VII. Appendices

A. Stream Assessment 2001 summary of Stream Type data.

B. Draft Watershed Assessment Protocol, NYCDEP.

C. PAC Project Site ranking questionnaire.

D. PAC Project Site ranking results.

E. Chestnut Creek Demonstration Restoration Project Site Report.

1. Location map for Town Hall Demonstration Restoration Project Site, 2003.
2. Cornell Soil Sample Nutrient Analysis Results, Town Hall planting site, Neversink, NY.
3. Catskill species Planting List.
4. Topographic survey of Project Site.

F. Chestnut Creek Demonstration Restoration Project Site Planting Plan and Eroded Bank specifications.

G. Riparian Buffer Monitoring Plan for the Town Hall Demonstration Restoration Site.

Chestnut Creek Stream Assessment Survey, 2001 - Summary of Data							
LP stn	**Feature break**	**Distance (feet)**	**Cross Sections included**	**Notes**	**Slope**	**Stream type**	**Management Unit/Reach #**
0-123	tp to tp	123'	1,2		0.039	E4b	MU1/ R 1
123-136	tp to tp	13'	3		0.110	A3a+	MU1/ R2
136-167	tp to tp	31'	4		0.021	B4	MU1/ R 3
167-186	tp to tp	19'	5		0.044	F4a	MU1/ R 4
186-199	tp to tp	13'	6		0.041	C4b	MU1/ R 5
199-381	tp to tp	182'	7,8,9,10		0.068	B4a	MU1/ R 6
381-404	tp to tp	23'	11		0.047	A3	MU1/ R 7
404-430	tp to tp	26'	12		0.071	E3a	MU1/ R 8
430-450	tp to tp	20'	13		0.030	F3b	MU1/ R 9
Begin Curry							
0-437	tr to tr	437'	16-19	Begin Curry	0.0044	E5	MU2/R1
437-853	tr to tr	416'	20,22,23,24,25		0.0043	C5	MU2/R2
853-879	tr to tr	26'	26		0.0004	E5	MU2/R3
879-1540	tr to tr	661'	27,27.5,28,29,29.5,29.6,32,33,34		0.0081	C4	MU2/R4
1540-1596	tr to tp	56'	34.5		0.0105	F4	MU2/R5
1596-2327	tp to tp	731'	35.5-42		0.014	C4	MU 3/R-1
2327-2426.5	tp to tp	99.5'	43/44		0.018	B4	MU 3/R-2
2426.5-2665.5	tp to tp	218.5'	45	top of dam	0.016	C4	MU 3/R-3
2665.5-2887	tp to tp	330'	46,47	btm of step	0.039	F4b	MU 3/R-4
2887-3198	tp to tp	391.5'	48,49		0.037	B1	MU 3/R-5
3198-3281	tp to tp	83'	50		0.021	C4b	MU 3/R-6
3281-3311	tp to tp	30'	51		0.029	F4b	MU 3/R-7
3311-3501	tp to tp	220'	52		0.027	B4	MU 3/R-8
3501-3591	tp to tp	90'	53		0.020	F4b	MU 3/R-9
3591-3713	tp to tp	122'	54		0.023	C4b	MU 3/R-10
3713-3885	tp to tp	172'	55		0.030	F3b	MU 3/R-11
3885-3972	tp to tp	87'	56		0.020	B4	MU 3/R-12
3972-4003	tp to tp	31'	57		0.030	F4b	MU 3/R-13
4003-4353	tp to tp	350'	58,59,60,61,62,63	Bedrock Control-cascade	0.038	B1a	MU 4/R-1
4353-4515	tp to tp	162'	64,65	BEHI 2 cascade	0.058	B1/4a	MU 4/R-2
On Scott Brook Tributary	tp to tp	at 4500 LP sta.	66	BEHI 1 Scott Brook	N/A	F	Tributary
4515-4552	tp to tp	37'	67		0.033	B4	MU 4/R-3
4552-4931	tp to tp	379'	68,69,70	BEHI 3	0.022	F3b	MU 4/R-4
4931-5423	tp to tp	492'	72,73,74,75		0.034	B3	MU 4/R-5
5423-5693	tp to tp	270'	76,76.5,76.6,76.7,77	Slater Bridge/Culvert	0.030	F3b	MU 4/R-6
5693-6312	tp to tp	619'	78,79,79.1,79.2,79.3,80,81	includes Scheirer/Botsford Bridge	0.024	F3b	MU 4/R-7
6312-8668	tp to tp	2356'	82,180,180.5,181,182		0.027	B	MU 4/R-8
8668-9094	tp to tp	426'	182.5, 183		0.024	Fb	MU 4/R-9
On Claryville, unnamed trib	tp to tp	bxs extent of bridge	96,97,98,99	Claryville Bridge and Tributary	N/A	F/B	Tributary
9094-9740	tp substrate change	646'	HG01,83,84,101,102, 85	Kelly Bridge	0.015	F1/F3	MU 4&5/R-10&1

