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Bankfull Characteristics of Select Streams in the Four Rivers and Upper Cumberland River Basin Management Units

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Executive Summary

Regional curves provide a baseline of stream characteristics that are useful in the design of stream restorations (Rosgen, 1998) and in the evaluation of stream stability, which includes the assessment of channel siltation, degradation, and bank erosion. In Kentucky, stream geomorphic assessment and restoration design currently are being conducted without the benefit of regional curves for geomorphic parameters. The main purpose of this project was to provide quantitative descriptions (regional curves) that would represent expected values and variation of bankfull flow and channel cross-sectional area, width, and depth in riffles as a function of upstream contributing drainage area in the Four Rivers and Upper Cumberland river basin management units of Kentucky.

Kentucky Division of Water requested that streams over the entire Four Rivers and Upper Cumberland river basin management units (RBMUs) be included in the project, which would necessitate collecting data from only the portions of the physiographic regions falling within those RBMUs. These two RBMUs include all watersheds with tributaries that drain to the Cumberland, Tennessee, and Mississippi Rivers in Kentucky. Because a second project on stream morphology in the Mississippi Embayment (Parola *et al.*, 2005) was initiated during this project, this assessment was completed at sites in the Mississippian Plateau and Land Between the Lakes regions of the Four Rivers river basin management unit and in the Mississippian Plateau and Eastern Kentucky Coal Field regions of the Upper Cumberland river basin management unit.

The intention of the project team was to use standard and well established procedures reported in Rosgen (1996), the *Interagency Stream Corridor Restoration Handbook* (FISRWG, 1998), and Harrelson *et al.* (1994) to obtain bankfull data from stream reaches at or near gauge stations with more than 10 years of recorded data. These techniques involve identification of the bankfull stage using (1) indicators described by Harrelson *et al.* (1994) at or near a gauge station and (2) measurement of stream bankfull cross section characteristics on a riffle at or near the gauge station. Determinations of bankfull flow, the active floodplain, and geometric characteristics of all but a few streams in the river basin management units were complicated, however, because of channel response to extensive and intensive human disturbance. Consequently, the intended method was revised to use only ungauged sites where bankfull indicators were consistent and less ambiguous.

Following reconnaissance, 17 ungauged reaches along 13 streams were selected for assessment. Using HEC-RAS 2.2 (see USACE, 1998), bankfull flow was calculated using (1) estimates of the channel roughness coefficient (Manning *n*) based on Limerinos (1970) and pebble count data, (2) estimates of bankfull depth at individual cross sections, and (3) cross section data. Each site was classified according to the method developed by Rosgen (1996). Bankfull flow discharge, depth, width, and cross-sectional area for each ungauged site in the Eastern Kentucky Coal Field physiographic region were plotted as a function of basin drainage area. Power functions relating channel bankfull flow characteristics to the upstream drainage area were developed for the data of the Eastern Kentucky Coal Field, although the portion of the Eastern Kentucky Coal Field represented by the Upper Cumberland RBMU is relatively small (31.0% of the physiographic region's land area). The data represents a very small population of streams that are moderately or deeply entrenched (B-type or F-type channels, respectively) and have bed material surface D_{50} in the very coarse gravel or small cobble size class. The curve information will be most applicable for stream assessment and for stream restorations in the same region of the Eastern Kentucky Coal Field and in other regions where the hydrology and sediment supply are similar.

A separate assessment of Mississippi Embayment streams was conducted (Parola *et al.*, 2005) during the same period as this assessment project. Additional data is required from the Mississippian Plateau to conduct separate regression analyses for that physiographic region and to determine differences between streams of different physiographic regions.

Consistent and reliable bankfull indicators were found in mainly two types of streams: (1) Rosgen F-type channels, located in alluvial valleys, in which an identifiable bankfull bench depositional feature formed within the F-type channel and (2) in higher gradient and less entrenched B-type channels located in valleys where the planform is confined by the valley sides. Reconnaissance of gauge stations and examination of ungauged streams in forested and currently protected watersheds in three different physiographic regions indicated that stream reaches that are not responding to either recent disturbances or legacy effects are rare. Even in protected, heavily forested, and in some cases, pristine-looking watersheds, Kentucky streams appear to be responding to current and legacy effects, including channel modifications and land-use changes.

Introduction and Background

1

1.1 INTRODUCTION

Based on the assessment of a select number of Kentucky streams, siltation, habitat modification and flow alteration are the cause of nearly half of the stream impairments in the Commonwealth (KDOW, 2004), with siltation listed as the most frequent cause of stream impairment. These primarily physical causes of stream impairment are all dependent on the entrainment, transport and storage of sediment, the geomorphology of stream channel networks, and the presence of riparian vegetation. Despite this dependence, geomorphologic data required to assess the current physical state of streams have not been developed for Kentucky streams.

Among the most useful practical tools for assessment of streams are regional channel characteristics relations, often referred to as regional curves. The curves are relations, as a function of upstream drainage area, of bankfull width, depth, cross-sectional area and discharge at a cross section of a stream. Given the strong influence of local climate and geology on stream channel form, regional curves are typically developed with respect to physiographic region (e.g., Wolman, 1955; Brush, 1961; Kilpatrick and Barnes, 1964; Leopold *et al.*, 1964; Everett and McCandless, 1999; Smith and Turrini-Smith, 1999; Harman *et al.*, 1999).

Regional curves provide a baseline of stream characteristics that are useful in the evaluation of stream stability, which includes the assessment of channel siltation, degradation, and bank erosion—factors that have substantial effects on aquatic habitat and sediment loads. Evaluation of channel stability is essential for the assessment of clean sediment loads, which may be needed for development of the sediment total daily maximum loads (TMDLs) required by recent US Environmental Protection Agency (USEPA) guidelines (USEPA, 1999). Furthermore, these regional relations can be used as a basis for some restoration design methods (Rosgen, 1998).

At present, stream geomorphic assessment and restoration design in Kentucky are being conducted without the benefit of regional curves for geomorphic parameters. The main purpose of this project was to provide quantitative descriptions (regional curves) that would represent expected values and variation of bankfull flow and channel cross-sectional area, width, and depth in riffles as a function of upstream contributing drainage area in the Four Rivers and Upper Cumberland river basin management units of Kentucky.

1.2 BACKGROUND AND PROTOCOLS

The development of "hydraulic geometry" relations by Leopold and Maddock (1953) provided a relationship between channel dimensions and mean annual discharge within specific physiographic regions. Wolman and Leopold (1957) introduced the concept of a bankfull discharge, where the bankfull flow return interval was found to be in the range of a 1- to 2-year flow event and whose stage is just contained within the streams banks. In the late 1970s, bankfull hydraulic geometry relations (regional curves) were introduced to graphically emphasize mathematical relations between upstream drainage area and bankfull discharge, width, depth and cross-sectional area in streams (Dunne and Leopold, 1978). Wolman (1955), Brush (1961), Kilpatrick and Barnes (1964), and Leopold *et al.* (1964) undertook some of the earliest hydraulic geometry research, which was based in geographic regions of the Eastern US. More recently, Smith and Turrini-Smith (1999), Everett and McCandless (1999), and Harman *et al.* (1999) completed state funded projects in Western Tennessee, Maryland, and North Carolina, respectively.

Smith and Turrini-Smith (1999) and Everett and McCandless (1999) provided protocols used to identify suitable stable stream channels for regional curve data collection. Those protocols included a wide range of drainage basin areas within designated "ecoregions"; operating discharge gauges with long-term hydrological records, preferred in order to determine discharge at the identified bankfull stage; and as many high quality streams—those having a channel environment that is alluvial, relatively stable, and not obviously modified—as possible.

Initially, a protocol similar to that used by Smith and Turrini-Smith (1999) and Everett and McCandless (1999) was to be followed for this project, which represents one of the first efforts to assess reach-scale morphology of streams in Kentucky. Preliminary reconnaissance undertaken at gauge stations in western and eastern Kentucky, however, suggested that Kentucky gauge station sites are often highly unstable with ambiguous bankfull indicators. As a result, an alternative protocol of regional curve site selection was developed. The initial purpose of this project, therefore, had to be augmented: not only was the final purpose of this project to develop regional curves for reference reaches in the Four Rivers and Upper Cumberland river basin management units, but regional curve data collection procedures also were developed for reach characterization of bankfull flow at ungauged sites.

1.3 OBJECTIVES

The goal of this project was to develop regional curves that would relate bankfull flow and channel characteristics along streams in the Four Rivers and Upper Cumberland river basin management units. The following objectives were established in order to meet the project goal:

1. Collection and review of site information for all USGS gauging stations in the Four Rivers and Upper Cumberland river basin management units in order to develop a list of potential sites.
2. Field reconnaissance of each potential site in order to identify reaches with unambiguous bankfull indicators.
3. Development of a procedure with which to extract bankfull flow channel characteristics data from ungauged locations.

4. Identification of stable reaches in each of the studied physiographic regions in which unambiguous bankfull stages could be identified.
5. Collection of bankfull flow channel characteristics and associated data.
6. Analysis of bankfull flow data.
7. Development of bankfull flow regional curves.

1.4 RESEARCH TASKS

The objectives of this research were accomplished through the following sequence of tasks:

1. Collection and review of maps and photographs to identify reaches likely to present consistent and reliable bankfull indicators.
2. Identification of the different physiographic regions in Western and Eastern Kentucky, and geomorphic reconnaissance to assess the overall stability of Kentucky channels within designated physiographic regions.
3. Establishment of a method to determine bankfull flow discharge from ungauged reference reaches; documentation of site selection protocols; and inventory of field data that had to be collected to both classify the project reach and characterize its bankfull flow geometry and discharge.
4. Selection of stream reaches in each physiographic region of the project and undertaking of all required field surveys and sediment samples; insertion of permanent monuments at each site; and photographic documentation and notation of site locations and characteristics.
5. Classification of each stream reach using collected geometric and sediment data according to the Rosgen classification scheme; calculation of the frequency and magnitude of the bankfull flow discharge; and determination of bankfull flow dimensions.
6. Development of regional curves.

