for a letter of exemption, do not complete this block):**

A. _____ Economic
B. _____ Safety
C. _____ Health/welfare
D. _____ Does not provide public benefits
E. _____ Other _____

F. Description _____

8. OTHER APPROVALS NEEDED/GRANTED:

A. Agency	B. Date Sought	C. Decision 1. Granted	C. Decision 2. Denied	D. Decision Date	E. Other Status

9. MITIGATION PLAN: Please provide the following information:

a. Description of a monetary compensation proposal, if applicable (for **state requirements** only). Attach another sheet if necessary.

b. Give a brief description of the proposed mitigation project.

c. Describe why you selected your proposed mitigation site, including what other areas were considered and why they were rejected.

d. Describe how the mitigation site will be protected in the future.

10. HAVE ADJACENT PROPERTY OWNERS BEEN NOTIFIED?: A. _____ Yes B. _____ No

Provide names and mailing addresses below (Use separate sheet, if necessary):

a. b. c.

11. HISTORIC PROPERTIES: Is your project located in the vicinity of historic properties? (For example: structures over 50 years old, archeological sites, shell mounds, Indian or Colonial artifacts). Provide any supplemental information in Section 13.

A. _____ Yes B. _____ No C. _____ Unknown

12. ADDITIONAL INFORMATION: Use this space for detailed responses to any of the previous items. Attach another sheet if necessary:

Check box if data is enclosed for any one or more of the following (see checklist for required information):

A. _____ Soil borings
B. _____ Wetland data sheets
C. _____ Photographs
D. _____ Field surveys
E. _____ Alternate site analysis
F. _____ Market analysis
G. _____ Site plan
H. _____ Avoidance and minimization analysis

I. _____ Other (explain) _____

CERTIFICATION:

I hereby designate and authorize the agent named above to act on my behalf in the processing of this application and to furnish any information that is requested. I certify that the information on this form and on the attached plans and specifications is true and accurate to the best of my knowledge and belief. I understand that any of the agencies involved in authorizing the proposed works may request information in addition to that set forth herein as may be deemed appropriate in considering this proposal. I certify that all Waters of the United States have been identified and delineated on site, and that all jurisdictional wetlands have been delineated in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands. I grant permission to the agencies responsible for authorization of this work, or their duly authorized representative, to enter the project site for inspection purposes during working hours. I will abide by the conditions of the permit or license if issued and will not begin work without the appropriate authorization. I also certify that the proposed works are consistent with Maryland's Coastal Zone Management Plan. I understand that none of the information contained in the application form is confidential and that I may request that additional required information be considered confidential under applicable laws. I further understand that failure of the landowner to sign the application will result in the application being deemed incomplete.

LANDOWNER MUST SIGN: _____ DATE: _____

WHERE TO MAIL APPLICATION

Maryland Department of the Environment
Water Management Administration
Regulatory Services Coordination Office
1800 Washington Boulevard, Suite 430
Baltimore, Maryland 21230
Telephone: (410) 537-3762
1-800-876-0200

BEFORE YOU MAIL… DON'T FORGET…

- **SIGN AND DATE THE APPLICATION. THE LANDOWNER MUST SIGN.**
- **FIVE (5) COPIES OF ALL DOCUMENTS (APPLICATION, PLANS, MAPS, REPORTS, ETC.) MUST BE RECEIVED TO BEGIN OUR REVIEW.**
- **INCLUDE FIVE COPIES OF A VICINITY MAP (LOCATION MAP) WITH THE PROJECT SITE PINPOINTED.**

SAMPLE PLANS MAY BE OBTAINED BY PHONE (1-800-876-0200)
OR E-MAIL acunabaugh@mde.state.md.us.

Revised 9/06

SUPPLEMENTARY INFORMATION TO BE INCLUDED ON PLANS, DRAWINGS, OR VICINITY MAPS

In addition to the information indicated on the previous pages, you should include the following on the 8 1/2 x 11 site plans and any blueprints you have submitted:

1. Delineation of any wetland buffers or expanded buffers, clearly marked and differentiated.

2. Location of mitigation area, if proposed on the same site as the project.

Note: If you are proposing a complex project you may wish to submit engineering blueprints of your project with the application form to expedite review.