Chestnut Creek Stream Assessment Survey, 2001 - Summary of Data							
LP stn	**Feature break**	**Distance (feet)**	**Cross Sections included**	**Notes**	**Slope**	**Stream type**	**Management Unit/Reach #**
9740-10215	tp substrate change	447'	86, 87, 88		0.025	B3	MU 5 / R-2
10070-10652	tp substrate change	582'	89, 90, 104		0.020	F3	MU 5 / R-3
10652-10761	tp substrate change	109'	105,106	Includes Mohrs Bridge	0.020	B3	MU 5 / R-4
10761-11036	tp substrate change	275'	107		0.015	F3	MU 5 / R-5
11036-11370	tp substrate change	334'	cxs01		0.020	B3	MU 5 / R-6
11370-12028	tp substrate change	658'	108, 109, 110, 111, 112	Includes Clark's Bridge (111 not surveyed)	0.010	F1/F4	MU 5 / R-7
12028-12979	tp substrate change	951'	xs-1, 112.5, 113, 114, 115		0.020	B1/B4	MU 5 / R-8
12979-13331	tp substrate change	352'	116		0.015	F1/F3	MU 5 / R-9
13331-14663	tp substrate change	1332'	117,117.1,117.3,118,119,120,121	Includes Hilltop Bridge	0.020	B1/B3	MU 5 / R-10
14663-14910	tp substrate change	247'	122		0.020	F3	MU 5 / R-11
14910-17836	tp substrate change	2926'	123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134.135,136,BEHI 7, BMX 3		0.020	B3	MU 5 &6/ R-12&1 Break below Covered Brg
17836-18377	tp to tp	541'	137,138,139		0.02	C3	MU 6 / R-2
18377-19273	tp to tp	896'	141,144,145,147,148		.01 / .02	B3c	MU 6 / R-3
On Bullet Brook Tributary	tp to tp	at 18314 LP sta	140	On Bullet Brook	N/A	C	Tributary
19273-19594	tp to tp	312'	149		0.014	F3	MU 6 / R-4
19594-20081	tp to tp	487'	150,151		0.017	B3c	MU 6 / R-5
20081-20350	tp to tp	269'	152,153		0.012	F3	MU 6 / R-6
20350-21216	tp to tp	866'	154,155	monumented xs 0301-0303-behi @ xs 0303	0.015	F3/B3c	MU 6 / R-7
21216-21812	tp to tp	596'	159,160		0.017	F1 / 3	MU 6 / R-8
21812-22358	tp to tp	546'	160.5,161,162		0.013	B3c/B1c	MU 6 / R-9
22358-22772	tp to tp	414'	163,164,165		0.013	F1/ 3	MU 6 / R-10
22772-23339	tp to tp	567'	168,168.5		0.016	B3c	MU 7 / R-1
23339-23702	tp to tp	363'	169.5,170,171	BEHI DEP 1	0.009	C3	MU 7 / R-2
23702-23837	tp to tp	135'	172	BEHI DEP 2	0.023	B	MU 7 / R-3
23837-25258	tp to tp	1421'	173		0.014	C	MU 7 R-4
On Red Brook Tributary	tp to tp	N/A	174		N/A	C	Tributary
25258-25569	tp to tp	311'	175		0.006	F	MU 7 / R-5