1.5 PROJECT SCOPE

This project was completed with the joint participation of the University of Louisville Stream Institute (ULSI), the Kentucky Division of Water (KDOW), the Kentucky Nature Preserves Commission (KNPC), the US Forest Service (USFS), the US Fish and Wildlife Service (USFWS), the US Army Corps of Engineers (USACE), and the USDA Natural Resources Conservation Service (NRCS).

In an attempt to parallel the biological assessment of streams, Kentucky Division of Water requested that streams over the entire Four Rivers and Upper Cumberland river basin management units (RBMUs) be included in the project, which would necessitate collecting data from only the portions of the physiographic regions falling within those RBMUs. These two RBMUs include all watersheds with tributaries that drain to the Cumberland, Tennessee, and Mississippi Rivers in Kentucky. Because a second project on stream morphology in the Missis–sippi Embayment (Parola *et al.*, 2005) was initiated during this project, this assessment was completed at sites in the Mississippian Plateau and Land Between the Lakes regions of the Four Rivers river basin management unit and in the Mississippian Plateau and Eastern Kentucky Coal Field regions of the Upper Cumberland river basin management unit.

Materials and Methods 2

2.1 PHYSIOGRAPHIC REGIONS AND WATERSHEDS OF KENTUCKY

The landscape of Kentucky features five physiographic regions, as illustrated in Figure 2.1: the Mississippi Embayment, Mississippian Plateau, Western Kentucky Coal Field, Bluegrass, and Eastern Kentucky Coal Field. The physiographic regions of Kentucky correspond to geologic regions (see Figure 2.2) identified across the state, as the effects of bedrock surface weathering and erosion play a dominant role in shaping the land surface. For administrative purposes, Kentucky also groups its river basins into seven management units (KDOW, 2003). Two of the management units (also shown in Figure 2.1) are the Four Rivers (Mississippi, Ohio, Tennessee, and Cumberland) and the Upper Cumberland. Streams from three of the five physiographic regions of Kentucky contribute to these two river basin management units. The Four Rivers RBMU encompasses the entire Mississippi Embayment physiographic region (2532.46 mi^2) and the southwestern portion (19.4%, or 2174.12 mi^2) of the Mississippian Plateau; the Upper Cumberland includes the southeastern portion (13.9%, or 1551.66 mi^2) of the Mississippian Plateau and the southern portion (31.0%, or 3611.76 mi^2) of the Eastern Kentucky Coal Field physiographic region.

Differences in climatic conditions over these two RBMUs are minor, but the geology is very dissimilar in each of the physiographic regions that coincide with the RBMUs. The different geologies of the three different physiographic regions produce landscapes and streams of dissimilar characteristics. The Eastern Kentucky Coal Field drainage produces gravel bed mountain streams that dissect the Cumberland Plateau, which is capped with Pennsylvanian age sedimentary rock. Some of the Mississippian Plateau drainages are complicated by solution cavities (caves) formed in the massive limestone strata. On the other hand, the Mississippi Embayment is a coastal plain in which the current channels dissect unconsolidated coastal and continental deposits of the ancestral Tennessee and Cumberland/Ohio Rivers (Parola *et al.*, 2005).

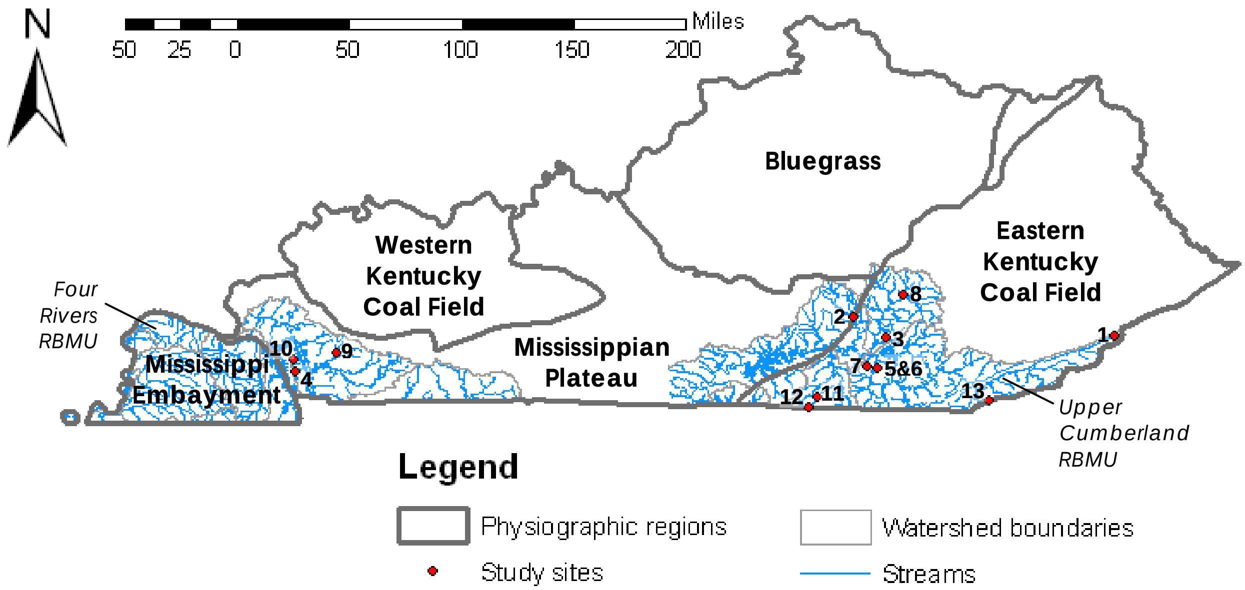

Figure 2.1 Physiographic Regions of Kentucky. Shaded areas are the Four Rivers and Upper Cumberland river basin management units (KGS, 1930; Noger, 1998; KGS, 2003; KDGI, 2005).

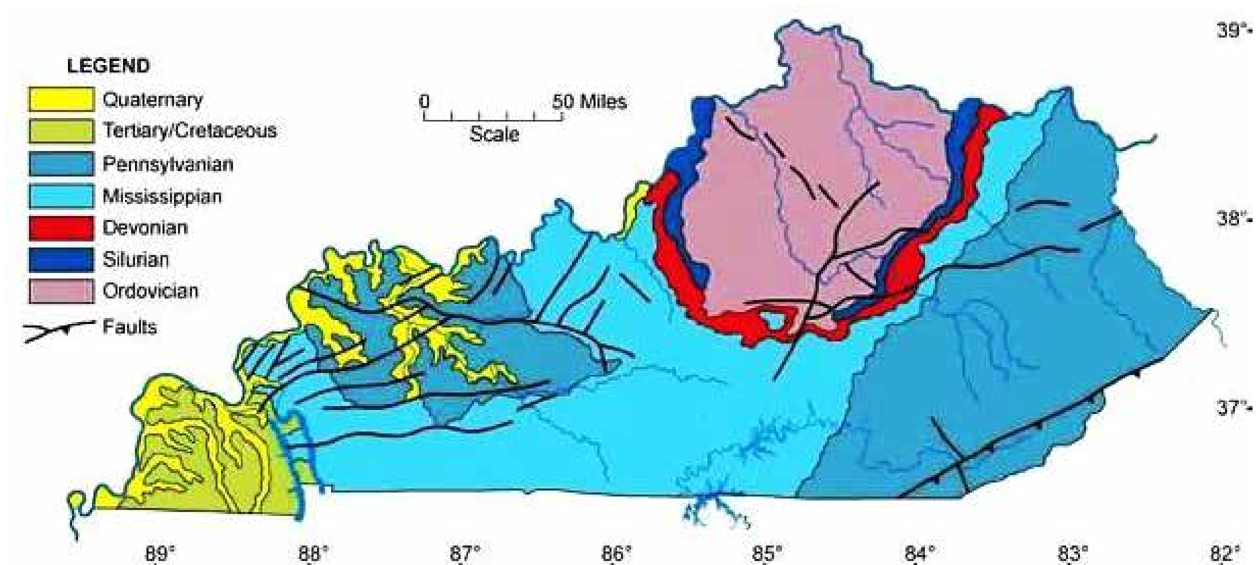

Figure 2.2 Geologic Map of Kentucky (adapted from KGS, 1997).

Land-use activities (Coleman, 1971) and their effects on streams, both dependent on the landscape, were also different in each of the regions. Land clearing, silviculture, agriculture, mining, transportation and other anthropogenic modifications may have had widespread direct and indirect impacts on Kentucky streams. Simpson (1999) identified probable sources of impacts to streams in both eastern and western areas of the state dating back to the mid-nineteenth century. These physical modifications to both large and small stream systems often cause channel instability and may severely debilitate the ecological function of the system.

In the Eastern Kentucky Coal Field region, mining, logging and removal of timber, and agriculture (Clark, 1992) directly affected streams. In the coastal plain, extensive channelization of all but a few stream systems has completed changed the flow regime of the channels (Parola *et al.*, 2005). Little is known about how anthropogenic activity has changed the flow dynamics, sediment transport regimes, and channel morphology in the Mississippian Plateau, though western areas of the state tend to have landscapes modified primarily by silviculture and agriculture and, in the Western Coal Field region, mining.