Mitigation Location Map: If you are proposing that nontidal wetland mitigation be done at a different location than the proposed project, you should submit a map showing the location of the mitigation site in relation to the proposed nontidal wetland losses.

WETLAND DELINEATION

Wetlands should be identified according to methods described in the publication Federal Manual Identifying and Delineating Jurisdictional Wetlands. Copies of the manual may be obtained by calling the U. S. Government Printing Office at 202-783-3238 and requesting document #024-010-00-683-8 at a cost of $7.50. Wetlands must be shown on all plans submitted with the application. All wetlands on site must be delineated and shown on the overall site plan. 8½ x 11 inch plans with topography showing relation of the wetlands and project impacts must be submitted. Copies of the wetland reports and data sheets used in making the determination be included with your application submittal.

Regulatory Agencies

Federal Permits

U.S. Army Corps of Engineers
Baltimore District
Attention: CENAB-OP-R
P. O. Box 1715
Baltimore, MD 21203-1715
Telephone: (410) 962-3670

Coastal Zone Consistency Statement

MD Dept. of the Environment
Water Management Administration
Wetlands and Waterways Program
1800 Washington Blvd, Ste 430
Baltimore, MD 21230
Telephone: (410) 537-3745

State Authorizations

MD Dept. of the Environment
Water Management Administration
Tidal Wetlands Division
1800 Washington Blvd, Ste 430
Baltimore, MD 21230
Telephone: (410) 537-3837

MD Dept. of the Environment
Water Management Administration
Nontidal Wetlands and Waterways Division
1800 Washington Blvd, Ste 430
Baltimore, MD 21230
Telephone: (410) 537-3768

APPENDIX D
SAMPLE CONSTRUCTION SPECIFICATIONS

TABLE OF CONTENTS

SECTION 1: MAINTENANCE OF PUBLIC AREAS

A. DESCRIPTION

1. The Contractor's operations shall cause no unnecessary inconvenience to the public. The public rights-of-way shall be maintained at all times unless interruption is authorized by proper local authority.
2. Safe and adequate access shall be provided and maintained to all public protection devices and to all critical utility control locations. Facility access shall be continuous and unobstructed unless otherwise approved.
3. Construction materials and equipment shall not be stored or parked on public streets, roads, or highways.
4. During any material or equipment loading or unloading activities that may temporarily interfere with traffic, an acceptable detour shall be provided for the duration of the activity.
5. Excavated material, including suitable material that is intended for backfill or other use in this project shall not be stored on public streets, roads, or highways that remain in service for the public. Any waiver of this requirement must be approved by DDOT and approved by the Project Inspector.
6. It is the responsibility of the Contractor to prevent any mud and surface debris accumulation beyond the limit of disturbance, and is responsible for daily clean up.

B. MEASUREMENT AND PAYMENT

1. This item will not be measured but will be paid for at the Contract lump sum price for Maintenance of Public Areas for each Project Area.

SECTION 11: FURNISHED CHANNEL GRAVEL

A. DESCRIPTION

1. This work shall consist of furnishing Channel Gravel for use in the project. Furnished Channel Gravel is used to prepare "Cobble-Gravel Mix" (Section 12) and for "Placed Furnished Channel Gravel" (Section 17).

B. MATERIALS

1. Furnished Channel Gravel shall be hard, durable, rounded gravel (river gravel) resistant to weathering and water action, free from overburden, spoil, shale, slate, and organic material. Crushed aggregate or angular stone is not acceptable.
2. Furnished Channel Gravel from a quarry producing aggregate of asbestos content or having asbestos present at the quarry are prohibited.
3. Furnished Channel Gravel shall have a uniform range in sizes and have no gaps or steps in the grain size distribution.
4. The grain size distribution of the Furnished Channel Gravel shall satisfy the following requirements:

    - The largest particle size[1] shall be less than 4.5 inches.
    - The particle size of between 87% and 97% of material by weight shall be less than 3.5 inches.
    - The particle size of between 79% and 89% of material by weight shall be less than 3.0 inches.
    - The particle size of between 47% and 57% of material by weight shall be less than 1.25 inches.
    - The particle size of between 26% and 36% of material by weight shall be less than 0.50 inches.
    - The particle size of between 16% and 26% of material by weight shall be less than 0.25 inches.
    - The particle size of between 6% and 16% of material by weight shall be less than 0.079 inches (2.0 mm).
    - No more than 10% of material by weight shall be less than 0.019 inches (0.5 mm).