DRAFT

Watershed Assessment Protocol

NYCDEP Stream Management Program

Prepared by M. A. Vian

v.4.26.02

DRAFT

Table of Contents

1.0 Introduction..3

2.0 Purpose..3

3.0 Outcomes..4

4.0 Procedures..6

4.1 Office Procedures...6

4.2 Field Procedures..

7

4.2.1 Preliminary reconnaissance and GPS procedures.......................................7

4.2.2 Profile and cross-section survey procedures..9

4.2.3 Bed surface material characterization

procedures.....................................14

4.2.4 Riparian vegetation characterization ground truthing procedures.............15

5.0 Analysis..15

6.0 References..16

Figures

Table

Appendices

Appendix A - PDA data logging

1.0 Introduction

This reconnaissance protocol is intended to aid in the development of subbasin-scale Stream Management Plans by providing baseline information on the condition of the stream system. These plans will summarize assessments and surveys of stream hydrology and hydraulics, the condition of biota in the stream and riparian ecosystem, point- and non-point sources of pollution and flood risks associated with unstable channel morphology. They will also anticipate potential future development within each sub-basin on the basis of local land-use patterns, regulations and landscape conditions, with the goal of providing local decision-makers with information they can use to determine the impacts on community flood risk, ecosystem function and water quality that might result from future development. Finally, these plans will make recommendations on what management strategies and practices might be implemented to remediate current problems, mitigate potential negative impacts of future development, and enhance ecosystem function and quality of life for the local community.

2.0 Purpose

The purpose of this reconnaissance protocol is fourfold. First, it is meant to provide for the field researcher a general inventory of conditions throughout the stream corridor, by defining the focus of observation during the assessment. This baseline inventory may include, but is not necessarily limited to, conditions that affect hydraulic function, particularly sediment transport function (such as bedrock sills and banks, cultural and natural grade controls, berms, and riprap or other revetment placements), potential sources of water quality impairment (especially eroding banks, clay exposures, or exposed septic leach fields or other hazards), "buffer" functionality of riparian vegetation (including locations of functional reference riparian communities, locations where riparian vegetation management is warranted to improve ecosystem function, and occurrences of invasive exotic vegetation of significant consequence to stream stability and ecosystem function), infrastructure (including road crossings, bridge abuttments, culverts and outfalls, and utility lines or poles), and other features such as tributary confluences, springs, wells or diversions. This inventory may be used to define and prioritize further assessment and scope the issues that will be addressed in the management plan.
Second, this protocol is meant to support quantitative and comprehensive verification of the

Rosen Level I geomorphic classification performed in the office prior to field work, and to add field-verified Level II and Level III classification detail to this classification (Rosgen 1996). This classification will allow general management interpretations regarding channel morphology on a watershed-wide basis.

Third, this protocol is meant to provide data to support ground-truthing of subsequent characterization of the vegetative community structure of riparian areas from remotely-sensed data. Characterizing the structure of the riparian vegetation will support analysis of the capacity of the riparian "buffer" to mitigate potentially deleterious water quality impacts from upland land uses. In addition, riparian classification will define the role of vegetation in the cohesion of stream bank soils and the integrity of the stream and riparian ecosystems. This analysis should lead to recommendations for where improvement of buffer functionality might be most critical or effective, and locations of reference riparian vegetative communities within the watershed.