2.2 MEASUREMENT OF BANKFULL DATA

Identification of Bankfull Flow Conditions

The main objective of the field data collection phase of this project was to obtain bankfull characteristics of channels over a broad range of channel conditions throughout the Four Rivers and Upper Cumberland RBMUs. While several indicators of bankfull flow conditions have been identified (Williams, 1978; Leopold, 1994; Pruitt *et al.*, 1999; Smith and Turrini-Smith, 1999; Harman *et al.*, 2002; Doll *et al.*, 2003; McCandless, 2003; Sweet and Geratz, 2003), this project based determination of bankfull flow conditions on indictors of the flow that completely fills the channel so that its surface is level with the active floodplain; the active floodplain is the flat portion of the valley that is adjacent to the channel, constructed by the present river in the present climate, and frequently inundated by the river (Dunne and Leopold, 1978) at intervals of 1 to 2 years. Recognizing the co-evolution of channel and floodplain formation (Lauer and Parker, 2004) is of particular importance in defining the bankfull level and the active floodplain; if the river has incised, it may have abandoned the floodplain, which will have become a low terrace. Thus, distinguishing the active floodplain from low terraces is critical to identifying the bankfull stage.

The intention of the project team was to use standard and well established procedures reported in Rosgen (1996), the *Interagency Stream Corridor Restoration Handbook* (FISRWG, 1998), and Harrelson *et al.* (1994) to obtain bankfull data from stream reaches at or near gauge stations with more than 10 years of recorded data. These techniques involve identification of the bankfull stage using (1) indicators described by Harrelson *et al.* (1994) at or near a gauge station and (2) measurement of stream bankfull cross section characteristics on a riffle at or near the gauge station. If the cross section is at or very close to the gauge station and bankfull indicators are present, the bankfull discharge can be determined from the gauge information. Where the gauge has more than 10 years of record, frequency analysis based on the peak flow annual series (USIACWD, 1982) can provide an estimate of the return interval of the bankfull discharge. Where channels are not incised, or where incised channels have evolved to a point where signs of a redeveloping active floodplain are consistent and unambiguous, this method is straight-forward.

Determinations of bankfull flow, the active floodplain, and geometric characteristics of all but a few streams in the river basin management units were complicated because of channel response to extensive and intensive human disturbance. Several of the gauge stations were located in obviously straightened channels with piers in the channel that accumulated debris. Bank erosion, bed and bank scour, and the lack of established benches in these channels, which appeared incised, indicated that a reliable bankfull stage could not be identified. Consequently, the intended method was revised to use only ungauged sites where bankfull indicators were consistent and less ambiguous. Wherever possible, data on stream reaches were collected using the methods given in Harrelson *et al.* (1994). Only depositional features of the active floodplain were used as bankfull indicators, however; erosional indicators were not used.

Although the procedure for obtaining channel-cross sectional measurements, channel slope and bed materials at ungauged sites is similar to that at gauged sites, bankfull channel flow must be estimated based on computational methods rather than on measured values. In addition, direct frequency analysis based on flow history is not possible at ungauged sites. The method for development of the regional curves therefore was revised as described below.

Site Selection for Reach Assessment

During this assessment project, a second project on stream morphology in the Mississippi Embayment was initiated (Parola *et al.*, 2005). Therefore, this project focused on streams in the Four Rivers and Upper Cumberland river basin management unit portions of the Mississippian Plateau (including the Land Between the Lakes) and the Eastern Kentucky Coal Field regions.

USGS Gauging Stations

Site information for all USGS stream flow gauging stations in the Four Rivers and Upper Cumberland river basin management units was compiled prior to site visits to determine which stations (1) had ten or more continuous years of annual peak series data sufficient for conducting flood-frequency analysis, (2) had a stable stage-discharge relationship over the period of record for flood-frequency analysis, and (3) were located on sites with public access. Reach-scale instability, the lack of consistent and unambiguous bankfull indicators in incised channels, non-alluvial bedrock conditions, and recent channel modifications near gauge stations precluded the collection of bankfull data at those sites. At that time, the project team was unable to locate reliable indicators of bankfull stage at any sites examined at or near gauge stations; the experience developed by the project team during the course of the assessment, however, would increase the likelihood of locating and collecting useful data in the future at some of these sites.

Un-Gauged Reaches

Because of the obvious instability and recent disturbance at most examined gauges, we decided to focus efforts on streams that might represent reference conditions where bankfull indicators were consistent and reliable. Topographic maps and aerial photographs were extensively reviewed to identify reaches where channels had some curvature that would enhance channel widening processes and the formation of consistent bankfull features. Once such reaches were identified, reconnaissance of potential reaches was conducted to confirm that suitable conditions did indeed exist. An extensive field search was conducted for stream reaches with unambiguous bankfull indicators that, in incised channels, include depositional features indicating the development of an active floodplain.

Initially, a search was conducted to locate reference conditions in which signs of the effects of channel straightening or effects of channel incision due to some other anthropogenic cause, such as channel dredging or removal of woody debris, were not apparent. This task proved to be much more difficult than anticipated. Channel incision and bank erosion is pervasive in the examined streams. Many factors are considered to contribute to channel incision (Schumm, 1999), including changes in watershed hydrology. Although a few steep gradient stream sites without obvious signs of past channel manipulation were located, all stream reaches with valley flats in excess of 50 feet appeared to have been straightened either for agricultural purposes or to provide room for roadways and/or railroads, many of which have been abandoned.

Under the time constraints of the project, we could not verify the extent to which the affected streams had incised in most cases. We adopted the following criteria to select reaches from which to obtain bankfull cross section measurements:

- No visible channel instability (bed incision/aggradation, wide-scale bank erosion)
- System free to adjust to current flow regime (access to floodplain, pool scour, bar deposition)
- Flow not overwhelmingly controlled by local structures (bridges/culverts, trees in the flow path, bedrock, impingement zones) or influenced by downstream tributary
- Relatively straight section of channel between bends
- Pool-riffle-pool sequence
- Stable (riffle) cross section needed for flow modeling
- Clear, well-defined bankfull flow indicators on both banks

We then focused our search on stream reaches in the Daniel Boone National Forest (Eastern Kentucky Coal Field), the Land Between the Lakes (western edge of the Mississippian Plateau region), and a few other streams outside of these now protected areas. In conducting reconnaissance of large lengths of these streams, we observed channel instability in all examined stream reaches where valley flats of more than 50 feet were present. Channel straightening, channel dredging, confinement of floodplains by embankments, and removal of woody debris from streams appear to have caused channel incision and instability in many stream reaches. We were unable to locate a sinuous channel reach in a wide alluvial valley setting that was not obviously modified or affected by downstream channelization or recent dredging.

Our examination of gauge stations and reconnaissance of protected and forested watersheds in the Daniel Boone National Forest and in the Land Between the Lakes (LBL) indicate that channel networks have been highly modified in these regions of Kentucky for streams with contributing watersheds of less than 175 mi^2. Our examination of streams in the Mississippi Embayment indicate that the upper limit of highly modified channel networks may extend to watersheds of up to 400 mi^2 (see Parola *et al.*, 2005) in that physiographic region.

Although the watersheds are now primarily covered by forest, the streams in the LBL region are unstable and appear to be evolving from channel straightening that occurred prior to its designation in 1963 as a national recreation area. Upland channel degradation caused by upstream migration of headcuts into forested swales was pervasive in the LBL streams. Some low gradient channels were completely filled by the deposition of gravels derived from upstream headwater channel extension and degradation.

In the Daniel Boone National Forest, many remote streams that today have completely forested watersheds appeared to be unstable in reaches located in wide alluvial valleys. Roadway and railroad embankments, remnant sinuous channel reaches disconnected from existing channels, and highly straightened reaches of channel indicate past modification of all examined streams.

Following reconnaissance, 17 ungauged reaches along 13 streams were selected for assessment (see Table 2.1). Consistent and reliable bankfull indicators were found in mainly two types of streams: (1) Rosgen F-type channels in which an identifiable bankfull bench depositional feature formed within the F-type channel and (2) in higher gradient and less entrenched B-type channels located in valleys where the planform is confined by the valley sides. The F-type channels were incised channels located in alluvial valleys. Although channel and valley modifications were evident at all sites, the B-type channels used in this project were located in stream reaches that appeared to be less sensitive to channel and valley modifications.

Table 2.1 Assessment Site Location Summary

	Stream Name	Physiographic Region*	River Basin Mgmt. Unit†	County	Latitude	Longitude
1	Bad Branch	EC	UC	Letcher	N37º 04.09'	W82º 46.25'
2	Buck Creek	MP	UC	Pulaski	N37º 11.19'	W84º 27.37'
3	Cane Creek	EC	UC	Laurel	N37º 03.34'	W84º 14.48'
4	Crooked Creek	MP, LBL‡	FR	Trigg	N36º 49.81'	W88º 03.38'
5	Dog Slaughter	EC	UC	Whitley	N36º 51.60'	W84º 18.06'
6	South Fork Dog Slaughter	EC	UC	Whitley	N36º 51.52'	W84º 17.94'
7	Eagle Creek	EC	UC	McCreary	N36º 52.17'	W84º 22.16'
8	Horse Lick Creek	EC	UC	Jackson	N37º 20.15'	W84º 08.23'
9	Kenady Creek	MP	FR	Trigg	N36º 57.33'	W87º 47.77'
10	Racecourse Hollow	MP, LBL‡	FR	Lyon	N36º 54.87'	W88º 04.10'
11	Rock Creek (lower)	EC	UC	McCreary	N36º 39.76'	W84º 41.49'
12	Rock Creek (upper)	EC	UC	McCreary	N36º 35.99'	W84º 44.71'
13	Shillalah	EC	UC	Bell	N36º 38.95'	W83º 34.80'

* EC is Eastern KY Coal Field; MP is Mississippian Plateau; LBL is Land Between the Lakes; ME is Mississippi Embayment.
† UC is Upper Cumberland; FR is Four Rivers
‡ Crooked Creek and Racecourse Hollow are located in the Land Between the Lakes, whose geophysical characteristics are dissimilar from both the Mississippi Embayment and Mississippian Plateau physiographic regions.

