Guidelines for Stream and Wetland Protection in Kentucky

Goldenrod and Cardinal Flower along Straight Creek, Lewis County. Photo by Lewis "Lew" Kornman, Kentucky Department of Fish and Wildlife Resources.

Kentucky Division of Water
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This manual is available in electronic format on the world wide web. Anyone who wishes to access this document on the Internet may do so at this address:

http://water.nr.state.ky.us/dow/dwwqc/guide.htm

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Agencies To Contact

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Kentucky Division of Conservation (502) 654-3080

Kentucky Department of Fish and Wildlife Resources (502) 564-5448

Kentucky Nature Preserves Commission (502) 573-2886

Louisville Metropolitan Sewer District (502) 540-6000

Natural Resources Conservation Service (NRCS) (606) 224-7350

US Fish and Wildlife Service (615) 528-6481

US Environmental Protection Agency, Region 4, Atlanta (404) 562-9416 or (404) 562-9401

US Army Corps of Engineers:

Huntington, WV, District (304) 529-5210

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Nashville, TN, District (615) 736-5181

Memphis, TN, District (901) 544-3471

Guidelines for Stream and Wetland Protection in Kentucky

Chapter I. Introduction

In Kentucky, there are more than 89,430 miles of rivers and streams and more than 324,000 acres of jurisdictional wetlands that form complex aquatic ecosystems (Kentucky Division of Water, *Kentucky Report to Congress on Water Quality 1996*). Many of these streams and wetlands are degraded because of human disturbances within the watershed. Many have been eliminated entirely.

Streamside forests protect rivers, streams, and wetlands by improving water quality and aquatic habitat (USDA Forest Service, *Riparian Forest Buffers* 1991). The removal of streamside forests has adversely affected the vitality of the water resources across the United States, including Kentucky. The loss of habitat because of in-stream activities such as channelization and dredging has greatly impaired rivers, streams, and wetlands. These surface water resources are of important economic, social, and environmental value to the people of the Commonwealth.

Section 401 of the Clean Water Act strives to protect state surface waters by ensuring that projects comply with state water quality standards. The Section 401 program in Kentucky is often referred to as Water Quality Certification. One of the principal ways of protecting surface water resources is through restoration and appropriate mitigation, particularly when surface water disturbances cannot be avoided. The guidelines in this manual attempt to identify some approaches for restoring streams and mitigating wetlands so that water quality and aquatic life are not severely impaired. This manual should be used in consultation with Kentucky Division of Water, state or federal fish and wildlife agencies, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the Natural Resources Conservation Service, or local state government agencies responsible for stream and wetland protection. These resource agencies can also provide additional publications on streams and wetlands.

This manual introduces the reader to concepts of stream and wetland restoration. It is not intended to be a fully comprehensive technical guide. Many of the components are presented in a simplified version in an introductory, summary format. Chapter 2 discusses some of the principles of how streams behave and general concepts of stream restoration. This chapter further discusses bank erosion, how to prevent streambank erosion, and when to contact professional help to repair bank erosion. Chapter 3 introduces concepts of stream types and aquatic habitat in the stream that should be designed and installed by stream professionals. Chapter 4 discusses riparian buffer zones along streams, while Chapter 5 deals with wetland issues. Finally, Chapter 6 discusses when to apply for a Water Quality Certification pursuant to Section 401 of the Clean Water Act.

Chapter 2. Streambank Erosion and Restoration

Streambank erosion occurs when the energy of flowing water exceeds the ability of the soil and vegetation to hold the banks in place. Human-induced activities that try to solve stream problems most often accelerate streambank erosion. Activities such as channelizing (straightening and widening stream channels), dredging stream channels, and agricultural activities occurring on the streambank create an unstable stream system (Fig. 1). Urbanization will also increase the erosion potential of the streambank (Fig. 2). All of these types of activities, without regard to the receiving stream system, produce an unhealthy watershed that cannot sustain the conditions for improved water quality and aquatic life management.

Figure 1: Aerial view of a channelized stream

Figure 2: Vertical stream banks (entrenchment)

Loss of streambank and streamside (riparian) vegetation make streambanks more susceptible to erosion (Fig. 3). The erosive ability of a stream varies with water velocity, flow depth, and slope. Deeply rooted bank vegetation (riparian zone), composed of trees and shrubs, increases resistance to erosion by adding strength to the soil (Fig. 4).

Figure 3: Fleming Creek, Fleming County, illustrating unstable stream banks

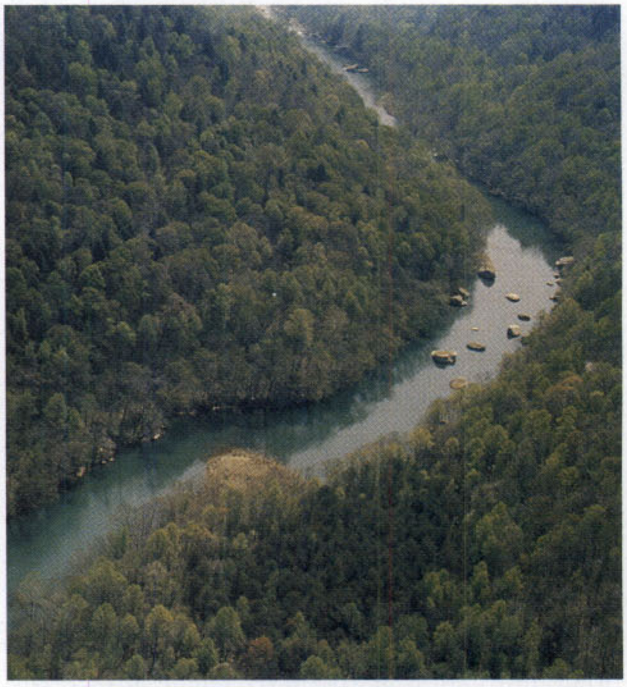

Figure 4: Vegetated and stable stream banks of Cumberland River, aerial view

Section A. How Streams Behave (Stream Dynamics)

A healthy stream provides habitat for aquatic life and reflects the health of the watershed.

The basic elements needed to support a healthy aquatic life population are good water quality, adequate flow, adequate water temperature, proper habitat diversity, and food availability. The plants and animals that inhabit a healthy stream create a delicate balance. This balance affects water quality, which directly impacts humans (Izaak Walton League, *A Citizen's Streambank Restoration Handbook* 1995).

A stream is a dynamic resource that moves within its channel and floodplain. The stream adapts to natural and human-induced changes occurring in the watershed. Streams constantly shift, change course, and meander. The shape of the stream channel is a result of the flow of the water, the sediment carried, and the composition of the stream bed and streambank materials.

Streams assume their appearance and channel shape from a combination of events, such as gravity, friction, speed, and volume of water flow. Gravity causes water to move down a slope. Friction between the stream, the stream bed, and the banks creates resistance to flow. The speed with which water flows depends on several factors: the angle of the slope, the unevenness of the stream bed, the depth of the water, and the type of geologic materials the stream flows through (Izaak Walton League, *A Citizen's Streambank Restoration Handbook* 1995).

A stream channel must simultaneously accommodate the flow and carry its sediment load within the stream banks. The stream forms a continuous system of pools, riffles, bars, and curves to absorb the energy of the water flow (Fig. 5). The adjustments a stream makes must balance the amount of water flowing in the channel, the amount of sediment it is transporting, and the changing slope and size of the channel. The natural erosion of channel bends (meanders) along outside banks is usually offset by deposition along inside banks (Georgia Soil and Water Conservation Commission, *Guidelines for Streambank Restoration* 1994).

Figure 6: Meandering stream illustrating point bar and thalweg

Streams are not perfectly straight-line channels. Flowing water has a natural tendency to meander from one side of the channel to the other (Fig. 6). This is all part of balancing the energy of the water flow. Soil, sand, and gravel are washed away from the area where the current is fastest and deposited where the water moves more slowly. Points within the stream where sand, silt, and gravel deposits occur are known as point bars. These are areas of natural deposition. On the opposite bank of the point bar is the meander or channel bend.

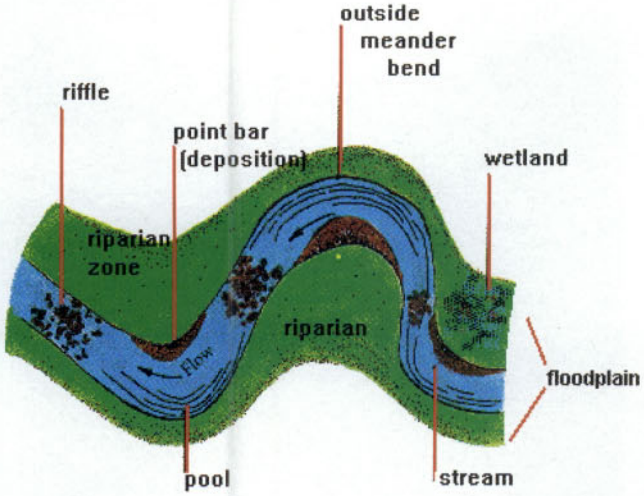

Figure 5: Stream diagram

Meanders are features of a stream that help balance and disperse the energy of flowing water. The stream prefers to distribute the energy in flowing water uniformly with minimum effort by producing meandering patterns. The meander side of a stream is where most of the energy of flowing water is located. The profile of the channel between the point bar and the meander is often referred to as the thalweg during normal stream flow (baseflow). The greatest velocity and energy of water occurs within the thalweg during normal flow. The thalweg is sometimes defined as a line where opposite slopes meet at the bottom of a river or stream.

Any slight change in a stream profile, including removal of streamside vegetation or instream disturbance, will disrupt this delicate balance. Changes in stream flow and sediment load will cause the stream to seek a new balance. Paved areas with parking lots, highways, malls, or sidewalks will reduce the infiltration of rainfall while increasing water volume in a stream (Fig. 7). The same episode will occur when the vegetation is removed within the watershed. This increase in storm water will lead to higher water volumes and velocities with an increased capacity for streambank erosion. Soil erosion from adjacent lands will cause increased sediment buildup if the stream flow is insufficient to carry the load of soil (sediment) along the stream.

Streams in urban areas are constantly in the process of adjusting to increased runoff. The result is highly eroded channels that become artificially wide and deep, referred to as entrenchment (see Fig. 2).

Streams are highly complex and dynamic. Stream profiles consist of alternating patterns of meanders, point bars, pools, riffles, and runs that exist according to width, depth, slope, soils, sediment size, roughness, and velocity. Each of these components is unique to each stream. The study of stream processes and channel geometry is known as fluvial geomorphology.