The fourth purpose of this protocol is to support analysis that would determine, for certain reach types and conditions, the extent to which channel geometry and stream bank stability departs from its potential stable form[1]. This will allow determination of locations for which restoration of stable channel geometry is required, or alternatively where bioengineered bank stabilization would be sufficient to reasonably assure future stability. In this regard, the protocol represents a "first cut" to identify where further assessment is warranted, both of potential stable reference reaches and reaches where instability is indicated. Reference reaches will subsequently be surveyed in greater detail and over time to verify their stability and to provide data on the range of values they exhibit in variables such as facet dimensions, Bank Erodibility Hazard Index (BEHI) scores (Rosgen 1996), measures of bed aggradation and degradation, bank erosion rates, and substrate size distribution. Stable channel geometry derived from these reaches can be used in the design of channel stability restoration projects. Unstable reaches will be subsequently surveyed in greater detail to allow comparison to the stable ranges of these same variables

[1] This approach assumes that for any valley setting, a variety of channel morphologies might be found, and that some of these forms, in that setting, convey the range of water and sediment discharges supplied by the landscape in a manner which allows them to maintain their morphology with relatively little change from year to year (stable forms), while others are less effective and are likely to evolve relatively rapidly through a sequence of channel forms due to vertical and/or lateral adjustments (unstable forms). For any valley setting, there are a discrete number of potential stable forms.

exhibited by reference reaches, and among themselves to characterize their relative severity and support the prioritization of their remediation.

This paper presents office, field data collection, data plotting, data analysis, and administrative procedures for conducting this reconnaissance.

3.0 Outcomes

The product of this reconnaissance study is a comprehensive stream corridor map which features:

1) **Continuous delineation of channel morphology**, characterized to Rosgen Level II class types on the mainstem (and, where practicable, on major tributaries) with locations of classification cross-sections;

2) **Locations of hydraulic controls,** including bedrock sills and banks, rip-rap or other revetment, weirs, and bridge abuttments;

3) **Locations of natural and man-made drainage confluences**/divergences, including tributary inlets, springs, stormwater and culvert outfalls, and roadside ditch outfalls, stream diversions and split channels;

4) **Locations of problematic riparian vegetation**, such as stands of invasive species like Japanese knotweed (*Polygonum cuspidatum*)**;**

5) **Locations of transects along which changes in riparian vegetation community structure has been documented** for use in subsequent ground-truthing of office characterization of the riparian buffer using remotely-sensed data (optional);

6) **Locations of eroding banks, with initial classification of bank erodibility hazard;**

7) **Locations of potential reference reach sites** for further assessment and monitoring**;**

8) **Locations of infrastructure within the stream corridor or intersecting the stream channel,** such as bridges and abuttments, road crossings, wells or other utilities**.**

4.0 Procedures

4.1 Office Procedures.

Preparation of base maps. Reference maps (scale approximately = 1:2400) should be prepared prior to field work which can be annotated in the field with the location of features identified. These maps should include:

a. Recent aerial photography.

b. Historic channel alignments from historic aerial photography. Note on maps where these indicate both significant laterally instability and stability (the latter as potential reference reach sites).

c. Elevation contour lines

d. Characterization of significant valley slope and confinement breaks.

i. Valley slope can be calculated from contour line crossings.

ii. Valley confinement can be interpreted from contours, or alternatively, a preliminary estimate of entrenchment ratio can be roughly calculated at regular intervals along the stream to cue field observation of changes in floodplain width. Using 100 yr (or preferably, 50 yr) floodplain boundaries from a flood study, the ratio of floodplain width to bankfull width (as predicted from regionally developed relationships of hydraulic geometry to drainage area) can be calculated. The objective is to cue field observation of changes in floodplain width.

e. Line coverage of the stream network. This coverage should be classified to Rosgen Level I, using the protocol described in "Procedure for Rosgen Level I Stream Classification" (NYCDEP, 2001), attached as Appendix ().

f. Drainage area and expected bankfull channel cross-sectional area, identified from regionally derived hydraulic geometry curves and displayed at:

i) points both immediately upstream and downstream of all significant confluences on the mainstem and major tributaries to be assessed, or

ii) if there is greater than 10% change in drainage area between confluence points, at points identified along the stream network such that there is no more than a 10% increase in drainage area between points, or

iii) at all cross-over reaches, as identified from aerial photography.