5. The Contractor will locate potential sources for stone. The Contractor shall submit to the Project Inspector documentation from the quarry or other supplier that verifies the stone sizes, grain size distributions, weight densities, specifications, and weight range of stone being supplied.
6. Furnished Channel Gravel may be prepared or mixed at a remote location or on-site.
7. The Contractor is responsible for ensuring that the Furnished Channel Gravel does not become segregated into separate size classes during transport or handling at the site.
8. If Furnished Channel Gravel is mixed or prepared off-site, then before delivery to the site, the Contractor shall provide a representative sample of Furnished Channel Gravel to the Project Inspector for approval prior to delivery to the site.
9. If the Contractor intends to mix or prepare the Furnished Channel Gravel on-site, then the Contractor must submit to the Project Inspector a written work plan discussing the methods, equipment, materials, and quality control plan used to prepare the Furnished Channel Gravel.
10. Furnished Channel Gravel will be subject to visual inspection at the point of usage and may be rejected by the Project Inspector if it does not meet specifications.

C. MEASUREMENT AND PAYMENT

1. Measurement and payment for Furnished Channel Gravel shall be made at the specified units for the items Cobble-Gravel Mix and Placed Channel Gravel.

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[1] All particles sizes are measured along the intermediate (b-) axis.

SECTION 20: ROCK AND ROCK/LOG CROSS VANE

A. DESCRIPTION

1. This work shall consist of the procuring, transporting, and installation of Rock Cross Vanes as specified in the Construction Specifications and Plans.
2. These structures are designed to remain stable over the full range of flows, maintain vertical grade control across the channel, and allow efficient sediment transport.
3. The Contractor shall note that the principal objective is to create Rock and Rock/Log Cross Vane structures that have a natural appearance in addition to adequate function.

B. MATERIALS

1. All rock shall consist of rectangular blocks with parallel faces and flat in appearance, dark brown or dark gray in color, and meet the gradation requirements indicated on the Construction Plans.
2. Rocks shall be selected that are stackable, free of projecting edges and uneven surfaces.
3. Rock shall meet the specifications for "Rock" (Section 10) in the Construction Specifications and Plans. Rock will be accepted by the Project Inspector upon visual inspection at the point of usage.
4. Logs shall be from hardwood trees that are straight, solid, and free of branches and rot. The diameter of the log shall be no less than 12 inches and not greater than 30 inches; the length of the log shall be no less than 40 feet.
5. Geotextile fabric shall conform to DDOT Construction Specsifications for Class SE geotextile fabric.
6. The cobble-gravel mix shall meet the specifications for "Cobble-Gravel Mix" (Section 12) in the Construction Specifications. Cobble-Gravel Mix will be accepted by the Project Inspector upon visual inspection at the point of usage.

C. CONSTRUCTION

1. Rock Cross Vanes shall be installed according to the Sequence of Construction and Standard Detail Sheets in the Construction Plans, and the following Construction Specifications.
2. All field changes to structure locations, dimensions, and/or elevations must be approved, in writing, by the Project Inspector, prior to installation.
3. The Contractor shall install Rock Cross Vanes to the line, grade, and detail described on the Construction Plans.
4. Rock Cross Vanes shall be constructed by excavating a trench slightly larger than the vane and footer rock dimensions.
5. Geotextile fabric shall be placed on the sub-grade and along the streambank parallel to the direction of stream flow. Each layer shall overlap a minimum of 1 foot. Geotextile fabric torn or damaged shall be replaced or repaired at the Contractor's expense in a manner acceptable to the Project Inspector. The edges of the geotextile fabric shall terminate 0.5 foot below the finished grades.
6. A minimum of two footer rocks that shall be firmly embedded a minimum of 2 feet below the finished grade of the channel along the entire length of the structure.
    a. All rocks (except bottom layer of footer rocks) shall be supported by a footer rock and shingled upstream or into stream bank. All rocks shall be interlocked and shall not rock or rotate in place.
    b. All rocks shall be placed with the parallel faces oriented up and down with the top face tilting up from the bed at 5 to 15 degrees in the direction of flow on the crossover and vane arms.

c. All rocks (except top layer of crossover) shall be placed so that they firmly abut adjacent rocks leaving no gaps between rocks. Gaps shall be left between rocks in the top layer of the crossover as shown in Construction Plans.
d. A layer of geotextile shall be placed on the landward side of each of the vane arms and the upstream side of each of the crossovers as shown in the standard details.