Because of the highly complex nature of streams, any attempt at stream restoration to a more stable, balanced, natural system requires professional training and experience. One should never use a "cookbook" approach to stream restoration. Rather, the restoration should follow science-based decisions about specific sites. Stream restoration should incorporate appropriate techniques such as described in David Rosgen's *Applied River Morphology*, 1996, to design a stable, balanced, and natural stream system. Other techniques may be available that incorporate similar stream restoration principles. Without this professional guidance, well intended efforts may cause more harm to the stream, and to the watershed, than good.

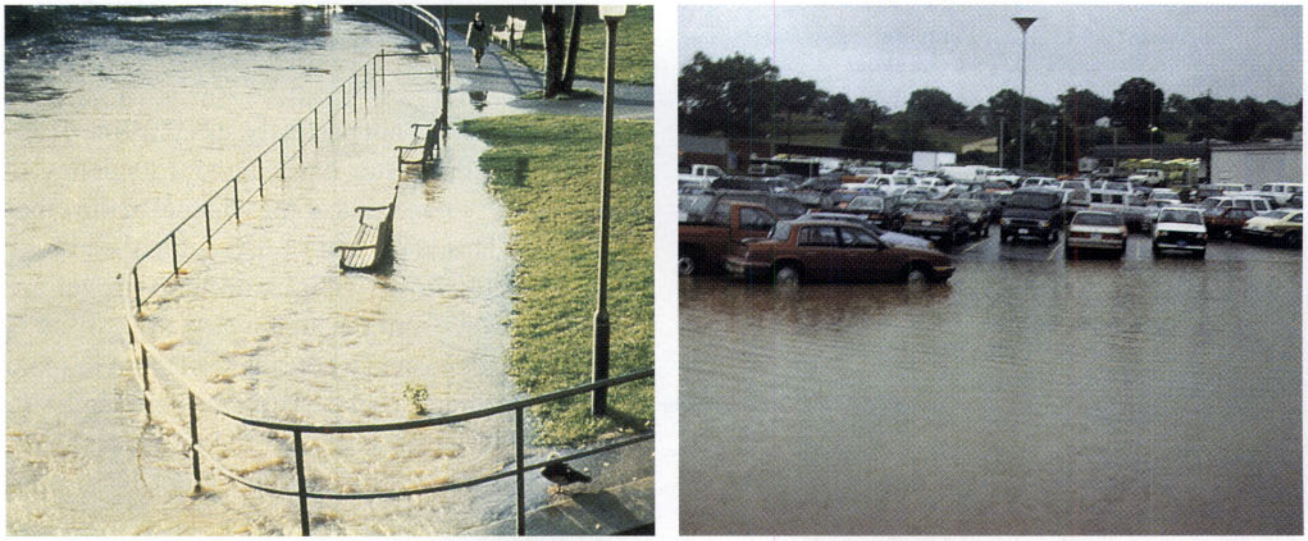

Figure 7: Flooded urban areas after storm event

Figure 8: Bank scouring on Cumberland River

Section B. Common Types of Streambank Erosion

There are several types of streambank erosion caused by excessive water velocities. Some of the common types are bank scour, toe erosion with upper bank failure, local streambank scour, and overbank runoff (Georgia Soil and Water Conservation Commission, *Guidelines for Streambank Restoration* 1994). Bank scour is widespread erosion of streambanks caused by excessive velocities (Fig. 8). Scouring of streambanks is usually confined to banks composed of easily erodible, unconsolidated material, such as soil, gravel, or sand. The streambanks usually lack adequate vegetative cover, particularly trees and shrubs. Well vegetated streambanks are less susceptible to widespread bank scour. Extensive reaches of exposed soils on sloping banks will be prone to bank scouring.

Figure 9: Undercutting of streambank on Buck Creek, Pulaski County

Undercutting or removal of toe support usually leads to failure of the upper bank. Undercutting is the major cause of bank erosion, or bank sloughing, on the outside of meander bends (Fig. 9). Bank sloughing is attributed to loss of toe support at the base of the slope, causing the bank to fail. Sloughing banks characteristically have nearly vertical slopes which lack vegetation. Loss of vegetation and streambank degradation contribute to upper bank failure, or sloughing. The deepest, fastest, perennial flow of water in the stream channel (thalweg) is generally found adjacent to the failed bank.

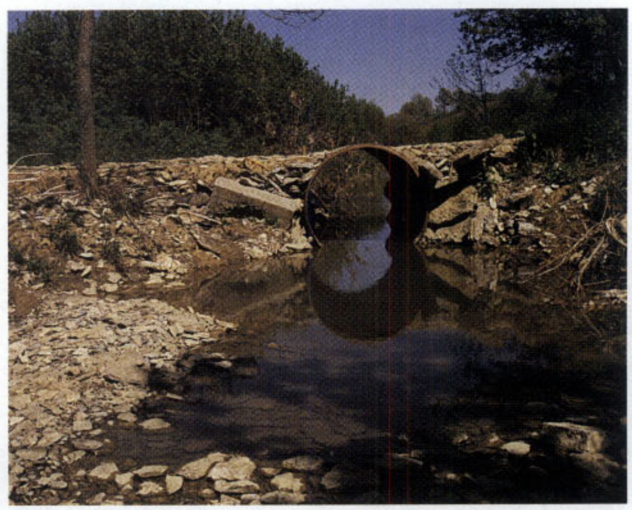

Figure 10: Constrictions from culverts

Localized streambank scour is observed when isolated sections of eroding banks are found within otherwise stable reaches. Local bank scour may be associated with the presence of sand or other highly erodible material that is unable to maintain long-term vegetative cover. Channel constrictions and flow obstructions may produce secondary currents that scour the stream bed and banks (Fig. 10). Local streambed scour can usually be observed below culverts. Streambed degradation also results from channel modifications that increase flow depths or slopes.

Overbank or surface runoff from streets, parking lots, malls, or sidewalks can cause erosion problems. Surface runoff can flow over the streambank creating gully-like scars in the banks. Impervious surfaces such as parking lots and roads will accelerate surface runoff resulting in increased storm water velocities in the stream channel.

Section C. Managing Streambank Erosion

Managing streambank erosion is less expensive than repairing the damage after problems occur. It is important to take steps to prevent streambank erosion from occurring. Preservation and protection of the native streamside vegetative community (riparian zone) is an important key to streambank protection (Fig. 11). The easiest and most effective activity landowners can initiate on their own is to restore the natural vegetation alongside streams.

Figure 11: Streambank with and without riparian vegetation, Rolling Fork, Boyle County (photo provided by U.S. Army Corps of Engineers, Louisville)

Since woody vegetation usually is the best streambank stabilizer, every effort should be taken to maintain existing trees and shrubs. The riparian vegetation will form a root mat that stabilizes and reinforces the soil on the streambank. These plants lessen the impact of rain directly on the soil, trap sediment from adjacent land, and hold the soil in place with their root structures.

Plants also enhance the appearance of the stream and serve as wildlife habitat. Trees provide additional benefits by shading the stream to maintain the lower summertime water temperatures necessary for a healthy aquatic population. Shading helps prevent the growth of sun-loving vegetation like algae (Fig. 12).

Figure 12: Algae in stream. Shading prevents excessive algae growth

Some practical measures that an individual property owner can safely take to protect streambanks from erosion are as follows.

- Maintain an undisturbed riparian buffer zone at least 25 to 50 feet wide from the water's edge back on both sides of the streambanks (see Chapter 4 on Riparian Buffer Zones). These areas need the protection of a permanent vegetative cover. Where adjacent slopes are steep, a wider corridor of woody plants and shrubs is appropriate (Fig. 13).

- Restrict the operation of heavy machinery, construction, animal grazing, and other intensive activities from within the riparian buffer zone. These types of

Figure 13: Riparian buffer zone, aerial view

activities compact the soil, which decreases infiltration, percolation, and soil aeration. This in turn leads to destruction of plants and riparian habitat (Fig. 14).

Figure 14: Preventing livestock from grazing in Elkhorn Creek helps maintain stable banks (Photo provided by NRCS, Scott County)

- Use wise management practices for agricultural and forestry activities. Applying best management activities as described in the Kentucky Agriculture Water Quality Plan will greatly benefit streambank protection (refer to Chapter 6, Section C). Some of the suggested activities are conservation tillage, contour cultivation, fencing to keep livestock out of the stream, and maintaining vegetated filter strips (Fig. 15).

Figure 15: Conservation tillage (Photo provided by NRCS, Fayette County)

Where existing riparian vegetation is sparse, plant native tree and shrub species for added bank protection (Fig. 16). There are many native plant species that prefer streambank habitat and are usually quite available to landowners. Appendix 4 and 5 of this manual may offer a few suggestions, or contact the Kentucky Nature Preserves Commission.

Figure 16: Planting trees along Cane Run, Fayette County (photo provided by NRCS)

- When stream flow becomes interrupted by log jams or similar obstructions, the wise approach is to attach a cable and physically remove the log obstructions without excavating with heavy equipment. When obstructions become numerous, or involve long reaches of a stream, the Stream Obstruction Removal Guidelines (SORG) should be used. Kentucky Department of Fish and Wildlife, Kentucky Division of Water, or other similar agencies can offer consultation on the SORG approach to improving stream flow.

- Do not straighten channels to correct streambank or flow problems (Fig. 17). This procedure, although appearing to be quick and easy, is never effective at resolving stream-flow problems. Past experience has shown that channel straightening will simply change the location and nature of an erosion problem. Channel straightening will only make the problem worse because of increased water velocities. Detrimental effects may also occur both downstream and upstream from the channelization (Georgia Soil and Water Conservation Commission, *Guidelines for Streambank Restoration* 1994). Streams naturally meander, and once straightened, the stream immediately begins eroding the banks to re-establish curves and bends.

Figure 17: Channelized stream, Obion Creek, Hickman County

Section D. Repairing Streambank Erosion

Once a streambank or stream-flow problem exists, a trained professional experienced in these types of problems should be contacted to offer guidance. Trying to correct the problem without professional help could make the problem worse. Kentucky Division of Water, state and federal fish and wildlife agencies, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Natural Resources Conservation Service, or local government agencies responsible for stream protection can offer consultation on repairing erosion problems.

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. **In general**, there are four approaches to streambank protection: 1) soil bioengineering and revegetation; 2) soil bioengineering combining vegetation and rock; 3) conventional bank armoring; and 4) cover logs and log cribbing.