Drainage area at these points can be determined through computer-based GIS analysis (as in NYCDEP, 2001 above), by planimeter, or developed manually through delineation of drainage basins on USGS topographic maps, overlaying gridded tracing paper, counting the grid squares in each drainage area, and multiplying the number of grid cells by the area represented by each cell at the scale of the map. Use the most locally-verified hydraulic geometry curves available (describing bankfull channel dimensions as a function of drainage area) to obtain values for the predicted cross-sectional area.[2]

g. Property boundaries, with owners' names.

h. Locations of benchmarks at bridges referenced in bridge surveys. These will be identified in the field, and tied into the longitudinal profile survey and monitoring cross-section resurveys to estimate scour at the bridges.

4.2 Field Procedures

The following field procedures should be performed in a specific sequence. In general, the assessment is conducted in a series of iterative steps, to the detail necessary and practicable given the management objectives and resources available.

The preliminary GPS reconnaissance (Section 4.2.1) is intended to provide sufficient inventory of conditions in the stream corridor to determine 1) the scope and intensity of subsequent assessments, and 2) the general scope of the stream management plan. Following preliminary reconnaissance, the field researcher should analyze the data collected, and divide the study area into preliminary management segments. Integrate this analysis with data available from other agencies and the public into a preliminary report, and request review of the report by partnering agencies, public officials, and area residents to determine the appropriate level and focus of effort for each segment with

[2]For the Catskill Region, see Miller and Davis, 2001.

regard to subsequent assessment and research. The more detailed subsequent components of the protocol can be initially conducted in high priority reaches, or comprehensively, as is appropriate to the geographic scale of the project.

Where further morphological characterization is warranted,[3] it will be useful to first develop hydraulic geometry functions, *specific to the stream under investigation,* describing the relationship of drainage area to bankfull cross-sectional area (See Section 4.2.2b). This function should be created using survey data from reference cross-sections identified for this purpose during the preliminary reconnaissance on the basis of relatively clear bankfull field indicators. Because slope and roughness will influence local cross-sectional area, the longitudinal profile should be surveyed prior to the survey of these hydraulic geometry reference sections, and Wolman pebble counts should be conducted at these locations. These data should also be used in quality control measures in the field identification of bankfull stage at these reference sections (see Section). These data on slope and relative roughness can also be added to the plot of drainage area and cross-sectional area (see Figure XXX), to allow explanation of variation around the regression line in terms of these additional variables.

Add detail on goal of each assessment component.

4.2.1 Preliminary reconnaissance and GPS procedures.

For all locations field-identified using Global Positioning System (GPS) technology, use standard GPS survey practice, (e.g., Leick, 1995). If GPS points are offset from actual features, record compass bearing and distance to feature.

a. Navigate with GPS and/or aerial photography base maps to target area(s)

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[3]There are many management concerns that warrant geomorphic characterization. For a detailed discussion, see Rosgen (1996, chapters 3 and 8), and Dunne and Leopold (1978, chapters 14-18).

identified in office protocol as top of furthest upstream reach to be classified. Monument top of study area if not already monumented. Position monument in a retrievable location, sufficently back into the floodplain such that the monument will not be lost to bank erosion or hidden by deposition. Map the location of the monument on field maps, GPS the monument coordinates and photodocument.

Walking downstream:

b. Establish cross-section locations for Level II classification and record coordinates (see below). Identify and establish temporary monuments or flags at the riffle or step, flag bankfull stage, and identify whether the cross-section will be used as a reference section to construct a stream-specific hydraulic geometry curve (see Section 4.2.2b, below) and label monument / flag with:

i) sequential cross-section numbering (eg., BSHX1, BSHX2...etc.),

ii) indication if the section is a reference section.

c. Record coordinates of stormwater and culvert outfalls, road ditch outfalls into stream.

d. Record coordinates of top and bottom points of hydraulic controls: rock sills and banks, rip-rap placements, weirs, bridge abutments, centers and benchmarks at crossings.