The Buck Creek site located west of the Daniel Boone National Forest represents the only C-type stream included in the project and is the site with the highest contributing watershed (175.6 mi^2). Examination of aerial photographs of Buck Creek upstream of Kentucky Highway 80 indicate a past anabranched channel system that has subsequently been modified for agricultural purposes to a single thread channel.

2.3 DATA COLLECTION

Stream cross-sectional characteristics were measured along a riffle at each site from which a one-dimensional flow model could be used to estimate bankfull flow using HEC-RAS 2.2 (see USACE, 1998). Bankfull indicators were identified and measured along the channel and in each cross section. These basic data and parameters—see Rosgen (1996) for a detailed description of each—include

- Channel area
- Width
- Mean depth (area divided by width)
- Maximum depth
- Floodprone width (measured at twice maximum depth)
- Entrenchment ratio (floodprone width divided by bankfull width)

Field Surveys

On the floodplain, behind the bank edges and along the riffle at each cross-section, two permanent monuments (rebar set in concrete to a depth of at least 18 inches below the ground surface) were installed. Prior to field data collection, bankfull flow indicators were flagged along both banks at each cross section. Where a number of possible bankfull flow levels were identified, all indicators were marked.

Detailed cross-sectional and thalweg surveys were completed using a TOPCON ALP-1 robotic total station. The accuracy of the survey equipment was ± 1 mm in both the horizontal and vertical directions. Survey data were collected at each major break in the topographic slope. Additional measurements were taken near the bank top and at bankfull flow indicators to highlight any profile irregularities.

A series of at least five cross sections were marked in each reference reach, based on a pool-riffle-pool sequence. Cross sections were selected at the deepest point of the thalweg in the upstream pool, at the crest of the riffle, at two sections on the gentle slope of the riffle downstream of the crest and in the deepest part of the downstream pool. Extra cross-sections were added where the channel width markedly varied. To permit calculation of the entrenchment ratio and classification of the channel, the flood prone area at twice the bankfull depth was quantifiably wider than the channel at each cross section (Rosgen, 1994).

Sediment Sampling

The Wolman pebble counting procedure as described in Bunte and Abt (2001) was used to measure the surface particle size distribution of the bed material. In order to characterize the bedload, a bulk sample (surface and subsurface) was collected from the downstream third of a bar in or near to the assessment reach approximately halfway between the thalweg and the bankfull stage. Bar samples were obtained at some sites according to the method used by Rosgen (1996) to estimate the characteristics of the bedload.

2.4 DATA REDUCTION

Bankfull Analysis of Ungauged Site Data

Using HEC-RAS 2.2 (see USACE, 1998), bankfull flow was calculated using (1) estimates of the channel roughness coefficient (Manning *n*) based on Limerinos (1970) and pebble count data, (2) estimates of bankfull depth at individual cross sections, and (3) cross section data. The water surface profiles were computed through an iterative calculation sequence: bankfull flow was assumed, then the water surface was computed and checked against bankfull indicators; flow and downstream boundary conditions continued to be modified until the water surface profiles of two flows (high and low) bracketed the bankfull indicators along the channel profile. A third flow was computed that was considered to be the mid-range flow that, in some cases, was the best fit through the upstream portion of the riffle. This analysis procedure produced estimates of low, intermediate, and high bankfull flow. Although critical depth (where the flow cross section Froude number is equal to 1.0) and uniform flow provide reasonable upper bound limits to the flow estimation procedure (see Henderson, 1966), the accuracy of the method is unknown for estimating bankfull flow. Appendix C provides the data from each site used in the analysis.

Development of Regional Curves

Each site was classified according to the method developed by Rosgen (1996). Bankfull flow discharge, depth, width, and cross-sectional area for each ungauged site in the Eastern Kentucky Coal Field physiographic region were plotted as a function of basin drainage area. Power functions relating channel bankfull flow characteristics to the upstream drainage area were developed for the data of the Eastern Kentucky Coal Field, although the portion of the Eastern Kentucky Coal Field represented by the Upper Cumberland RBMU is relatively small (31.0% of the physiographic region's land area). Data for the diverse geologic conditions of the Mississippian Plateau were insufficient to develop regional curves under this project.

Database Development

A Microsoft Access database (Appendix C) was developed to present data from each of the ungauged sites. The database includes site location data, bankfull cross sectional parameters, surface sediment characteristics, Rosgen stream classification (1996), and a photograph of the site.

Results and Discussion 3

Data from 13 stream reaches were collected and analyzed to obtain bankfull characteristics. The results of the data analysis are provided below.

3.1 BANKFULL FLOWS, CHANNEL CHARACTERISTICS, AND CLASSIFICATION

Analysis of flow based on one-dimensional steady-state modeling using HEC-RAS 2.2 resulted in the bankfull flows and channel cross-sectional characteristics given in Table 3.1. The flow that provided the best fit to bankfull indicators along the riffle profile is given as the bankfull flow. In addition, a range of flows that fit the indicators is also given. Channel cross-sectional characteristics are given for the best fit bankfull flow conditions.

The stream types provided in Table 3.1 were determined for each reach using the Rosgen (1996) classification method. While a value of 1.4 typically differentiates entrenchment ratios of F-type streams from B-type streams, the entrenchment ratios that delineate one stream type from another may vary by ±0.2 units. Thus streams with entrenchment ratios as low as 1.2 can be classified as B-type streams depending on several factors (see Rosgen, 1996). Three of the stream reaches with entrenchment ratios of less than 1.4 were classified as B-type rather than F-type; a B-type stream classification was applied to streams in which colluvium was present as part of the bed and bank materials and valley confinement force entrenchment. The “F” classification was given to streams in which channel incision and widening was evident and a wide alluvial valley flat existed adjacent to the channel. The “/1” in two of the steam classifications indicates an abundance of bedrock exposure in the examined reach. Only one of the streams from which bankfull parameters were obtained was a C-type stream and none were E-types.

Table 3.1 Bankfull Flow Characteristics and Channel Classification

Stream	DA (mi^2)	Q_{BKF}* (cfs)	$\overline{V}_{BKF}$ (fps)	A_{BKF} (ft^2)	W_{BKF} (ft)	D_{BKF} (ft)	W/D Ratio	ER†	D_{50} (mm)	S‡ (%)	Stream Type§
1 Bad Branch	2.6	110 (100–130)	3.8	29.0	24.7	1.17	21.1	1.3	78.0	1.80	B3c
2 Buck Creek	175.6	2200 (1750–2500)	4.4	504.7	115.5	4.37	26.4	>2.2	41.0	0.11	C4
3 Cane Creek	7.5	153 (125–175)	2.5	60.3	33.0	1.83	18.1	1.4	46.3	0.46	B4c
4 Crooked Creek	4.8	150 (125–175)	3.8	39.6	38.1	1.04	36.7	1.2	28.5	0.58	F4
5 Dog Slaughter	6.0	200 (150–225)	3.6	56.0	37.5	1.49	25.2	1.2	90.5	0.96	B3c
6 S. Fork Dog Slaughter	3.5	135 (110–150)	3.2	42.2	26.3	1.61	16.3	1.7	135.0	1.60	B3c
7 Eagle Creek	3.5	150 (125–200)	3.2	47.4	31.8	1.49	21.3	1.1	37.0	0.33	F4/1
8 Horse Lick Creek	55.8	750 (700–800)	3.6	210.0	62.6	3.36	18.7	1.7	27.5	0.17	B4c
9 Kenady Creek	27.0	275 (250–325)	3.4	81.6	49.3	1.65	29.8	1.2	29.5	0.31	F4
10 Racecourse Hollow	1.8	90 (80–110)	3.1	28.9	23.6	1.22	19.3	1.4	18.5	0.31	F4
11 Rock Creek (lower)**	29.8	250 (225–300)	3.9	63.3	39.3	1.61	24.4	1.6	42.0	0.48	B4c
12 Rock Creek (upper)	18.8	350 (300–400)	4.1	85.4	53.0	1.61	32.9	1.2	46.3	0.76	B4c/1
13 Shillalah Creek	1.9	85 (75–100)	3.2	26.4	25.4	1.04	24.3	1.7	63.5	1.70	B4c

* Numbers in parentheses give range of possible values.
† ER is entrenchment ratio.
‡ Bankfull friction slope from flow modeling.
§ Based on Rosgen Classification System (1996).
** Data not used in Eastern KY Coal Field regression.

Channels on Wide, Flat Floodplains (C- and E-Type Channels)

Based on a limited examination of streams, we suspect that channel straightening, primarily for agricultural purposes, is the most frequent cause of the lack of sinuous streams such as Rosgen C- and E-types. Consequently, most small streams appear to be incised. Many stream reaches in the Upper Cumberland RBMU have been moved to the base of the valley hillside and have incised to bedrock. Figure 3.1 shows a reach of Pitman Creek, a tributary to the upper Cumberland River in the Mississippian Plateau, that has been extensively channelized and, as a consequence, has incised into very weatherable (i.e., susceptible to chemical, mechanical, and/or biological breakdown) and erodible shale. The valley and extensive floodplain indicate that these streams were probably sinuous streams with pool and riffle morphology. As is indicated in Figure 3.1, the aquatic habitat has been degraded substantially from that provided by typical pool-riffle morphology.