1. Soil Bioengineering and Revegetation

Soil bioengineering is the combination of living and nonliving materials to provide soil reinforcement and prevent erosion (Fig. 18). Living materials would include shrubs or trees that

Before

During

After

Figure 18: Before, during, and after soil bioengineering bank protection of Beargrass Creek, Jefferson County (photos provided by Fuller, Mossbarger, Scott & May; Louisville, Ky.)

play the major structural role in bioengineering. Nonliving materials include rock, logs, root wads, geosynthetic materials, coir fiber rolls, and mats (Fig. 19). A range of effective soil bioengineering revegetation measures may be used to solve common streambank erosion problems rather than conventional methods of using riprap. These techniques are relatively inexpensive and provide environmental benefits such as improving water quality and habitat for wildlife (Georgia Soil and Water Conservation Commission, *Guidelines for Streambank Restoration* 1994).

Figure 19. NRCS and UK staff installing coconut fiber log, Cane Run, Fayette County (photo provided by NRCS)

Revegetation includes seeding, sodding, and the planting of woody riparian vegetation. Seeding or sodding streambanks after regrading offers immediate erosion protection. Woody vegetation is installed to provide long-term streambank stability. Revegetation measures may suffice if the stream is small, the slopes are not steep, and the stream bed is stable.

Typically, the eroded streambank will need to be graded prior to revegetating the banks. A 2:1 or 3:1 side slope is recommended. Once the excavated side slopes have been seeded and mulched for immediate erosion control, woody vegetation cuttings can then be planted along the streambank. A few suggested woody plants which will root with relative ease are shrub dogwoods, alders, and willows. Cuttings can be made of the young growth and planted directly into the prepared site. It is important to remember that plant cuttings placed directly into the soil should be done during the dormant season (November to March), while seedlings should be planted in early spring or late fall. When first installed, the cuttings and seedlings will not offer any immediate stabilization to the streambank. However, the species recommended will quickly grow, stabilize the bank, and restore the riparian habitat zone.

2. Soil Bioengineering Combining Vegetation and Rock

This method combines conventional methods with woody cuttings to produce a more naturalized streambank (Fig. 20). The use of rock

Figure 20: Vegetation with riprap combination

work in conjunction with plants is a technique which combines vegetation with riprap. This technique is generally used in perennial streams with steep slopes requiring additional armoring at the toe of the slope. The intent is to increase the effectiveness of riprap, or field stone, by forming a living root mat underneath the rock and improve the environmental function and aesthetics of the rocked bank. In perennial streams with high flow velocities, riprap may be used at the toe of the slope for bank armoring followed by planting woody vegetation. Combining vegetation with conventional methods assists in dissipating energy and causes deposition of sediment along the streambanks. The woody vegetation will provide shade over the water, thus reducing the water temperature and making it more suitable for aquatic habitat.

3. Conventional Bank Armoring

Current efforts in stream restoration are to move away from the old approaches of bank armoring through riprap or gabion walls. The stabilization should follow the concepts in the Rosgen Stream Classification System (Rosgen, 1996) or similar technique to design a stable, balanced, and natural stream system. Long-term stabilization or restoration of streams should be designed only by trained professionals.

Conventional armoring is a third technique which includes the use of riprap and gabion walls to reinforce the banks (Georgia Soil and Water Conservation Commission, *Guidelines for Streambank Restoration* 1994). Adequately sized riprap is used to armor the stream banks. In severe erosional problems on steep slopes and limited space, gabion walls can be constructed for streambank protection (Fig. 21). **However, the design and installation of gabion walls must be engineered precisely.**

Figure 21: Conventional bank armoring using gabion walls

4. Cover Logs and Log Cribbing

Care must be taken when using this technique to stabilize a bank. Inappropriate design or placement of these structures can drastically alter stream flow and cause bank failure. Before considering this technique, consult with a trained professional experienced in stream restoration for adequate design and installation considerations.

A single log (cover log) can be anchored parallel to the base of a streambank at the water level to provide stabilization. Cover logs should be at least 16 inches in diameter and should be anchored with rebar driven through the log and into bedrock at each end or secured with cable. This type of structure can also be constructed by driving two or three abutment logs into the streambank (at least 4 to 6 feet and up to 10 feet in unstable soils) and then attaching the cover log on top of the first layer of logs with rebar (driven through both sets of logs). Boulders can be placed along the top of the cover log or vegetation can be planted for additional protection. (USFS 1992)

Cribbing consists of several overlapping layers of logs (Fig. 22). Initially, two or three abutment logs or more, depending upon the length of the cribbing, are driven 4 to 10 feet into the streambank just below the low-flow water level to form the first layer. The abutment logs should extend 18 to 20 inches from the bank. A cover log(s) is attached on top of the abutment logs, at the water level, with rebar. This process is continued to the top of the bank with each proceeding layer inset, forming a small step or terrace. It may be desirable to use a couple of cover logs, placed side by side near the bottom of the structure and a single cover log for upper layers. If wide enough, boulders can be placed along the top of each log terrace or vegetation can be planted for additional protection. (USFS ibid.)

Figure 22: Cribbing illustration

Chapter 3. Restoration of Aquatic (In-Stream) Habitat

Stream restoration involves highly complex methods that, if done incorrectly, can cause several problems. Before attempting any stream restoration work, a trained stream professional must be contacted for appropriate design and installation criteria. Never undertake a stream restoration effort on your own without guidance from stream professionals. **Because of the highly complex nature of streams, any attempt at stream restoration to a more stable, natural system requires professional training and experience.** One should never use a "cookbook" approach to stream restoration. Rather, the restoration should follow the concepts in the Rosgen Stream Classification System (Rosgen, 1996) or **other similar technique** to design a stable, balanced, and natural stream system.

Many aquatic habitat enhancement structures can actually destabilize a stream system if designed and installed incorrectly. Appendix 6 lists a few consultants in stream restoration. Also, Kentucky Division of Water, Kentucky Department of Fish and Wildlife Resources, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Natural Resources Conservation Service, U.S. Environmental Protection Agency, or local agencies involved in stream protection can offer their expertise.

On-site or off-site stream mitigation/restoration is often required under the 401 Water Quality Certification (WQC) process whenever stream relocation, filling of a stream, or similar alterations are proposed. The purpose of the mitigation requirement is to replace aquatic habitat which is expected to be eliminated or significantly impaired as a result of certain instream activities. Candidate streams for off-site mitigation are those in which the habitat has been entirely removed or nearly so, as seen with channelized streams. When feasible, on-site mitigation is usually preferred. In addition, the Division of Water strongly discourages the use of artificial channel linings within blueline streams, such as concrete, or quarry rock, which is homogeneous in size, shape, and distribution.

The threshold for requiring stream mitigation under the 401 WQC program varies with the type of activity (refer to Chapter 6). With the exception of coal mining, agriculture, and silviculture, mitigation generally pertains to situations where the watershed upstream of the point of disturbance is greater than 200 to 300 acres (watershed size). The stream channel should be large enough to accommodate aquatic habitat (e.g., the stream is something more than a small ditch), and more than 200 linear feet of stream will be disturbed. Coal mining, agriculture, and silviculture are governed by industry-specific state laws (Chapter 6).

Section A. Stream Types and Aquatic Habitat Enhancement

There are several stream types characterized in *Applied River Morphology*, each structurally unique and highly variable. Rosgen identifies streams as types A through G, depending on slope, soils, sinuosity, width, depth, landform and valley shape. Streams vary considerably from region to region. Certainly, stream character in Western Kentucky differs from stream character in Eastern or Central Kentucky. Individual stream character results from natural erosional and depositional processes as a result of climate, geology, and vegetation patterns over time (Rosgen 1996).

For example, unimpacted streams in Eastern Kentucky are generally characterized by an alternating pattern of riffles, runs, and pools (Fig. 23). Pools are deep, calm water sections of the stream, whereas riffles have an obvious drop in gradient, faster moving water, and a high percentage of gravel/rubble substrate material. Runs are intermediate zones between riffles and pools.

Streams in Western Kentucky, however, can be low-gradient systems with extensive floodplains, adjacent wetlands, and braided to multiple

Figure 23: Riffle, run, and pools in stream, Big South Fork, McCreary County

channels (Fig. 24). Alluvium is deposited frequently along the broad valley of these stream types, creating terraces in the floodplain. The floodplains and associated wetlands become well vegetated with trees and shrubs characteristic of a bottomland hardwood community.

Riparian areas are also an important component of aquatic habitat (refer to Chapter 4). Other habitat types commonly found in streams include fibrous root mats, exposed root systems of large trees, logs, leaf packs, beds of aquatic herbaceous vegetation, undercut banks, and rock ledges.

According to Rosgen, before initiating a stream restoration effort, a reference stream must be located within the same or approximate watershed to "pattern" the restoration effort. In the planning and design of a stream restoration project, the stream type should be fully assessed in advance, particularly if the project cannot avoid the stream. A stream assessment becomes far more important when a stream must be relocated and alternatives to relocation do not exist. A relatively unimpacted stream can be used as a reference to model the restoration effort while providing some indication of success. This application is well described in *Applied River Morphology* by David Rosgen (1996).

Because different aquatic organisms gravitate to different habitat types, it is important to re-create as much habitat variability as possible. The naturally occurring structural variability present before disturbance should be restored in the stream channel. This can be achieved by replicating the natural riffle/run/pool makeup of streams and by promoting streambed variability using a variety of aquatic habitat enhancement devices. Meanders should be constructed within the restored channel that resemble pre-disturbance conditions. All instream work should be conducted during low-flow conditions, and, whenever a new channel will be constructed, all

Figure 24. Two Western Kentucky streams

earthwork should be completed before water is allowed to enter.

An advantage of stream restoration is that durable, nontoxic shot rock and/or rot resistant logs such as red cedar or hardwoods derived on-site can often be used as construction materials. Hence, habitat replacement may actually be less expensive than conventional riprap channel lining or concrete lining.

The following sections describe aquatic habitat devices and techniques sometimes used by stream restoration professionals for enhancing habitat for aquatic life. It should be noted however, that these structures are not always suitable for every stream in every situation because of the variable nature of stream types. These techniques should only be applied to the appropriate stream class (refer to Rosgen, 1996).