e. Record coordinates of approximate upstream and downstream extents of eroded banks. This can be accomplished with two points or as a line feature recording the upslope extent of the failure or along the bankfull intercept. Document height sufficiently to roughly determine area of exposure; this will be used later to determine if a full survey is warranted at the site. Establish endpoints of cross-section at the failure (see below), monument and record coordinates. Photodocument, ideally with compass bearing. Visually assess the cause of failure, and determine a Bank Erodibility Hazard Index (Rosgen 1996) rating representative of the reach as a whole. Characterize water quality threat, in terms of sources of turbidity. Document approximate distances to structures or infrastructure where a threat is evident.

f. Record coordinates of occurrences of problematic bank vegetation (eg., invasive exotics like Japanese knotweed (*Polygonum cuspidatum*) or locations of insufficient vegetation).

g. Photodocument all GPSed points and identify location on reference maps.

h. Habitat (this section under development)

Following preliminary reconnaissance, analyze the data collected, and divide the study area into preliminary management segments. Integrate this analysis with data available from other agencies and the public into a preliminary report, and request review of the report by partnering agencies, public officials, and area residents to determine the appropriate level and focus of effort for each segment with regard to subsequent assessment and research.

4.2.2 Profile and cross-section survey procedures. Survey both the long profile and cross-sections into a clearly identified common benchmark, preferably point of known elevation. This can be accomplished at bridge crossings along the profile. The profile should include classification cross-section bankfull stage locations and/or endpoint monuments in each of the monitoring cross-sections to tie them into the same reference elevation. Recorded survey data should enable determination of actual elevations, and sufficient notes should be associated with each measurement to clearly identify the feature being surveyed as well as relevant site data. The data recorder should be continually comparing measured data to the observed site condition, and the data recorder should produce field plots as a quality control check. Use standardized survey field sheets to record measurements (see Appendix ( ) for options). Each traverse should include two turning points.

<u>a. Survey longitudinal profile.</u> Beginning at the top of the study area survey elevations of water surface at edge of water. Use thalweg stationing for distance measurements. Survey elevation at:

i. bankfull stage flags

ii. monitoring cross-section endpoint monuments

iii. water surface, at edge of water, at cross-section stations

iv. water surface, at edge of water, at upstream extent of pools

Water surface slope measurements for stream segment classification and quality control calculations using Manning's Equation are taken from top-of-pool to top-of-pool, as a surrogate for energy grade at bankfull discharge. For slope calculations used in stream classification, the reach limits should be chosen to most accurately reflect the energy grade slope through the section being classified. While it is acknowledged that feature boundaries (e.g., riffle/pool transition) may vary somewhat with stage, pools are identified as features with less than reach average slope, and riffles as features with greater than average slope. Further, a pool ideally contains control at downstream end that runs the full width of the channel, so as to create a single water surface elevation across the channel at low flow (but not necessarily perpendicular to flow; i.e., the control can be transverse).

Cross-sections, general. The cross-section should include the entire channel (bank to bank) and the adjacent floodplain and terraces on both sides of the channel, and be established perpendicular to the direction of bankfull flow. The cross-section should extend on both the right and left banks so as to include some area beyond "floodprone stage," which is defined as the elevation at twice maximum bankfull depth (Rosgen 1996), to enable classification based on entrenchment ratio. The suggested sequence is to identify the cross-section location, identify bankfull stage, survey bankfull elevation, survey thalweg elevation, calculate floodprone elevation, identify floodprone stage, establish cross-section endpoints beyond floodprone stage, and survey cross-section.

Survey each cross-section including not fewer than ten stations spaced at major grade breaks. Optional: Record cross-section bearing. Use a standardized cross-section field sheet (see Appendix ( ) for optional electronic data recorder) and follow general guidelines in Harrelson, et al., 1994, Chapter 6. The station and elevation of bankfull stage, current left and right edge of water surface, and thalweg should be surveyed into the cross-section. Photo document.