Small tributaries appear also to be have been affected by (1) straightening of the tributary near the valley bottoms at their confluence with the main stem, (2) changing of the base level at their confluences, associated with main stem degradation, and (3) channel shortening related to the relocation of the main stem closer to the valley hillside. The changes in tributary channel geometry and in the sediment supply generated from the head cut and subsequent incision can be large, as shown in Figure 3.2.

These factors appear to cause channel incision in many very small tributaries that may have influenced the extension of the channel network into the hillsides and exposure of bedrock in the tributary channel beds. The positioning of channels along valley hillsides, the incision of tributary channels, and the up-valley extension of the channel network may influence landslide activity. Figure 3.3 shows a small surficial landslide that appears to have been initiated by the erosion of the base of the hillside caused by the relocated stream channel.

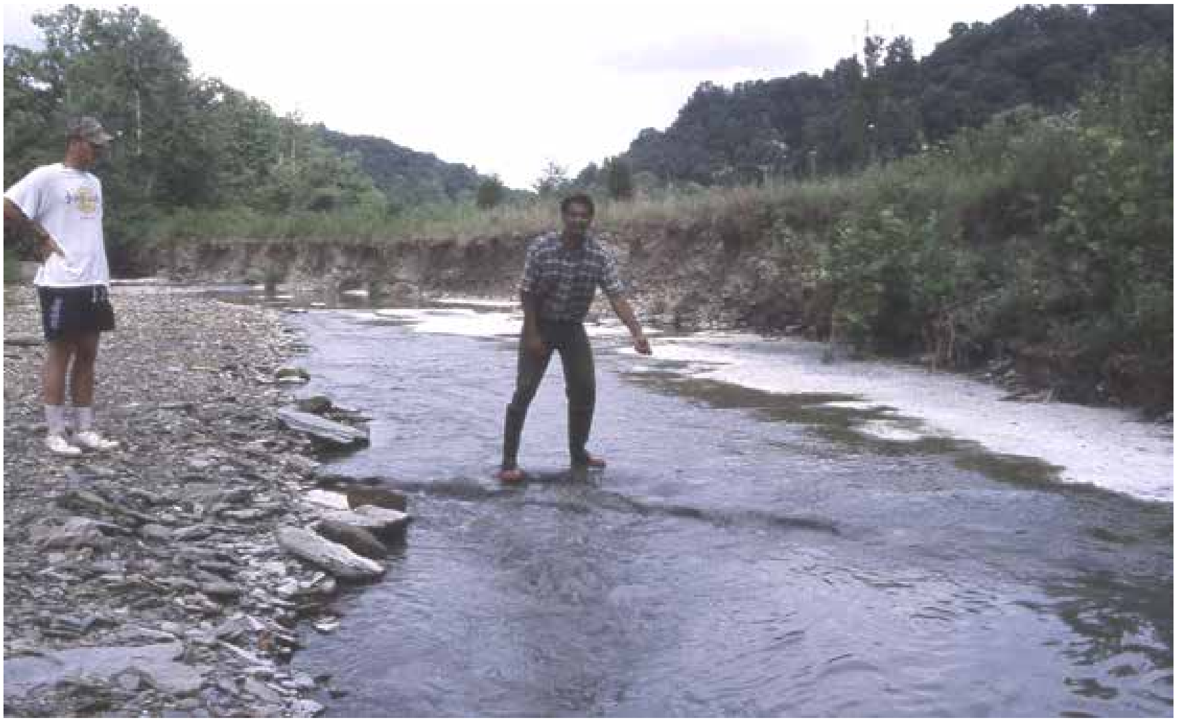

Figure 3.1 Exposure of shale bedrock caused by channel incision associated with straightening of Pitman Creek, a tributary of the upper Cumberland River, Pulaski County.

Figure 3.2 A headcut is migrating upstream in this small tributary in the Land Between the Lakes (LBL) region of western Kentucky. Bed degradation appears to have migrated upstream from the confluence of larger downstream channels that have been straightened.

Figure 3.3 Surficial landslide caused by erosion of the base of the hillside by Indian Creek (tributary of Buck Creek in the Upper Cumberland RBMU) in Lincoln County.

3.2 REGIONAL ANALYSIS OF BANKFULL FLOW AND CHANNEL GEOMETRY

The characteristics of bankfull flow, channel cross section area, top width, and depth collected in this assessment project were examined with respect to the watershed drainage area contributing to the channel at the locations of the observations. Curves of bankfull flow and cross-sectional characteristics as a function of contributing drainage area, collectively referred to as bankfull regional curves, were developed for data obtained from the portion of the Eastern Kentucky Coal Field physiographic region falling within the Upper Cumberland RBMU. Data collected from other physiographic regions was insufficient for curve development.

Polynomial regression based on the method of least squares (Neter and Wasserman, 1974) was used to develop power functions of the following form:

$$Y_{BKF} = a\ DA^{b} \qquad (2)$$

The variable Y_{BKF} represents the following bankfull parameters: bankfull discharge, Q_{BKF} (cfs); flow area, A_{BKF} (ft^2); channel bankfull width, W_{BKF} (ft); or average flow depth, D_{BKF} (ft). The variable DA (mi^2) is the drainage area. Table 3.2 provides the results of the regression analysis for each parameter. Figures 3.4 through 3.7 show plots of the resulting power curves and the data from which they were developed.

Although not used in the development of the regional curves for the Eastern Kentucky Coal Field region falling within the Upper Cumberland RBMU, data from the Mississippi Embayment and Mississippian Plateau physiographic regions are plotted for comparison. Data from the lower Rock Creek site were separated from the Eastern Kentucky Coal Field dataset in the regression analysis because that section of Rock Creek may be influenced by subsurface flow in solution cavities located in Mississippian age rock beneath its valley.

Table 3.2 Regression Equations of Channel Bankfull Characteristics for Streams of the Upper Cumberland River Basin Management Unit Within the Eastern Kentucky Coal Field Physiographic Region

Bed Material	Regression Equation	Coefficient of Determination, R^2
Gravel and cobble	$Q_{BKF} = 60.3\ DA^{0.61}$	0.96
	$A_{BKF} = 19.1\ DA^{0.57}$	0.97
	$W_{BKF} = 20.1\ DA^{0.30}$	0.93
	$D_{BKF} = 0.95\ DA^{0.28}$	0.80

3.3 DISCUSSION

The surface particle size for each site is provided in Table 3.1. Table 3.3 shows the distribution of sites with respect to sediment size class. Three of the four streams with D_{50} of coarse gravel (Table 3.3) were located in the Mississippian Plateau (Table 3.1). All but one stream (Horse Lick) in the streams of the Eastern Kentucky Coal Field had a D_{50} in the size class of very coarse gravel or small cobble.

Table 3.3 Distribution of Sediment Size Classes for Assessed Streams

Size Class	Bed Material Surface D_{50} Size Range (mm)	Number of Sites
Coarse gravel	16–32	4
Very coarse gravel	32–64	6
Small cobble	64–128	3

The regression analysis shows a high coefficient of determination ($R^2 > 0.90$) for the log transform of bankfull flow, channel cross-sectional area, and channel top width for the relatively small number of selected streams of the portion of the Eastern Kentucky Coal Field falling within the Upper Cumberland river basin management unit. The coefficient of determination on the log transform of bankfull depth was slightly lower ($R^2 = 0.80$) for the same data. The data on which the regression was performed represents a very small population of streams that are moderately or deeply entrenched (B-type or F-type channels, respectively) and have bed material surface D_{50} in the very coarse gravel or small cobble size class.

A separate assessment of Mississippi Embayment streams was conducted (Parola *et al.*, 2005) during the same period as this assessment project. Additional data is required from the Mississippian Plateau to conduct separate regression analyses for that physiographic region and to determine differences between streams of different physiographic regions. Despite the dissimilarity of regional geology, however, the two data points from the LBL streams (Crooked Creek and Race Course Hollow) appear to be consistent with the Eastern Kentucky Coal Field data for flow and channel cross-sectional area. Data from streams outside of the LBL region of the Mississippian Plateau (Kenady Creek and Buck Creek) do not indicate the same similarity.