Section B. Single-Wing Deflector

Single-wing deflectors can be constructed from logs at least 14 inches in diameter and/or boulders. They are designed to divert flow toward one side of the stream (Fig. 25 and 26). This structure will create pools, eddies, and small bars through scouring and deposition of fines and gravel. For construction, the main deflector log is placed at approximately a 30 to 35 degree angle to the shoreline and a brace log is pinned to the main log at about 90 degrees. When possible, insert the logs into the streambank and secure them with 3/4 inch rebar which is driven through the log and into bedrock. The logs can also be anchored with boulders or with cable.

Figure 25: Rock deflector (single-wing deflector)

Figure 26: Log deflector (single-wing deflector)

The end of the log extending into the stream should be at the same level as the bed of the stream. This will allow for the movement of bedload during high-flow events.

Depending upon stream size, flow, bank stability, etc., the deflector can extend anywhere from 1/3 to 4/5 across the stream channel at low-flow. The triangle-shaped area formed by the two adjoining logs should be filled with boulders or can be filled with boulders and soil and planted. It may be necessary to place a cover log or boulders along the opposite bank to prevent erosion (USFS ibid., USCOE no date). A log or rock deflector, whether single- or double-wing (Section C), should be placed every 15 to 20 stream widths (bankfull widths).

These structures must be designed and installed by a trained professional.

Section C. Double-Winged Deflector

A double-wing deflector works in the same manner as a single-wing deflector except that flow is directed toward the middle of the stream via a pair of deflectors (Fig. 27). Again, logs will need to be securely anchored. Streambank erosion is not as much of a concern with a double-wing deflector as with a single-wing structure. These structures must be designed and installed by a trained professional.

Figure 27: Double-wing deflector

Section D. Riffles

In nature, riffles consist of a multitude of tiny pools and eddies and varying currents. In order to simulate this variability after reconstruction of a riffle, it is best to use rock of different sizes and shapes. Hence, locally obtained durable, nontoxic/nonacid-producing shot rock is preferred over quarry rock. The rock should be placed in a somewhat random fashion as well. Reconstructed riffles need to be located where there is at least some change in stream bed gradient. After construction, a pool will normally form immediately upstream of the riffle, providing additional habitat (riffles are often designed in-part to create pools). Riffles should be constructed every 5 to 7 stream widths (bankfull widths) within the restored stream channel (Fig. 28). These structures must be designed and installed by a trained professional.

Figure 28: Riffles

Section E. Boulder Cluster

Boulders can be scattered within the new stream channel at a spacing of approximately 20 per linear mile of restored channel (Fig. 29). Boulders provide overhead cover and resting areas for aquatic life. If the new channel is large enough, it is desirable to cluster the boulders in groups of 4 or 5 (COE ibid.). Boulders so large

Figure 29: Boulder cluster

that they will cause stream banks to erode as a result of flow displacement should not be used. These structures must be designed and installed by a trained professional, and many streams in Kentucky do not naturally have boulder habitat.

Note: Generally, restoration projects should consist of deflectors (one every 15 to 20 stream widths), riffles (one every 5 to 7 stream widths), and scattered boulders (at least 20 per linear mile). These structures must be designed and installed by a trained professional.

Section F. Cover logs, Cribbing, and Rootwads

Cover logs, log cribbing, or rootwads can be used to provide aquatic habitat as well as to provide bank stabilization along outside channel bends and at other locations where stability problems are expected or where additional habitat is desired (refer to Section D of this Chapter). Cover logs can also be anchored midstream to enhance habitat, or tree trunks can be driven into the streambank, leaving the roots exposed, for additional habitat and for stabilization (Fig. 30). Large stumps or rootwads, if available, provide ideal cover (Fig. 31). Cover logs and rootwads can provide optimum cover and present a natural appearance. Ideal locations would be next to open pools, runs, or flats that are at least 6 to 8 inches deep. The best bank locations are in stream meanders. These structures must be designed and installed by a trained professional.

Figure 30: Cover log with deflector

Figure 31: Rootwads or stumps

Section G. Creating Pools

There are a myriad of ways to use rocks and/or logs to construct small dams within the restored channel to create pool habitat. In addition to the impounded area upstream, a plunge pool may form just downstream of the dam. One of the simplest dam types is accomplished by placing a single log, notched in the middle, across the stream channel. The log should be embedded into both stream banks and should be secured with rebar or boulders (Fig. 32). Other log dams used for creating pool habitat are wedge dams and K dams. These structures must be designed and installed by a trained professional.

It should be noted that there is a tendency for upstream pools to fill with silt after a small log dam has been constructed. Also, the streams tend to scour around the dam widening the stream and eroding the banks.

Figure 32: Simple log dam for pools

Section H. Stream Crossings

While these structures do little to provide for aquatic life habitat, stream crossings are inevitable. They must be constructed and installed wisely by a trained professional. Whenever stream crossings must be constructed, consideration should be given to minimizing disturbances to the stream bed. For projects that involve multiple stream crossings and for areas where stream crossings already exist, the number of new crossings should be kept to a minimum. Bridges that span the entire channel are preferred over circular culverts (metal or concrete), box culverts, low water crossings, or bridges that require abutments within the stream (Fig. 33). When culverts are used, they should be installed so that they will not present a barrier to the movement of aquatic organisms. This is accomplished by placing the culvert flush against the stream bed or by burying the bottom of the culvert lower than the stream bed. If the bottom of the culvert is buried, a somewhat natural substrate will likely redevelop through deposition. In addition, a semicircular culvert or three-sided box culvert is recommended over standard culvert types (with bottoms).

Figure 33: Span bridge

Chapter 4. Riparian Buffer Zones and Restoration

Riparian areas are naturally vegetated lands directly adjacent to streams, lakes, and wetlands (Fig. 34). In Kentucky, these zones are typically composed of trees, shrubs, and other native types of vegetation that can tolerate periodic flooding. Riparian zones are recognized as an integral aspect of healthy watershed management. These zones can be very effective in protecting water quality, reducing bank erosion, and storing flood waters. Riparian areas offer the public many indirect values through functions of

- water storage;
- flood reduction;
- stabilizing stream banks;
- improving water quality by trapping sediment and nutrients;
- shading of streams to help maintain temperature for fish habitat;
- shading to control excessive algae growth;
- habitat;
- providing shelter, travel corridors, and food for wildlife;
- education;
- recreation;
- aesthetics.

Figure 34: Riparian zone of Cypress Creek, Muhlenberg County

Riparian areas play a critical role in reducing nonpoint source pollution. In highly developed urban areas, riparian buffer zones may be destroyed through construction, filling, channelization, or other significant alteration. In agricultural areas, riparian zones may be impacted by overuse of the area for grazing, removal of native vegetation, or replacement of the buffer zone with annual crops (Fig. 35). Other significant impacts may occur as a result of various activities such as highway construction, surface mining, deposition of dredged material, and excavation of marinas. All of these activities have the potential to degrade or destroy the water quality improvement functions of riparian buffer zones. These zones may need to be restored or enhanced to promote a healthy watershed landscape.

Figure 35: Stream laden with excessive algae from lack of shade.

There are many recommendations for buffer zone widths depending upon the riparian zone objectives, watershed size, slope, and soil type. Depending on site conditions, a riparian forest buffer as little as 50 feet wide on each side of the stream may filter the majority of nonpoint source pollutants from agricultural and urban runoff and provide some wildlife benefits. **Table 1** summarizes recommended widths with their related functions (Howard and Allen 1988).

When restoring the riparian zone, native trees and shrubs that reflect the natural vegetation of the region should be used. Non-native plant species should be avoided since they may cause problems in competition and biological diversity. Appendix 4 includes a brief list of plant species that can be used in restoring the vegetation to riparian zones. Additional recommendations can be found in the Landscape Restoration Handbook by Harker et al; 1993. Appendix 5 lists sources for obtaining plant materials.

WIDTH (feet)	FUNCTION	SOURCE
15	Stabilizing Stream Banks	Georgia Soil and Water Conservation Commission 1994
25	Water Quality	St. Tammany Parish, La. 1988
35	Water Quality (small streams)	Scott Paper Company 1988
50	Water Quality	Oklahoma State University Cooperative Extension Service
50	Water Quality	Nieswand et al 1990
50	Water Quality and Wildlife	University of Maryland Cooperative Extension Service 1988
65	Fisheries Management	Seehorn 1987
80	Fisheries Management and Water Quality	Scott Paper Company 1988 US Bureau of Land Management 1979
100	Water Quality (large streams and rivers)	US Department of Agriculture 1980
340	Water Quality and Wildlife Habitat (large streams and rivers)	US Fish and Wildlife Service 1988
1,310	Maintain Wild and Scenic Values of Rivers	Wild and Scenic Rivers Act (P.L. 90-542)

Table 1. Recommended riparian buffer widths per stream side

Figure 37: Otter (photo provided by Kentucky Dept. of Fish and Wildlife Resources)

Chapter 5. Wetlands

Section A. The Ecosystem: What are Wetlands?

Wetlands are transitional areas between upland and deepwater aquatic systems. Wetlands come in all shapes and sizes and go by names such as marshes, swamps, scrub-shrubs, bottomlands, oxbows, or sloughs (Fig. 36). The regulatory definition of wetlands is "land that has a predominance of hydric soils, and that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions" [40 CFR 230.3 (t)].

All wetlands have three things in common:

• a soil that is at least periodically saturated or ponded and exhibits anaerobic conditions (offering no air or free oxygen);

• vegetation that can tolerate anaerobic conditions;

• water to create ponding or saturated conditions of the soil in the upper layer during the growing season.

The water table of wetlands can be at or near the soil surface, or it can inundate the land with shallow water. Water controls the types of plant and animal communities living in wetlands. Most plants cannot survive in waterlogged soils found in wetlands, while others need soils that remain wet over a long period of time. The presence of certain water-loving plants is used as one indicator to identify wetlands. Two other indicators must be present to identify wetlands: hydric soil and hydrology. The U.S. Army Corps of Engineers is responsible for jurisdictional wetland determinations in Kentucky.

For a long time, wetlands were regarded as wastelands. They were excavated, converted, filled, developed, drained, or used as places to dump household or hazardous waste. Over time, these actions and attitudes resulted in losses of more than half (56 percent) of the wetlands in the lower 48 states. Kentucky alone has lost more than 80 percent of freshwater wetlands. Losses have caused increases in downstream flood events and water quality problems. There has also been a dramatic decrease in migratory waterfowl populations.