Select cross section stations that are representative of the feature and the reach, relatively uniform longitudinally and generally symmetrical in cross-section. The frequency of classification cross-sections will depend on the resources available for the effort; where resources permit, every riffle section should be surveyed in riffle/pool streams, and at least every other cross over feature should be surveyed in step/pool streams. If reach classification boundaries are determined subjectively and riffles are skipped, minimally:

i) survey cross-sections at the top and bottom riffles of the reach;

ii) at intervening riffles, determine bankfull width and floodprone width, as described below, to ensure that entrenchment ratios and width/depth ratios have not changed.

In step-pool stream architecture, locate cross-section through the top of the step, where the bed is controlling the pool above, taking care to avoid including bed elevations in the pool above or below the step. Where possible, avoid areas that are affected by debris jams or other channel obstructions, overly wide relative to the rest of the channel, where the planform or profile changes abruptly, or the cross-section is extremely asymmetric or transverse (such that a cross section perpendicular to bankfull flow contains sections in pool features above or below the cross over feature).

Identify bankfull stage using methods described in Harrelson, et al., 1994. Identify bankfull indicators along the reach adjacent to the cross-section. Use similar morphological features to establish the estimated bankfull elevation at the cross-section. Survey cross-section and determine cross-sectional area. Compare to predicted cross-sectional area from regional hydraulic geometry curves.

If cross-sectional area departs more than 50% from the expected regional or local value, estimate velocity using bankfull discharge from applicable regional curves, and evaluate whether the velocity is reasonable (4-12 fps) in the context of local hydraulic and roughness conditions. This percentage may have to be increased for first- and second-order headwater steams, where high upland slopes and thin soils may produce higher runoffs and therefore larger discharges and cross-sectional areas, and where supply of material typically has a larger D50, and the effective discharge is larger.

b. Survey hydraulic reference section cross-sections at thalweg cross-over reaches. These cross-sections are surveyed at locations throughout the sub-basin where field indicators of bankfull stage are relatively clear, and are used to created hydraulic geometry curves specific to the hydrologic regime in that sub-basin that can guide identification of bankfull where field indicators are less clear. They represent a subset of the classification cross-sections (below) and are surveyed following the same subsequent procedures. Prepare a stream-specific hydraulic geometry curve from these surveys before flagging and surveying the cross-sections where bankfull stage is less-easily identifiable.

When plotting the reference hydraulic geometry curves, coding the individual data points on these curves to represent both slope and D50 of the bed material particle size distribution will facilitate interpretation of the variation of bankfull cross-sectional area from the mean. (This will also be useful later at cross-sections locations with poor bankfull stage indicators.) Evaluate the reach for conditions that might explain the residual. For instance, for larger than expected cross-sectional areas, look for:

i) low water surface slope,

ii) high width/mean depth ratio,

iii) high roughness from bed or bank materials, channel form or vegetation

Where the residual cannot be explained by evident hydraulic conditions, re-evaluate identification of bankfull elevation and conduct a Wolman Pebble Count directly at the cross-section following Harrelson, et al., 1994.

During data review for quality control, use the relationships between relative roughness (d/D84) and friction factor (u/u*) and between friction factor and Manning's "n" value, given in Rosgen 1998, pp 188-189, to solve for discharge using Manning's Equation.

Determine the difference between current water surface elevation and bankfull elevation at clear bankfull indicators, and use this as a rough guide in determining bankfull elevation at subsequent cross-sections. Recognize that water-surface slope and bankfull slope can diverge, and that the difference in their elevation will change with changes in drainage area, channel width to depth ratio, roughness, and slope.

c. Survey reach classification cross-sections at thalweg cross-over reaches.