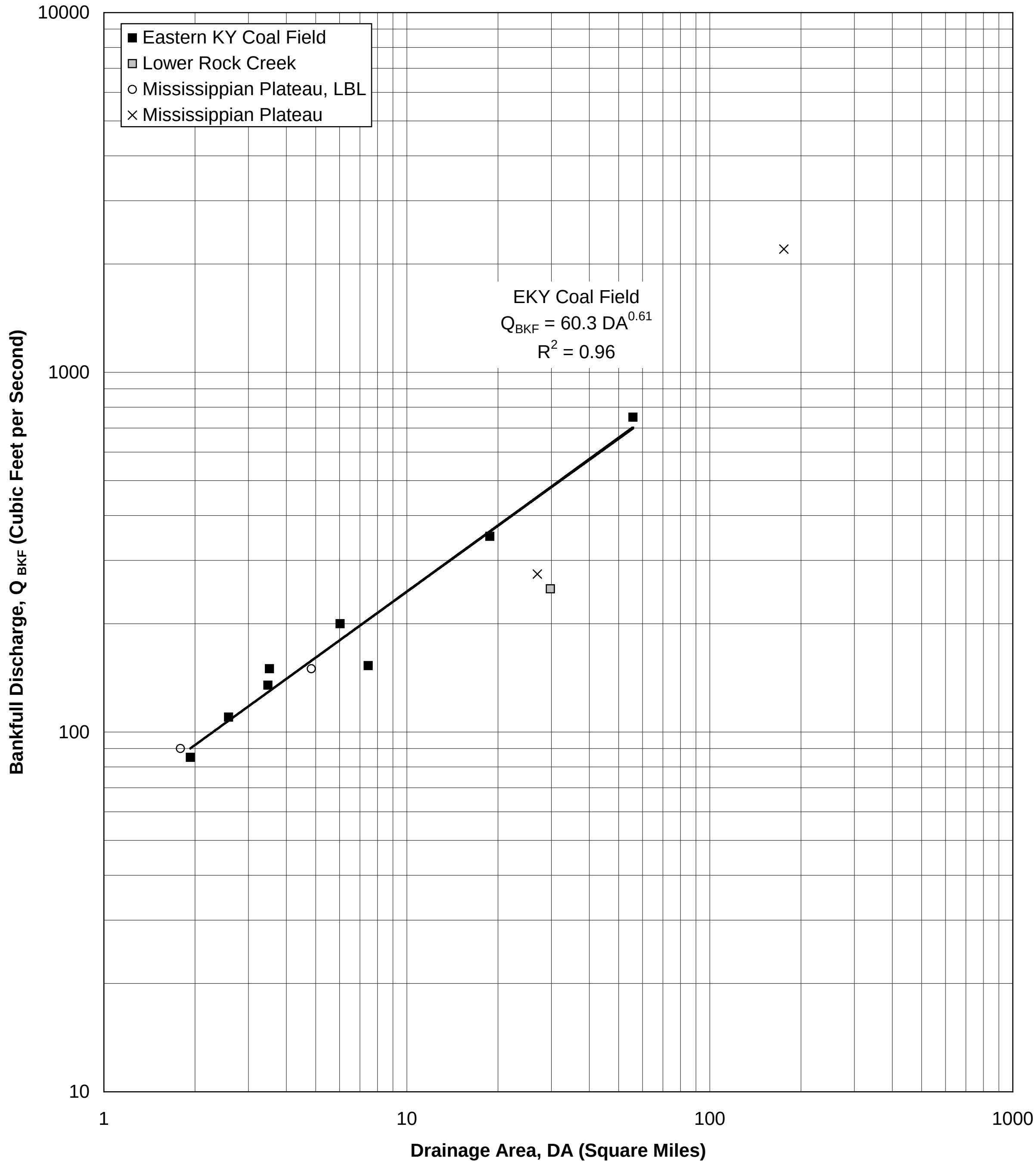

Figure 3.4 Calculated bankfull flow for select streams in the Four Rivers and Upper Cumberland river basin management units. The regression equation and line were developed from streams in the Upper Cumberland portion of the Eastern Kentucky Coal Field physiographic region.

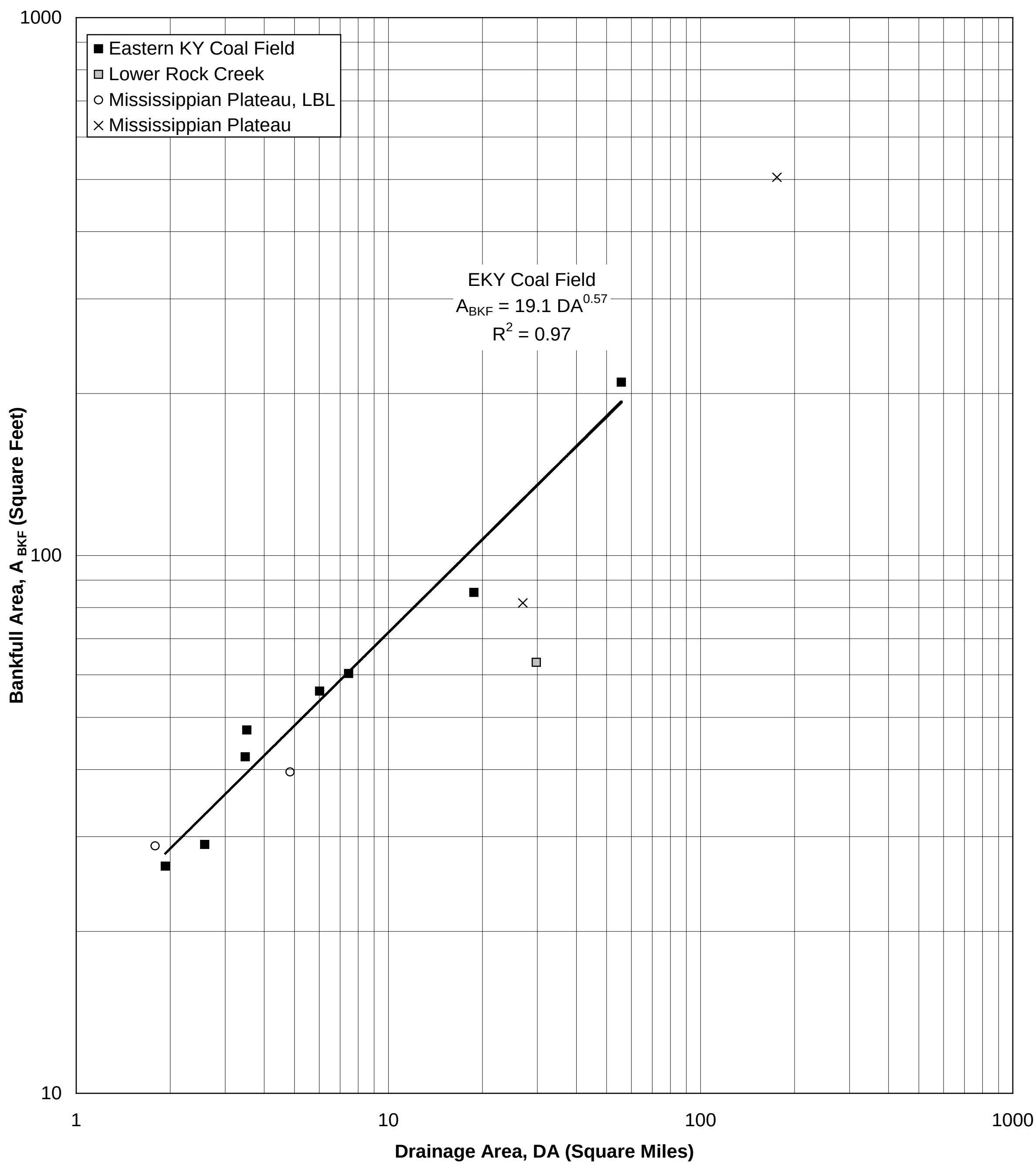

Figure 3.5 Bankfull flow area for select streams in the Four Rivers and Upper Cumberland river basin management units. The regression equation and line were developed from streams in the Upper Cumberland portion of the Eastern Kentucky Coal Field physiographic region.

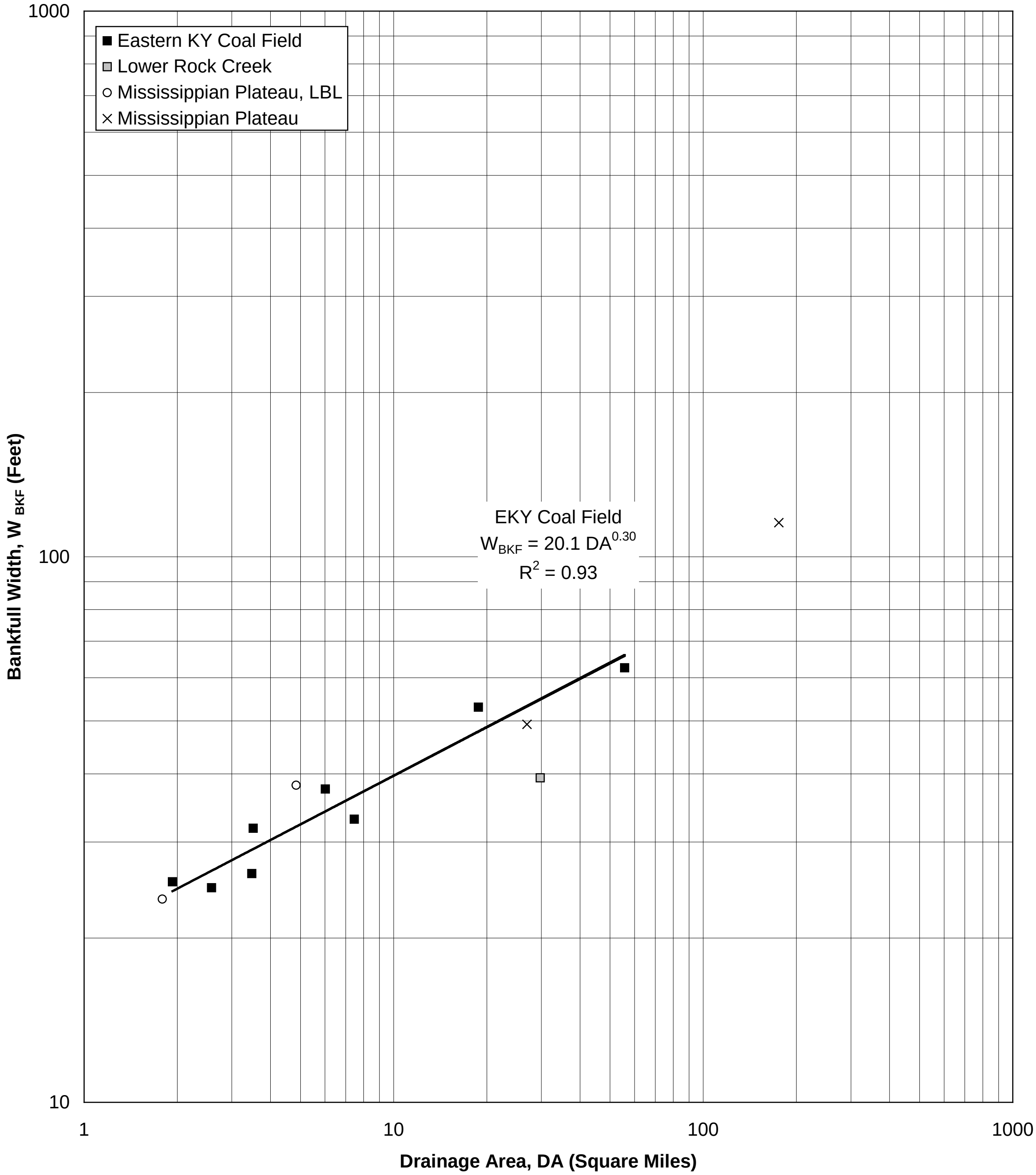

Figure 3.6 Bankfull flow width for select streams in the Four Rivers and Upper Cumberland river basin management units. The regression equation and line were developed from streams in the Upper Cumberland portion of the Eastern Kentucky Coal Field physiographic region.