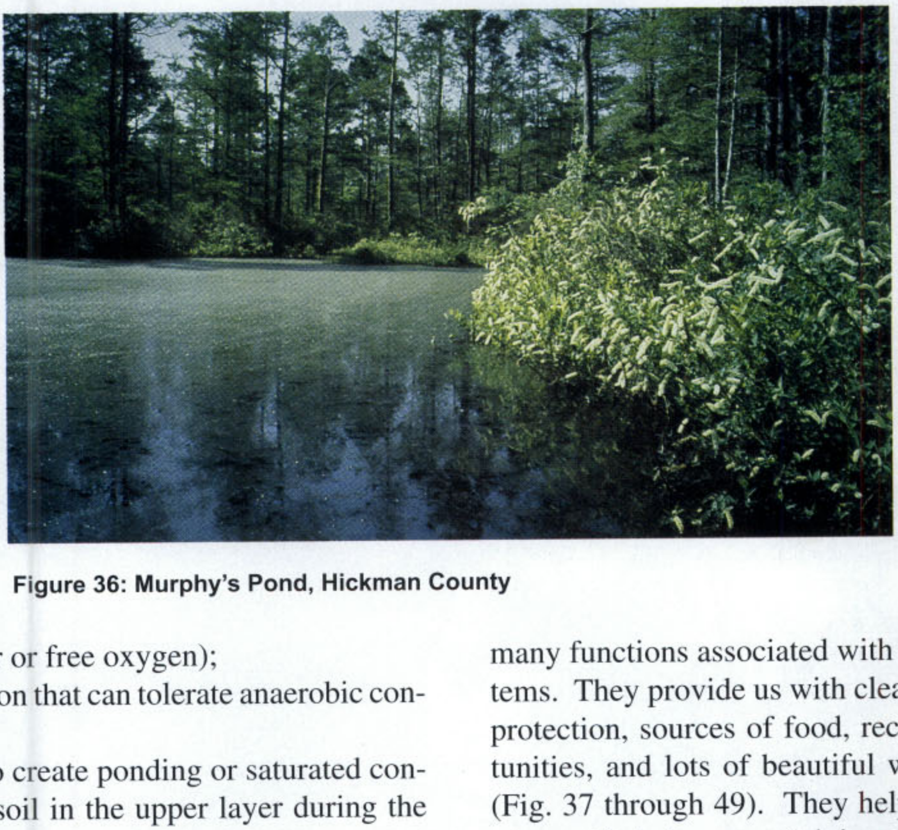

Figure 36: Murphy's Pond, Hickman County

By 1970, scientists began to realize the importance of wetlands and to identify the many functions associated with wetland ecosystems. They provide us with cleaner water, flood protection, sources of food, recreational opportunities, and lots of beautiful wildlife to enjoy (Fig. 37 through 49). They help keep the environment in balance, sustaining a healthier watershed.

Wetlands act as a type of filter, removing materials from storm water runoff before the runoff reaches streams. Wetlands remove pollutants, including sediment, from the water column. They substantially improve water quality by sediment

Striped Darter

Painted Turtle

Crayfish

Great Blue Heron

Willow Flycatcher

Mayfly

Figure 38 thru 49: Wetland Wildlife (photos provided by Lewis "Lew" Kornman with Kentucky Dept. of Fish and Wildlife Resources)

Figure 50: Cypress trees in early fall; Fish Pond, Fulton County

trapping, nutrient removal, and chemical detoxification.

Wetlands can store floodwaters, particularly frequently flooded bottomland hardwood areas along rivers. How much a particular wetland site can reduce flood levels depends upon the size, shape, and location of the wetland in the watershed. During high runoff, wetland soils temporarily store some of the floodwaters. After the flood event, the water is slowly released (Fig. 50).

Vegetated wetlands along shorelines of lakes, rivers, and streams help protect against streambank erosion. The energy released by wave action or water velocity is partially absorbed by the vegetation. The vegetation further helps bind the sediment and soil particles in dense root systems.

Wetlands provide essential habitat for numerous wildlife species. The dense vegetation adapted to wetlands serves as a food source for wildlife. The vegetation also provides cover, protection, habitat, and travel corridors for wildlife. In Kentucky, about 55 percent of the species listed by federal and state government as threatened, endangered, or of special concern depend heavily on wetland aquatic ecosystems (Fig. 51).

Anyone who would like specific wetland information concerning education, wetland functions, non-regulatory, regulatory, or options for wetland protection can contact the Environmental Protection Agency's (EPA) Wetland Hotline at 1-800-832-7828. This is a toll-free telephone service that also acts as a point of contact for the Wetlands Division within EPA's Office of Wetlands, Oceans and Watersheds. They provide a wide range of information on wetland protection efforts involving EPA and other organizations.

Figure 51: Observing wetland wildlife

Section B. The Interagency-Approved Kentucky Guidelines on Wetland Mitigation

Section 404 of the Clean Water Act requires that applicants who propose projects that will result in the loss of jurisdictional wetlands must demonstrate that the project 1) avoids impact to wetlands where practical, 2) minimizes the impacts to those wetlands that cannot be avoided, and 3) mitigates for the loss of any jurisdictional wetlands. This chapter presents guidelines on how to design a complete mitigation package so as to avoid delays in the permitting process.

The "Wetland Compensatory Mitigation and Monitoring Plan Guidelines for Kentucky (Kentucky Guidelines)" was jointly prepared in 1993 by representatives from the Louisville District Corps of Engineers, Region 4 U.S. Fish and Wildlife Service, Region 4 U.S. Environmental Protection Agency, the Kentucky Division of Water, and the Kentucky Department of Fish and

Red Salamander

Damselfly

Bull Frog

Green-backed Heron

Wood Ducks

Dragonfly

Wildlife Resources. It was revised in 1996 in a cooperative effort with resource agencies, consultants, and representatives from regulated industries. These Kentucky Guidelines are designed to assist applicants in the preparation and development of compensatory mitigation and monitoring plans associated with projects requiring Department of the Army (Corps) permits and Kentucky water quality certification.

The mitigation guidelines are intended to be just that, a set of guidelines. The guidelines are not regulatory requirements. However, many of the delays in the permitting process can be attributed to deficiencies in the applicant's proposed mitigation plan. Many or all of these deficiencies can be avoided by referring to the mitigation guidelines. Not all of the items listed in the guidelines will be applicable to every mitigation scenario. The applicant will need to choose those items that are applicable to the specific set of circumstances regarding both the impacted wetlands and the proposed mitigation site. In making these choices, the applicant should remember that the goal in wetland mitigation is the **replacement of those wetland *functions* that the pending project proposes to negate.**

These guidelines will serve to provide consistency in the permit application evaluation process for wetland-related impacts. For more information on the Guidelines, please refer to the U.S. Army Corps of Engineers, Louisville District, or visit the Kentucky Division of Water, Water Quality Certification World Wide Web site at this address: http://water.nr.state.ky.us/dow/dwwqc.htm. The Louisville District Corps should be contacted for any suggested changes to the Kentucky Guidelines.

Appendix 1 refers to maps, plans, and drawings needed for a wetland mitigation plan. Appendix 2 is the wetlands functions checklist needed for site description and monitoring. Appendix 3 is a list of wetland plants that may be used to revegetate a mitigated wetland. These appendices are directly from the interagency Kentucky Wetland Guidelines.

Part 1. Development Site Description

I. Introduction
   A. Brief summary of overall proposed project and purpose
   B. Impacted wetland acreage
      1. Primary
      2. Secondary

II. Location
   A. Narrative description
      1. Local (i.e., directions to the site using road names, highway numbers and mileage distances)
      2. Relative geographic location within watershed (e.g., headwater, stream order, floodplain, isolated, etc.)
      3. Surrounding land use
         a. Percentage of land-use types(s) occurring within at least a 1,000 ft band around the wetland area.
         b. Significant land use(s) within watershed which would affect the hydrological inputs or be affected by the hydrological outflows from the wetland
      4. Proximity to existing wetlands
         a National Wetlands Inventory Map
         b. Field observations
   B. Maps (8 1/2" x 11")
      1. County road map with proposed development site clearly outlined
      2. USGS quadrangle map with proposed development site clearly outlined
      3. Existing conditions (see Appendix 1)
      4. National Wetlands Inventory Map
      5. Aerial photography, if available

III. Identification of responsible parties (names[s],titles[s], address[es], and phone number[s])

A. Applicant(s)
B. Contact person(s) if applicant is a company
C. Consultant or preparers of compensatory mitigation plan (include resume with references)

IV. Site characterization
   A. Wetland classification (Cowardin et al, 1979) (Brinson 1993)
   B. Wetland functions and values (Narrative based on checklist in Appendix 2) (Include copies of completed checklist[s])
      1. Hydrology (surface and groundwater)
      2. Biogeochemical processes
      3. Plant maintenance (see Appendix 2)
      4. Habitat maintenance (see Appendix 2)
   C. Soils
      1. Soils series and description
      2. Field characteristics (soil color, texture, composition, percent of organic material and other hydric soil indicators)
   D. Vegetation (Refer to wetland delineation)
      1. Species composition and indicator status by stratum (overstory, understory, herbaceous) (list by scientific and common names)
      2. Community structure
         a. Dominant species for each stratum
         b. Zonation (if present)
   E. Hydrology (utilizing best available data)
      1. Surface Water
         a. Hydroperiod
            i. Gage data
            ii. Documented observation
            iii. SCS county soil survey
            iv. Wetland delineation hydrologic data/indicators
            v. Flow conditions (hydrodynamics)
         b. Source
            i. Overbank flooding
            ii. Precipitation
            iii. Groundwater seeps
            iv. Location and types of inflows and outflows
      2. Seasonal groundwater table elevations/fluctuations
         a. SCS county soil survey
         b. Other published data (e.g. Ky. Division of Water)
         c. Wetland delineation hydrology data/indicators

Part 2. Proposed Compensatory Mitigation Site Description

I. Location
   A. Narrative description
      1. Local (i.e., directions to the site using road names, highway numbers, and mileage distances)
      2. Relative geographic location within watershed (e.g., headwater, stream order, floodplain, isolated, etc.)
      3. Surrounding land use(s)
         a. Percentage of land-use type(s) occurring within at least a 1,000-foot band around the wetland area
         b. Significant land use(s) within watershed that would affect the hydrological inputs or be affected by the hydrological outflows from the wetland
      4. Proximity to existing wetlands
         a. National Wetlands Inventory Map
         b. Field observations
   B. Maps (8 1/2 " x 11 ")
      1. County road map with proposed compensatory mitigation site clearly outlined
      2. USGS quadrangle map with

proposed compensatory mitigation site clearly outlined
3. National Wetlands Inventory
4. Existing conditions (see Appendix 1)
5. Proposed conditions (see Appendix 1)
6. Aerial photography, if available

II. Proposed wetland classification (if out-of-kind, present rationale)
   A. Cowardin classification (Cowardin et al; 1979)
   B. Hydrogeomorphic classification (Brinson 1993)
   C. Natural Resources Conservation Service (NRCS) Mapping Conventions (if applicable)

III. Functions and values (narrative based on checklist in Appendix 2)
   A. Existing
      1. Hydrology
      2. Biogeochemical processes
      3. Plant maintenance
      4. Habitat maintenance
      5. Watershed map (see Appendix 1)
   B. Proposed
      1. Hydrology
      2. Biogeochemical processes
      3. Plant maintenance
      4. Habitat maintenance
      5. Watershed map (See Appendix 1)

IV. Soils
   A. Soils series and description
   B. Analytical data such as saturated hydraulic conductivity and redox potential
   C. Soil analyses
      1. Nutrients
      2. Texture
      3. Organic matter content

V. Proposed vegetation
   A. Species composition and indicator status (list by scientific and common names) (See Appendix 3 for recommended species)
      1. Overstory composition (minimum of 4 species recommended)
      2. Understory composition (minimum of 3 species recommended)*
      3. Herbaceous composition (minimum of 5 species recommended)*
      4. Species predicted to invade naturally

*Understory and herbaceous species may not need to be planted if a good seed source is available.