Survey each classification cross-section, recording station and elevation, including not fewer than ten stations spaced at major grade breaks. Record cross-section bearing. Use a standardized cross-section field sheet (see Appendix ( ) for optional electronic data recorder) and follow general guidelines in Harrelson, et al., 1994, Chapter 6. The station and elevation of bankfull stage, current left and right edge of water surface, and thalweg should be surveyed into the cross-section. Photo document.

d. Survey BEHImonitoring cross-sections to determine stress in the near-bank region (SNR) ratio (Rosgen, 1996) using the procedures above, but detailing the bank profile to allow for long-term monitoring of changes due to erosion or failure. At each eroding bank to be monitored, establish two cross-sections:

i) at the longitudinal station where the combined BEHI score and SNR appear to be most extreme (often near the head of a pool) and

ii) at a location that appears to be representative of local bank conditions in general.

For these purposes, SNR ratio is expressed as

$$A_{nb}/A_{bf}$$

where A_{nb} is cross-sectional area in the third of the channel nearest the bank at bankfull stage (determined by dividing bankfull width into thirds), and A_{bf} is total bankfull channel area. A high SNR ratio will, therefore, be evidenced by the most extremely asymmetric channel, where the thalweg is closest to the eroding bank. Establish permanent rebar monuments in a retrievable location on left and right cross-section endpoints and record coordinates. Monuments should be located sufficently back into the floodplain such that they will not be lost to bank erosion or hidden by deposition, and will include at least floodprone stage on both left and right extents.

The bank profile should capture undercut banks, depth of rooted vegetation, sand lenses or other relevant soil or sediment strata, and any other features related to erosion potential. This survey can be accomplished in a number of ways:

i) using a total station and prism;

ii) stretching a tape or cable at a recoverable elevation using control pins on the right and left banks, precisely locating a rod at a recoverable station along the tape/cable near the base of the eroding bank, measuring perpendicularly from the rod back to the bank profile, recording the rod reading at each perpendicular with the distance to each bank feature and the rod height to the tape/cable, and finally converting these measurements to stations and elevations to add into the cross section survey.

f. Measure width between bridge piers and abuttments at bankfull stage. To determine the stage at which to measure distance between piers or abuttments, measure the difference between water surface and bankfull elevations at the cross-sections immediately upstream and downstream of the bridge. Average the two differences and measure this distance up from water surface at the bridge. If bridge construction documents include an as-built survey at the bridge, establish the location of the as-built survey and resurvey the cross-section to determine bed aggradation/degradation since construction.

4.2.3 Bed surface material characteriztion. Perform a modified Wolman pebble count following procedures given in Harrelson, et al., 1994 with the following exceptions:

a. No pebble count is performed on “A” and “Aa” type reaches (where slope> 0.4)

b. For all other stream types, establish reach boundaries using top-of-pool endpoints used in slope calculations. Aggregate adjacent reaches with the same

Level I stream types into a single reach. Divide each reach into ten equal intervals, locate the long profile station at the midpoint of each interval, and measure ten particles along transects spanning the bankfull channel at each of these stations. Alternatively, divide the thalweg length of the reach by 10, define a random start from the top of the reach, and determine stations by adding the interval.

c. Additional 100-count pebble counts should be conducted in riffle areas at all reference sections and BEHI locations with slopes < .02. If resources permit, riffle pebble counts can be conducted at remaining reaches. These data can be used to determine a dimensionless shear stress ratio that characterizes flow competence after Olsen, et al. (1998), defined as

$$J_e = J_o / J_c$$

where J_e = entrainment ratio; J_o = average boundary shear stress and J_c = critical shear stress for the D84 of the bed surface material.

4.2.4 Riparian vegetation characterization ground truthing procedures. Characterize riparian vegetation at randomly selected cross-section locations (the number will depend on the cover types found at each transect; minimally every category of cover should be encountered at least once, categories= forest, shrub/brush, grass, cropped, or impervious). Extend, from the reach classification cross-section, a transect for characterization of riparian vegetation for 50m in both directions from center of channel, with 0-station at center of channel, and record changes in vegetative community type (with station) along the transect starting at the stream bank.

5.0 Analysis

Following quality control verification, the field data derived from the above assessment can compiled analysis using a Geographic Information System, such as ArcView. Figures (X-Y) and Table (x) demonstrate how the data may be displayed and analyzed.

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