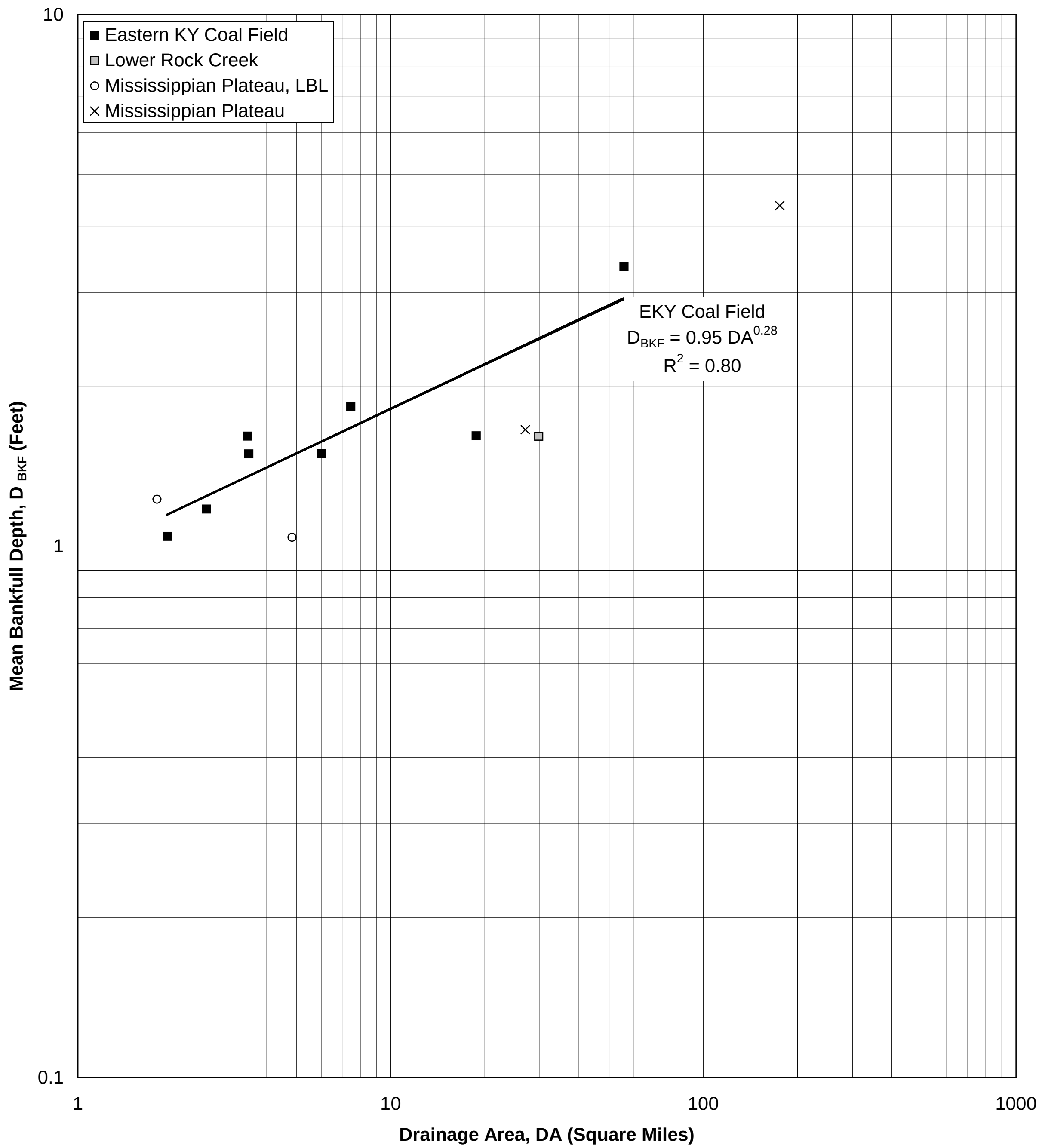

Figure 3.7 Bankfull flow average depth for select streams in the Four Rivers and Upper Cumberland river basin management units. The regression equation and line were developed from streams in the Upper Cumberland portion of the Eastern Kentucky Coal Field physiographic region.

Conclusion 4

The focus of this project, which represents one of the first efforts to assess reach-scale morphology of streams in Kentucky, was to develop a set of regional curves that would represent expected values and variation of bankfull flow and channel cross-sectional area, width, and depth in riffles as a function of upstream contributing drainage area. At the request of the Kentucky Division of Water, this project was conducted on the basis of the particular river basin management units targeted by KYDOW for funding during the 1999 grant year, rather than on a particular physiographic region of the state. Data was collected from streams in the Eastern Kentucky Coal Field and Mississippian Plateau regions of the Upper Cumberland RBMU and the Mississippian Plateau and Land Between the Lakes regions of the Four Rivers RBMU. A separate assessment of streams of the Mississippi Embayment, which also falls within the Four Rivers RBMU, was conducted (Parola *et al.*, 2005) during the same period as this assessment project.

The intention of the project team was to use standard and well-established procedures reported by Harrelson *et al*. (1994) to obtain bankfull data from stream reaches at or near gauge stations. Because reliable bankfull indicators could not be identified in the highly modified channels at gauge stations, however, bankfull cross section measurements were obtained only from un-gauged sites. Ungauged sites lack historic stream flow records, so frequency analysis at sites using direct measurements could not be developed and, therefore, the frequency of the estimated bankfull discharges could not be made directly. The Stream Institute did initiate a regional characterization of peak flow discharges that may be used in future evaluations of bankfull discharge at ungauged sites. The method used for obtaining an estimate of bankfull flow at ungauged sites was a straightforward application of the steady-state one-dimensional hydraulic model HEC-RAS 2.2 using field-identified bankfull indicators, cross section data, and surface roughness relations. The accuracy of this method for estimating bankfull discharge is unknown and should be examined at sites where computed discharges can be compared to gauge station values.

Power functions relating channel bankfull flow characteristics to the upstream drainage area were developed for the data of the Eastern Kentucky Coal Field. The data, though, represents a very small population of primarily coarse gravel- and cobble-bed streams from this physiographic region.. Thus the curve information will be most applicable for stream assessment and for stream restorations in the same region of the Eastern Kentucky Coal Field and in other regions where the hydrology and sediment supply are similar. While the data collected from the Mississippian Plateau will be useful for future assessment projects that may be completed based on that physiographic region, it was insufficient for development of a regional curve for that portion of the Four Rivers RBMU.

4.1 GENERAL FINDINGS AND CONCLUSIONS

Some stream restoration design techniques, including those proposed by Rosgen (1998), rely heavily on the concept of natural templates for design. The natural template, called a reference reach, should match the stream type of the proposed restoration reach; under ideal conditions, this reach would also contain the characteristics of an undisturbed channel. In the Rosgen method, reference reach geometric parameters are scaled through the use of dimensionless parameters to design the dimensions, profile characteristics and planform pattern of the restored channel. Our examination of stream channels in the Four Rivers and Upper Cumberland RBMUs indicates that the use of reference reaches for development of stream planform characteristics may be inappropriate for design of meandering streams on wide floodplains (Rosgen C- or E-type streams) unless the intent of the design is to create a stream that will continue to develop planform with generally increasing planform pattern parameters such as meander beltwidth and meander wavelength.

Our reconnaissance of gauge stations located at or near highway crossings and our examination of ungauged streams in forested and currently protected watersheds indicate that stream reaches that are not responding to either recent human disturbances or legacy effects are rare. Until this point, the probable extent of channel degradation associated with historic and contemporary direct modification of stream channels, particularly those in wide alluvial valleys, was not generally known. Several presentations by the project team have been made to inform the Kentucky Division of Water and other resource agencies of the extensive and intensive channel modifications that affect channel morphology and channel evolution in these river basin management units. Any channel located in valley bottoms that could be plowed and used for farming at any time in the post European-settlement history of Kentucky may have been directly modified to either drain adjacent wetlands (Biebighauser, in preparation), to reduce flood frequency, or to reduce the effects of the stream footprint. In our reconnaissance of streams (1) contributing to watersheds of up to 20 square miles, (2) located in an alluvial valley in which channel planform was not confined, and (3) having a floodplain of more than 50 feet in width we did not locate a single stream which had not been straightened or affected by straightening.

Even though channels may adjust rapidly to redevelop bankfull cross-sectional characteristics of the currently supplied sediment loads, channel profile characteristics (Parker *et al.*, 2003) and channel planform characteristics (Thorne, 1999), including bend radius, belt width, and bend-to-bend spacing, may require centuries to fully redevelop. In all three physiographic regions, tree fall and debris jam formation appear to play an important role in the evolution of channel planform, particularly in straightened reaches of incised channels. In fact, many straightened channels appear to be remaining straight until trees have grown sufficiently tall that those that fall are capable of at least partially spanning the channel and supporting debris jams. Once mature trees on the banks are undermined by bank erosion, the streams will migrate through bend scour, bank erosion in bends, and erosion around debris jams.