   B. Community structure
      1. Dominant species for each stratum
      2. Zonation (if applicable)
   C. Planting
      1. Rates (e.g. 1,000/acre for direct seeding)
         a. Wildlife objectives - 194/acre accomplished by 15 X 15 foot spacing
         b. Timber production - 437/acre accomplished by 10 X 10 foot spacing
      2. No single species comprising significantly more than 25% of total
      3. Concentrate on heavy masted species (e.g. oak and hickory) - light masted species (e.g. maple and ash) are expected to invade most sites naturally.
      4. Stock description and origin (e.g. acorn, bare root stock, balled & burlap, container grown)

VI. Hydrology
   A. Existing
      1. Surface water
         a. Hydroperiod
         b. Source
            i. Overbank flooding
            ii. Precipitation
            iii. Groundwater seeps
         c. Hydrodynamics

2. Groundwater
   a. Seasonal table elevations
      i. Soil survey
      ii. Well data (if available)
   b. Low-flow level in adjacent stream (if applicable)

B. Proposed
   1. Surface water
      a. Hydroperiod
      b. Source
         i. Overbank flooding
         ii. Precipitation
         iii. Groundwater seeps
      c. Hydrodynamics
   2. Groundwater
      a. Seasonal table elevations
      b. Low-flow level in adjacent stream channel (if applicable)

Part 3. Success Criteria and Performance Standards

I. Construction schedule: Construction should be completed prior to or concurrently with project completion.

II. Soils parameters (if necessary) will be used to provide supportive evidence of success but will not carry minimum requirements.
   A. Soils redox exhibits anaerobic conditions for 5 to 12 1/2% of the growing season (or as defined in the current wetland delineation manual). Provide statistical proof that sample data falls within success criteria.
   B. Organic matter should exhibit an increase over time

III. Vegetation
   A. Mean density per acre meets that proposed based on compensatory mitigation objectives and composed of at least 50% approved planted species, which have been established on-site for five consecutive successful years.
   B. No single species constitutes significantly more than 25% of he surviving species.
   C. Meets current federal delineation manual for hydrophytic vegetation.
   D. Meets proposed Cowardin classification (see Chapter 3.I.C.4)

IV. Hydrology - hydroperiod is restored as defined in Section B, VI.B.; at a minimum the site is inundated and/or saturated for 5 to 12 1/2% of the growing season (or as defined in the current wetland delineation manual). Provide statistical proof that sample data falls within success criteria.

V. Water quality
   A. Meets Kentucky Water Quality Standards
   B. Will be site specific and based on compensatory mitigation objectives.

VI. Functions and values of the compensatory mitigation site are comparable to those identified from the development site (see checklist - Appendix 2).
   A. Hydrology
   B. Biogeochemical processes
   C. Plant maintenance
   D. Habitat maintenance

Part 4. Monitoring

I. Parameters
   A. Construction schedule
      1. Duration of compensatory mitigation
      2. Plan showing each phase of the compensatory mitigation and the proposed dates of initiation and completion; e.g., earth moving, hydrology restoration, revegetation, and monitoring phases. (Deviations from projected dates will need to be pre-approved by the regulatory agencies.)
   B. Soils*
      1. Redox potential
      2. Organic matter content
      3. Nutrients
   C. Vegetation*
      1. Species composition and indica-

tor status (list by scientific and common names)
   2. Survival rate of planted species
   3. Ratio of planted species vs. volunteer species
   4. Individual species importance values
- D. Hydrology*
   1. Surface water hydroperiod
      a. Source
         i. Precipitation
         ii. Overbank flooding
      b. Depth(s)
      c. Frequency
      d. Duration of inundation
   2. Seasonal groundwater table elevations
- E. Water quality* (site specific and based on compensatory mitigation objectives)
- F. Functions and values (narrative based on checklist in Appendix 2)
   1. Hydrology
   2. Biogeochemical processes
   3. Plant maintenance
   4. Habitat maintenance

II. Sampling frequency
- A. If necessary, sample soils redox potential at frequency sufficient to demonstrate the site exhibits anaerobic conditions for 5 to 12 1/2% of the growing season (or as defined in the current wetland delineation manual).
- B. Sample vegetation (woody layer and herbaceous layer) once in late summer or early fall until there have been two consecutive successful years (see Chapter 4 for Success Criteria); afterwards, sample once in early fall for the remainder of the monitoring period.
- C. Hydrology
   1. Record surface water during each inundation event during the growing season (e.g., USGS data/cork staff gage).
   2. Record groundwater every 9 days from March 15 through June 30 and monthly the remainder of the growing season.
- D. Water quality sampling frequency will be determined on a site-specific basis.
- E. Complete the function and values checklist (Appendix 2) annually in the spring.

III. Monitoring reports
- A. Report format should follow guidelines format.
- B. Should include interpretation of data as performed by a qualified individual.
- C. Results and discussions should address each item included within these guidelines.
- D. Submit reports biannually until there have been two consecutive years of successfully meeting performance criteria; submit annually thereafter.
- E. Photographic documentation should be included of wetland and surrounding landscape(s) from all four cardinal directions using 35 mm color film from permanent photo stations (these photo stations need to be depicted on plan view sheets to promote consistency from one monitoring session to the next).
- F. List names, addresses, and phone numbers of persons/entities responsible for each type of sampling and report preparation.

— Follow standard sampling methods and provide specific citation for each. If alternative methods are selected, describe and reference for approval by the regulatory agencies. Characterize the compensatory mitigation site by using an adequate number of sample sites and locations. Ensure validity of sampling results through standard statistical methods.

Part 5. Contingency Plan

I. Reporting Protocol - If a success criterion is not met for all or any portion of the compensatory mitigation project in any year, and/or if the final success criteria are not satisfied, the permittee shall prepare an analysis of the cause(s) of failure and, if determined necessary by the regulatory agencies, propose remedial action for pre-approval.

II. Alternative locations for contingency compensatory mitigation - indicate specific alternative compensatory mitigation locations that may be used in the event that compensatory mitigation cannot be successfully achieved at the intended site.

Part 6. Permanent Protection Measures

I. To insure permanent protection, transfer of ownership of the compensatory mitigation site to nonprofit environmental organization or resource management agency is recommended.

II. Provide proposal for protection of all compensatory mitigation lands, in perpetuity, as functional wetlands in accordance with the compensatory mitigation plan.

III. Provide cop(ies) of all written agreements with land owner clearly describing compensatory mitigation site and restrictions.

IV. Provide copy of official deed showing compensatory mitigation site and restrictions binding on current and all future owners.

V. Provide copy of long-term management plan ensuring the maintenance of compensatory mitigation site in accordance with compensatory mitigation objectives.

Chapter 6. Kentucky's Section 401 Clean Water Act Water Quality Certification Program Overview and Requirements

Section A: Applying for a WQC

For the purpose of protecting water quality and aquatic life, those activities involving physical disturbances to streams and wetlands will require mitigation when impacts cannot be avoided by the site-specific project. This requirement is pursuant to Section 401 of the Clean Water Act (CWA), with state authority under KRS 224. When a complex surface water is involved, such as a watershed size greater than one-square mile, or wetland, the applicant should contact an environmental consultant who has training and experience in stream or wetland ecology. A partial list of consultants can be found in Appendix 6 of this manual.

For both wetland and stream disturbances, the applicant should complete and submit an application for Water Quality Certification (form #DEP6046) especially when the proposed activity will be authorized by the U.S. Army Corps of Engineers under their Nationwide Permit program.*

Upon receipt of a Water Quality Certification application, the Kentucky Division of Water will make an evaluation of the project to determine the level of site investigation and mitigation that will be required. A goal of the Water Quality Certification program in Kentucky is to prevent "loss" of surface water resources.

If there are not any practicable alternatives to avoid disturbances to surface waters, then the applicant should review the project to minimize, as much as possible, physical impacts to streams and wetlands. Mitigation will be required when disturbances cannot be avoided. Mitigation must address restoration of an aquatic ecosystem similar to that being impacted.

For wetland-related impacts involving greater than one acre of wetland loss or fill, the applicant should follow the "Interagency Guidelines" discussed in Chapter 5, Section B, of this manual. Additional guidance on wetlands and jurisdictional wetland determinations can be obtained from the U.S. Army Corps of Engineers.

For stream-related impacts, the following application guidelines should be followed and submitted along with the application. **Detailed plan and profile drawings that involve more than 200 linear feet of physical disturbance to a blueline stream should include this information:**

Pre-Disturbance or Reference of the Surface Water:

1. Channel morphology; e.g., channel width, bank height (normal pool to high water mark), bank slope, stream gradient, pool to riffle ratio, run to bend ratio, bottom shape.
2. Location of aquatic habitats; e.g., pools, riffles, woody debris, log jams, rootwads, gravel bars (point bars), instream vegetation beds, substrate types, and composition.
3. Hydrology; e.g., stream flow at low flow (7Q10); average annual flow. In an upper headwater situation, this data may not be generally available.
4. Riparian Zone composition and widths, including botanical species list. Stream shading, which is critical to maintaining water temperatures, and canopy percentage should be addressed.
5. Adjacent wetlands in accordance with the delineation manual currently being

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* The application form is re-evaluated on a regular basis; therefore, revisions to the form do occur. To obtain the most recently revised application, call the Water Quality Certification Section at (502) 564-3410

used by the U.S. Army Corps of Engineers.