7. Rock/Log Cross Vanes shall be constructed by excavating a trench slightly larger than the log vane and footer log dimensions.
    a. A minimum of one footer log shall be firmly embedded a minimum of 2 feet below the finished grade of the channel along the entire length of the structure.
    b. All logs (except bottom footer logs) shall be supported by a footer log and shingled upstream or into stream bank. All logs shall be interlocked and shall not rock or rotate in place.
    c. All logs shall be placed so that they firmly abut adjacent logs leaving no or nominal gaps between the logs.
    d. Geotextile fabric shall be nailed to the upstream side of the log vane. The cloth shall extend from the vane log to the footer log and to the toe of bank.
    e. The top logs shall be secured in place using Class III rock as shown in the Construction Plans.
    f. Where rocks are installed, the geotextile fabric shall be placed on the sub-grade and on the landward side of each of the vane arms and the upstream side of each of the crossovers as shown on the Standard Details in the Construction Plans. Each layer shall overlap a minimum of 1 foot. Geotextile fabric torn or damaged shall be replaced or repaired, at the Contractor's expense, in a manner acceptable to the Project Inspector. The edges of the geotextile fabric shall terminate 0.5 foot below the finished grades.
    g. The rock portion of the vane will have a minimum of two footer rocks that shall be firmly embedded a minimum of 2 feet below the finished grade of the channel along the entire length of the structure.
    h. All rocks (except bottom layer of footer rocks) shall be supported by a footer rock and shingled upstream or into stream bank. All rocks shall be interlocked and shall not rock or rotate in place.
    i. All rocks shall be placed with the parallel faces oriented up and down with the top face tilting up from the bed at 5 to 15 degrees in the direction of flow on the crossover and vane arms.
    j. All rocks (except top layer of crossover) shall be placed so that they firmly abut adjacent rocks leaving no gaps between rocks. Gaps shall be left between rocks in the top layer of the crossover as shown in Construction Plans.
8. The structure shall be constructed such that rocks form a continuous, uniform slope with a minimum of steep, high, or low spots along the top finished surface.
9. Finished elevations shall be within 0.10 feet of reference point elevations listed in Rock Cross Vane Structure Table. Locations and width of the Rock Cross Vane shall be within plus or minus 1 foot of locations specified on plan. For all structure dimensions and elevations, refer to the structure table, longitudinal profile, and geometry on the Construction Plans. Placed stone not conforming to these Construction Specifications or Plans shall be removed and replaced, as directed by Project Inspector, at the Contractor's cost.
10. Stream bottom around structure shall be backfilled with "Furnished Channel Gravel" (Section 11) to meet finished grade as directed in specifications.
11. Upon completing the construction of the Rock Cross Vane, voids between rocks and around the structure shall be hand filled and compacted. The disturbed ground around the structure shall be backfilled with compacted soil installed in 4-inch lifts.
12. The areas located upstream of the Vane Arms and between the Vane Arms and the banks shall be filled with "Cobble-Gravel Mix" (Section 12) as shown on the Construction Plans.

13. Stream banks around the structure shall be backfilled with Furnished Topsoil and hand compacted in 4-inch lifts as shown on the Construction Plans.

D. MEASUREMENT AND PAYMENT

1. The method of measurement and basis of payment for Rock and Rock/Log Cross Vanes shall be the Contract unit price per linear foot of Rock Rock/Log Cross Vane. The total length of the cross vane will be measured in the field by the Project Inspector and will consist of the sum of the lengths of the first and second crossovers (measured from Reference Points Al to Ar and from Reference Points Dl and Dr), plus the sum of the left and right vane arm lengths (Vl and Vr) as shown in the Structure Tables on the Construction Plans.
2. Price and0 payment will be full compensation for all materials, transport of materials to the site, Rock, Cobble-Gravel Mix, stockpile, excavation, and installation of rocks, backfill, resetting of rocks, and for all materials labor, equipment, tools, and incidentals necessary to complete the work. Furnished Channel Gravel will be compensated for as specified in the Construction Specifications.