4.2 RECOMMENDATIONS FOR FURTHER INVESTIGATION

Multiple physiographic regions may contribute to a single river basin management unit; because hydrology and sediment characteristics largely depend on geology, which varies between physiographic regions, development of a single set of regional curves that represent streams of an entire RBMU would be impractical. Rather, data for streams within an RBMU should be interpreted and applied with respect to the physiographic region in which the streams are located in the RBMU. Future assessments of bankfull channel geometry should therefore be conducted on a physiographic region basis.

The data, equations, and curves provided in this report should be used with consideration for the range of data they represent and the types of streams from which the data was collected. The portion of the Eastern Kentucky Coal Field physiographic region falling within the Upper Cumberland RBMU is relatively small and the data presented here represents a limited sample of the population of streams in that region. Data on high gradient (having slopes greater than 2%) cobble- and boulder-bed streams should be collected in both the Mississippian Plateau and the Eastern Kentucky Coal Field physiographic regions to determine the bankfull characteristics of those types of streams. Additional data on streams with low entrenchment (C-type and E-type) and smaller bed material sizes should also be collected. Because of channel response (mainly channel incision) to human disturbance, however, C- and E-type streams with small drainage areas are much more rare than the B- and F-type streams represented in this report. While many streams with drainage areas of at least 40 square miles have low entrenchment, streams of the Eastern Kentucky Coal Field that are located in wide valleys and have small drainage areas were extensively modified, causing channel incision and continued channel adjustment resulting in mostly F- or B-type channels.

Although bankfull indicators at gauge stations were found to be ambiguous in this assessment, examination of additional sites following the conclusion of this project suggested that a few of the gauge stations may have sufficient morphological indicators of bankfull flow conditions that they may be found to be useful in the future. As regional curve studies are conducted in each of the physiographic regions, gauge stations should be reexamined to determine whether useful information could be extracted for the sites.

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Appendices

TM

Financial and Administrative Closeout

A

APPLICATION OUTPUTS

Milestones	Expected Begin Date	Expected End Date	Actual Begin Date	Actual End Date
1. Obtain information on all gauging stations in the project area	Jan 2000	Feb 2000	Feb 2000	Feb 2000
2. Develop a list of potential reference sites	Jan 2000	Feb 2000	Feb 2000	Mar 2000
3. Visit each site and classify stream type	Feb 2000	Mar 2000	Feb 2000	Jul 2000
4. Eliminate unsuitable sites	Feb 2000	Mar 2000	Feb 2000	Mar 2000
5. Conduct reference site station frequency analysis	Mar 2000	Apr 2000	Feb 2000	Nov 2000
6. Collect reference reach data	Mar 2000	Oct 2000	Apr 2000	Aug 2000
7. Analyze reference site data	Apr 2000	Nov 2000	Apr 2000	Dec 2000
8. Develop regional bankfull geomorphic characteristic curves	May 2000	Dec 2000	Oct 2000	Dec 2000
9. Submit annual report	Sep 2000	Sep 2000	Oct 2000	Dec 2005
10. Submit final/close out reports	Aug 2000	Dec 2000	Dec 2002	Dec 2005

BUDGET SUMMARY: UNIVERSITY OF LOUISVILLE RESEARCH FOUNDATION'S DETAILED BUDGET

Budget Categories	319 Grant	University of Louisville Research Foundation	Total	Actual	Difference	Notes
Personnel	$42,247.00	$17,360.00	$59,607.00	$54,446.45	$5,160.55	Actual benefits were 9% less than estimated.
Supplies	$2,000.00	$0.00	$2,000.00	$2,202.65	($202.65)	Actual cost of supplies exceeded estimate by 10%.
Equipment	$0.00	$9,000.00	$9,000.00	$9,000.00	$0.00	
Travel	$6,000.00	$0.00	$6,000.00	$6,558.58	($558.58)	Actual cost of in state travel exceeded estimate by 9%.
Contractual	$0.00	$0.00	$0.00	$0.00	$0.00	
Operating Costs	$13,752.00	$23,020.00	$36,772.00	$36,836.41	($64.41)	Actual costs for basic office operations slightly exceeded estimate ($359.41 instead of $295).
Other	$6,000.00	$0.00	$6,000.00	$10,334.91	($4,334.91)	Costs for out of state training and travel exceeded estimates, almost doubling the cost of training expenses.
Total	**$69,999.00**	**$49,380.00**	**$119,379.00**	**$119,379.00**	**$0.00**	

The University of Louisville Research Foundation was reimbursed $69,999. All dollars were spent; there were no excess project funds to reallocate.

EQUIPMENT SUMMARY

No equipment was purchased for this project: the funds ($9,000) listed in the Equipment category were allocated as delineated in the MOA:

$6,000.00 toward the rental of a field vehicle
$1,000.00 toward maintenance costs for the field vehicle
$1,000.00 toward rental of one laptop PC
$1,000.00 toward maintenance for the robotic total station used to collect field data
$9,000.00 total

Although no purchases were made in this category, all equipment and vehicles were maintained and managed in compliance with the MOA and 40 CFR Part 31.32.

SPECIAL GRANT CONDITIONS

The Quality Assurance and Quality Control (QA/QC) Plan was submitted in February, 1999 and approved in February, 2000. Please see Appendix B for the QA/QC Plan.

Quality Assurance and Quality Control (QA/QC) Plan

B

Prepared by: Arthur C. Parola, Jr., Ph.D.
Department of Civil and Environmental Engineering
University of Louisville

February 17, 1999

Type of NPS Problem Addressed: Hydromodification

Project Organization and Responsibility

Key Personnel:

1. Project Officer: Arthur C. Parola, Ph.D.
University of Louisville
Department of Civil and Environmental Engineering
Louisville, KY 40292
Phone (502) 852-4599
Fax (502) 852-8851
E-mail a.c.parola@louisville.edu

2. QA Officer: Arthur C. Parola, Ph.D.

3. Field Sampling Supervisor: Arthur C. Parola, Ph.D.

4. Laboratory Supervisor: D. J. Hagerty, Ph.D. PE
University of Louisville
Department of Civil and Environmental Engineering
Louisville, KY 40292
Phone (502) 852-4565
Fax (502) 852-8851

List of Laboratories that will be used:

University of Louisville
Department of Civil and Environmental Engineering
Geotechnical Laboratory
Louisville, KY 40292
Phone (502) 852-4599
Fax (502) 852-8851

List of other agencies responsible for monitoring/monitoring activities:

N\A. The University of Louisville will be conducting the monitoring without assistance from outside agencies.

Stream Name(s): Various Streams of the Cumberland/Tennessee and Mississippi River Basin Management Units
Major River Basin: Cumberland/Tennessee and Mississippi River Basin Management Units
Stream Order: Various
County(s): Counties within the Cumberland/Tennessee and Mississippi River Basin Management Units

Monitoring Objectives

A. Obtain stream geomorphologic measurements to quantify bankfull stream characteristics at various stream reaches in the Cumberland/Tennessee and Mississippi River Basin Management Units.

Project Area Description

General description of the location of the project area(s):
The project area includes all river basins within the Cumberland/Tennessee and Mississippi River Basin Management Units.

Description of the physical environment of the project area:

The topography, soils, and geology vary across many geophysical regions in the Cumberland/Tennessee and Mississippi River Basin Management Units. Bedrock with Appalachian Mountains is present in the east, karstic conditions are present in the central part, and deep alluvium is present in the western part of the river basin management units.

Description of the local hydrologic regime including surface waters:

Because of the highly varied geologic conditions that are present, hydrologic regimes including surface water and groundwater interactions vary with the geologic conditions. The major basins of the watershed management units are the Cumberland, Tennessee and Mississippi River basins.

Description of land-use activities, past, present relevant to the project:

Past stream relocation associated with agricultural drainage practices, highway construction, livestock grazing, urbanization, mining, and silviculture has impacted the geomorphologic characteristics of streams in the Cumberland/Tennessee and Mississippi River Basin Management Units.

A site location map for the river basin management unit is provided in Attachment K of the 1998 319(h)-grant application.

Monitoring Program/Technical Design

A. The methods for developing the regional curves involve the collection of physical data at stream reaches that are representative of streams within specific geophysical and climactic regions (Rosgen, 1996). The physical data will be collected using a TOPCON APL-1 robotic total station and standard surveying techniques. The collection of the data using the survey equipment and standard surveying techniques will provide accuracy on the order of 1 cm in the vertical direction and 1 cm in the horizontal direction. The error associated with these measurements is approximately one order of magnitude lower than is required for geomorphic characterizations of streams.

B. The measurement stations and stream reaches where geomorphological measurements will be collected where established stream flow gaging stations exist.

C. The data collection will occur once during the period of the project in accordance with the procedures of the bankfull curve development methodology (Rosgen, 1996).

D. The data to be collected are standard geomorphic characteristics data as described in Rosgen (1996). Standard tables are provided for data collection in field data collection notebooks developed for measurement at reference reaches.

Chain of Custody Procedures

Chain of custody procedures are not applicable to this monitoring situation. The University of Louisville will retain all data collected with copies available for the project partners.

Quality Control Procedures

Standard quality control procedures are not applicable to this monitoring situation. All data will be collected by trained professionals or students of the University of Louisville under the direction of a trained professional.

The physical data will be collected using a TOPCON APL-1 robotic total station and standard surveying techniques. The collection of the data using the survey equipment and standard surveying techniques will provide accuracy on the order of 1 cm in the vertical direction and 1cm in the horizontal direction. The error associated with these measurements is approximately one order of magnitude lower than is required for geomorphic characterizations of streams.

References

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Four Rivers and Upper Cumberland Data — C

The data for each site are provided in the Microsoft Access database on the enclosed CD-ROM.