6. Sediment and erosion control measures (best management practices) to be used during construction; e.g., retention basins, silt fencing, rock check dams, or vegetated buffer zones.

Post-Disturbance — Mitigation

1. Minimizing net loss of stream length; i.e., replace meanders.
2. New channel morphology, which should be similar to the pre-disturbance morphology.
3. Restoration, creation, or enhancement of aquatic habitat
4. Restoration of riparian zone including width and species list. For the purpose of protecting water quality and maintaining bank stability, a permanent vegetated buffer zone should be restored along each streambank in the project area. A minimum width of 50 feet on each side of the stream is suggested, but even a width of 15 feet can offer some water quality benefits (see Table 1). The revegetation plan needs to include an immediate herbaceous groundcover mixture, as well as trees and shrubs, which can be planted on a 12' X 12' spacing. A minimum of four tree species and three shrub species should be planted in the riparian zone. Botanical species for riparian zones can be selected from the species list in Appendix 4. Exotic, invasive, and nuisance species should not be planted.
5. Monitoring plans to determine the success of the mitigation should be developed that check habitat structures, bank stability, vegetation plantings, and silt control structures. Aquatic life will need to be monitored after post-construction when the watershed size is greater than one square mile.
6. Contingency plan that addresses possible failure of the various mitigation construction aspects; e.g., spot grading, reseeding, replanting, maintaining bank stability, and replacement of habitat structures.
7. Permanent protection and maintenance of the mitigated stream channel and riparian zone.

Section B: Mining Activities

With respect to coal mining, Kentucky's 401 Water Quality Certification (WQC) program is largely governed by state law KRS 224.16-070. This law pertains to mining operations covered under Corps of Engineers Nationwide 404 Permits #21 (surface mining activities) and #26 (headwater and isolated waters). Situations requiring stream mitigation are defined by this provision and may involve on-site mitigation, off-site mitigation, or a combination thereof. Generally, a 1:1 mitigation ratio is required for stream loss; however, a .5:1 mitigation ratio is required for waters isolated as a result of a permanent structure. In addition, outstanding state or national resource waters and coldwater aquatic habitats are specifically afforded protection by KRS 224.16-070. Operations affecting larger streams may require an Individual 404 Permit from the Corps.

Coal mining operations covered under Nationwide 404 Permits #21 and #26 proposing to place any fill within a blueline stream will require a 401 WQC from the Division of Water. The type of 401 WQC will vary depending upon the degree of disturbance. Operations in which the watershed above any structure is less than 480 acres are covered by the Division's General Certification for Nationwide Permit #21. A 401 WQC application does not need to be submitted in this case. Operations in which the watershed above any "temporary" structure is greater than 480 acres requires a 401 WQC with standard conditions. The 401 WQC application in such cases needs to 1) provide a sediment/erosion control plan for sediment pond construction and removal and for other aspects of the operation and 2) address how streams are to be restored after sediment ponds are removed. Whenever the watershed above the toe of the farthest downstream permanent structure is greater than 480 acres, an Individual 401 WQC, sediment control plan, and stream mitigation plan are required

An Individual 401 WQC and mitigation plan are also required whenever more than one acre of wetland will be disturbed (refer to Chapter 5). The mitigation ratio for wetland loss begins at 2:1.

Section C: Farm-Related Activities: Impacts to Streams in Agricultural Areas

In 1994, the Kentucky General Assembly enacted the Kentucky Agricultural Water Quality Act (KRS 224.71) (Act). This legislation is designed to guide Kentucky's farmers in protecting water quality. In 1996, the Act was amended by the General Assembly to include provisions to reduce the paperwork burden on farmers who were intending to do stream work that would require a Water Quality Certification (WQC).

The Agriculture Water Quality Plan (Plan), which was developed as the result of the 1994 legislation, is a collection of Best Management Practices (BMPs) intended to cover a wide variety of activities in which a farmer may engage that could have a negative impact on Kentucky's water quality. One of the six sections in the Plan covers physical disturbances to streams that may result from road crossings, sand and gravel removal, streambank protection, and stream drainage maintenance.

In short, the requirements to obtain permission to work in a stream are different in those streams that flow through areas defined in the Act as "agricultural operations." This definition includes any farm or forestry operation situated on 10 acres or more of land that is involved in the production of income-producing crops. For stream projects where the Corps of Engineers has determined that an "individual permit" under Section 404 of the Clean Water Act is required, the requirement that an individual WQC be issued by the Division of Water is still in effect.

In those situations where the Corps of Engineers has determined that a Nationwide Permit is appropriate, it is not necessary to obtain a WQC from the Division of Water. However, the Agricultural Water Quality Authority has agreed that it is important for landowners to obtain on-site technical assistance from the Division of Water in order to design the project in such a manner as to avoid violation of Kentucky water quality regulations. The four stream BMPs contain language that spells out when the Division of Water needs to be involved.

For more information, call the supervisor of the Water Quality Certification Section in Frankfort at (502) 564-3410 or the Kentucky Division of Conservation at (502) 564-3080.

Appendix 1: Maps, Plans, and Drawings for Wetlands

I. Existing conditions (or in case of violation site - preexisting conditions as available) of development site and proposed compensatory mitigation site
   A. Plan view sheets (Scale: 1 inch = 400 feet)
      1. Soil types
      2. Hydrological conditions including 1-foot contours
      3. Vegetative distribution patterns
      4. Location and contours of drainage ditches, levees, berms, and spoil piles
      5. Surrounding land use(s)
   B. Cross sectional profiles
      1. Width, depth, and bottom elevation of ditches
      2. Height and width of berms, levees, and spoil areas

II. Proposed restored compensatory mitigation site conditions
   A. Plan view sheets (Scale: 1 inch = 400 feet)
      1. Monitoring stations; e.g., groundwater wells, staff gauges, etc.
      2. Soil types and depth used for areas without adequate hydric soils initially (primarily for creation)
      3. Proposed vegetation planting composition, planting rates, and species distribution patterns
      4. Hydrology restoration measures, including 1-foot contours, elevations, ditch checks, berms, levee breeches, etc.
      5. Sediment and erosion control; e.g., location of check dams, straw bales, etc.
      6. Earth moving and, if applicable, disposal area used for excess material.
      7. Surrounding land use(s)
   B. Cross sectional profiles
      1. Width, depth, and bottom elevation of ditches
      2. Height and width of berms, levees, and spoil areas

III. As-Built Plans - should be signed by a certified professional engineer and submitted to the Army Corps of Engineers within 60 days after compensatory mitigation project completion.

Appendix 2: Wetland Functions Checklist

This checklist was designed by the interagency reviewers of the Wetland Mitigation Guidelines for Kentucky. The list provided here is only a brief summary about hydrogeomorphic (HGM) processes of wetlands. The foundation of HGM assessment is reference wetland comparisons, which requires the completion of regional guidebooks. The Western Kentucky Regional Guidebook can be obtained from the Environmental Protection Agency when completed.

The assessment of function for mitigation sites should be based upon the Hydrogeomorphic Classification System for Wetlands (Brinson 1993). This classification is based upon three basic properties which provide insight into wetland function. These three basic properties are: geomorphic setting (riverine, depressional, fringe); water source (precipitation, lateral flows from upstream or upslope, and ground water); and hydrodynamics (vertical, unidirectional and horizontal, and bidirectional and horizontal). To determine the relative potential for a mitigated wetland to achieve similar hydrogeomorphic functions as a project site, selected reference wetland (or selected reference population), and therefore achieve success, the sites must be compared hydrogeomorphically. The mitigation site must be of a similar hydrogeomorphic class (i.e., have a similar hydrogeomorphic setting, water source, and hydrodynamics) to the project site to approach a successful mitigation project from a functional standpoint. It is important to note that "success" in this context refers to ecological replacement of functions lost due to development of a particular wetland site.

The following represents categories of function attributed to riverine and depressional wetlands. As further work on wetland systems is completed and new information is available, certain categories of function may be deleted or added.

Riverine wetland functions:

Hydrology -

Dynamic surface water storage [DSWS] - Capability of a wetland to detain moving water from overbank flow for a short duration when flow is out of the channel; associated with moving water from overbank flow and/or upland surface water inputs by overland flow or tributaries.

Long-term surface water storage [LTS] - Capability of wetland to store (detain) surface water for long durations; associated with standing water not moving over the surface. Sources of water may be overbank flow, channel flow, and/or subsurface flow. Storage is associated with standing water.

Energy dissipation [ED] - Allocation of the energy of water to other forms as it moves through, into, or out of the wetland as a result of roughness associated with large woody debris, vegetation structure, micro- and macrotopography, and other obstructions.

Subsurface water storage [SWS] - Availability of water storage beneath the wetland surface. Storage capacity becomes available as periodic drawdown of water table or reduction in soil saturation occurs.

Moderation of groundwater flow or discharge [MGWF] - Capacity of a wetland to moderate (slow) the rate of groundwater flow or discharge from upgradient (i.e., upstream) or upslope (i.e., lateral) sources.

Biogeochemical Processes -

Nutrient cycling [NC] - Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes.

Removal of imported elements and compounds [REC] - The removal of imported nutrients, contaminants, and other elements and compounds.

Retention of particulates [RP] - Deposition and retention of inorganic and organic particulates from the water column (>0.45 um including coarse woody debris) primarily through physical processes.

Organic carbon export [OCE] - Export of dissolved and particulate organic carbon from the wetland. Mechanisms include leaching, flushing, displacement, and erosion.

Plant Maintenance -

Maintain characteristic plant community [MCPC] - Species composition and physical characteristics of living plant biomass. The emphasis is on the dynamics and structure of the plant community as revealed by the dominant species of trees, shrubs, seedlings, saplings, and ground cover, and by the physical characteristics of vegetation.

Maintain characteristic detrital biomass [DB] - The processes of production, accumulation, and dispersal of dead plant biomass. Sources of organic matter may be onsite, upslope/ upgradient areas, or backwater.

Habitat Maintenance -

Maintain spatial structure of habitat [MSSH] - The capacity of a wetland to support animal populations and guilds by providing heterogenous habitats.

Maintain habitat interspersion and connectivity [MIC] - The capacity of a wetland to permit aquatic organisms to enter and leave the wetland via permanent or ephemeral surface channels, overbank flow, or unconfined hyporheic gravel aquifers. The capacity of the wetland to permit access of terrestrial or aerial organisms to contiguous areas of food and cover.

Maintain distribution and abundance of invertebrates [MDAI] - The capacity of a wetland to maintain characteristic density and spatial distribution of invertebrates (aquatic, semi-aquatic, and terrestrial).

Maintain distribution and abundance of vertebrates [MDAV] - The capacity of a wetland to maintain the density and spatial distribution of vertebrates (aquatic, semi-aquatic, and terrestrial) that utilize wetlands for food, cover, rest, and reproduction.

Depressional wetland functions:

Hydrology -

Surface water storage [DPSWS] - Capability of wetland to store or detain precipitation. The predominant water source is precipitation; however, some overland flow may originate from adjacent areas of higher elevation.

Subsurface storage of water [DPSSW] - Capacity to store water below the wetland surface.

Biogeochemical -

Nutrient transformations and processing [NTP] - Abiotic and biotic processes that convert elements from one form to another; primarily recycling processes. Growth or biomass accumulation and decomposition ensures that elements are converted between organic and inorganic forms.

Removal of elements and compounds in precipitation and dryfall [REC] - The removal of nutrients, compounds, and dryfall imported directly by precipitation or by overland flow from adjacent areas. This differs from the NUTRIENT TRANSFORMATIONS AND PROCESSING function where the emphasis is on interconversions and recycling on less than an annual time scale. Retention of elements and compounds is the removal from cycling on a more or less permanent basis by one or several of the following:

1) Loss to the atmosphere - occurs as nitrate is denitrified to N2 or N2O, ammonia is volatilized, and sulfur is converted to gaseous form;
2) Deposition and burial in sediments - occurs through burial, precipitation (removal of phosphorous by iron III, sorption (heavy metals with organic matter), and others.
3) Assimilation into biomass by storage in perennial plant parts of herbaceous species and storage in long-lasting woody biomass.

Organic carbon export [DPOCE] - Export of dissolved and particulate organic carbon from the wetland through leaching, flushing, displacement, and erosion.

Depressional wetlands also function to maintain characteristic plant communities, detrital biomass, vertical habitat structure, and food web support for animals. These functions are the same as those characterized for riverine wetlands and utilize the same indicators.

Brinson (1993) also discusses indicators of function as derivatives of the three basic properties of wetlands (geomorphic setting, water source, and hydrodynamics). These indicators entail short-term (e.g., high water marks, herbaceous plant cover, debris wracks) and long-term (e.g., geomorphic structure, forest canopy species composition) indicators of wetland function and processing. The following list represents those indicators of function which can be detected on mitigation sites within a short time frame and can be used as indicators of functional replacement.

Checklists should be completed annually and submitted to the Corps for analysis. However, many of these indicators are temporal in nature (i.e., occur only in spring season when water is on the sites), and notes should be taken during other monitoring visits to document the presence of any of these indicators. Direct observation of any function (e.g., observation of ponded water during the growing season, groundwater within 12 inches of the surface) should be documented whenever possible. Indicators on the checklist are marked only as being present or absent. However, observations quantifying any indicator (i.e., depth of water on the site, percent of site covered by water, depth to saturation, percent cover, zonation of surface or groundwater patterns, etc.) should be included whenever possible. This information will assist the Corps and other resource agencies in assessing the ecological development of the mitigation site.

Finally, this constitutes a preliminary list of indicators of function. Once the mitigation and monitoring commences additional signs of ecological function may be observed that are not on this list. These observations should be documented and their ecological significance discussed. It is anticipated that such observations may add a great deal of pertinent information to the resource agencies in assessing the mitigation site's success.

Indicators of function

—— Microtopographic relief (e.g. hummocks, scour around trees, small surface channels) [Microtopographic relief occurs on the order of a few meters or less, such as pit-and-mound features from windthrow, hummocks, buttressing of trees, large logs, etc.]

—— Overbank flooding (direct observation or indirect evidence such as water, aerial photographs, or gage data)

—— Sediment scour and deposition

—— Redistribution of detritus (e.g., wrack, debris jams, drift lines)

—— Localized sediment deposition

—— Structural roughness (e.g., vegetation, microtopographic relief)

—— Presence of debris jams and wrack

—— Intermediate soil porosity:

Sediments must be capable of developing unsaturated pore space in order to have the capacity to store water. (Fine-grained soils with low transmissivity function poorly in subsurface storage of water because of their resistance to infiltration and because they maintain thick capillary fringes that don't develop adequate unsaturated volume for subsurface storage).

—— Reduced soil conditions (e.g., mottling, gleying, organic matter accumulation, redox potential, etc.) Contributes to the maintenance of hydric soils, anaerobic biogeochemistry, and plant and animal species composition adapted to life in reduced conditions.

—— Saturated soils unrelated to overbank flooding (i.e., maintained in spite of the lack of precipitation and overbank flooding). Groundwater discharge originating upslope may maintain saturation when other supplies cease.

—— Seeps at upland/wetland interface or at surface of wetland (such seeps are indicative of water moving vertically upward)

—— Floodplain ponding (direct observation or indirect evidence)

—— Sparse herbaceous growth in depressions

—— Low permeability soils

—— Vegetation indicative of standing water (for example, submerged aquatic and/or obligate emergents)

—— Vegetative community (density, basal area, vertical stratification, cover, and species composition) typical of reference site with evidence of nutrient uptake and release (plant growth, litter production, decomposition rate, etc.)

—— Surface films or layers of recently deposited sediments

—— Debris blockages in active channels, blockages in side channels, accumulations in microtopographic depressions, accumulations in vegetation, redistribution off-site

INDICATOR CHECKLIST

INDICATOR	PRESENT	ABSENT
Microtopographic relief	_______	_______
Overbank flooding	_______	_______
Sediment scour and deposition	_______	_______
Redistribution of detritus	_______	_______
Localized sediment deposition	_______	_______
Structural roughness	_______	_______
Presence of debris dams and wrack	_______	_______
Intermediate soil porosity	_______	_______
Reduced soil conditions	_______	_______
Low permeability soils	_______	_______
Saturated soils unrelated to overbank flow	_______	_______
Seeps at upland/wetland interface or at wetland surface	_______	_______
Floodplain ponding	_______	_______
Sparse herbaceous growth in depressions	_______	_______
Submerged aquatic vegetation	_______	_______
Obligate wetland vegetation dominates	_______	_______
Vegetative community typical of "reference" (impact) site	_______	_______
Surface films or layers of recently deposited sediments	_______	_______
Debris dams in active channels	_______	_______
Debris dams in side channels	_______	_______
Debris accumulations in microtopographic depressions	_______	_______
Debris accumulations in vegetation	_______	_______
Debris redistribution off-site	_______	_______

Appendix 3: Wetland Plant List

The compensatory mitigation site should be revegetated based upon vegetation surveys of reference wetlands in the area and known information about species tolerance to various wetland conditions. The following list contains common species occurring in three different water regimes, as classified by the National Wetland Inventory, of Kentucky's forested wetlands. It should be used as a guide to recommended species composition. Please note that the light masted species such as red maple, green ash, sycamore, river birch, and cottonwood designated by an "I" are expected to invade most sites naturally and do not need to be planted. (Species designated by an asterisk, "*", are preferred dominants.)

Common Name	Scientific Name
PFO1A WETLANDS (Temporarily Flooded)	
Overstory	
Pin oak*	*Quercus palustris*
Shellbark hickory*	*Carya laciniosa*
Swamp chestnut oak	*Quercus michauxii*
Cherrybark oak	*Quercus pagoda*
Bur oak	*Quercus macrocarpa*
Green ash (I)	*Fraxinus pennsylvanica*
Red maple (I)	*Acer rubrum*
Sweetgum (I)	*Liquidambar styraciflua*
Sycamore (I)	*Platanus occidentalis*
Sugarberry	*Celtis laevigata*
Black gum	*Nyssa sylvatica*
Understory	
Arrow-wood	*Viburnum dentatum*
Deciduous holly	*Ilex decidua*
Gray dogwood	*Cornus racemosa*
Silky dogwood	*Cornus amomum*
American hornbeam	*Carpinus caroliniana*
Persimmon	*Diospyros virginiana*
Elderberry	*Sambucus canadensis*
Herbaceous	
Jewelweed	*Impatiens spp.*
Sedges	*Carex spp.*
Spikerushes	*Elocharis spp.*
Flatsedges	*Cyperus spp.*
Nutsedge	*Cyperus strigosus*
Chufa	*Cyperus esculentus*
Clearweed	*Pilea pumila*

PFO1C WETLANDS (Seasonally Flooded)

Overstory

Pin oak*	*Quercus palustris*
Shellbark hickory*	*Carya laciniosa*
Overcup oak	*Quercus lyrata*
Swamp white oak	*Quercus bicolor*
American elm (I)	*Ulmus americana*
Swamp cottonwood	*Populus heterophylla*
Black gum	*Nyssa sylvatica*

Understory

Withe-rod	*Viburnum cassinoides*
Silky dogwood	*Cornus amomum*
Sugarberry	*Celtis laevigata*
Persimmon	*Diospyros virginiana*
Spicebush	*Lindera benzoin*
Steeplebush	*Spiraea tomentosa*
Deciduous holly	*Ilex decidua*

Herbaceous

Beggarticks	*Bidens spp.*
Bulrushes	*Scirpus spp.*
Sedges	*Carex spp.*
Spikerushes	*Eleocharis spp.*
Wild millet	*Echinochloa muricata*
Cutgrass	*Leersia spp.*

PFO1F WETLANDS (Semipermanently Flooded)

Overstory

Overcup oak*	*Quercus lyrata*
Swamp white oak*	*Quercus bicolor*
Water tupelo	*Nyssa aquatica*
Water hickory	*Carya aquatica*
Bald cypress	*Taxodium distichum*

Understory

Swamp privet	*Forestiera acuminata*
Buttonbush	*Cephalanthus occidentalis*
Swamp-haw	*Viburnum nudum*
Winterberry	*Ilex verticillata*
Common alder	*Alnus serrulata*
Swamp rose	*Rosa palustris*

Herbaceous

Arrowhead	*Sagittaria spp.*
Lizard's tail	*Saururus cernuus*
Water-Plantain	*Alisma subcordatum*
Sweet flag	*Acorus calamus*
Spatterdock	*Nuphar luteum*
Bulrushes	*Scirpus spp.*
Sedges	*Carex spp.*
Cutgrass	*Leersia spp.*

The following species are recommended for establishing groundcover on wetland soils. The use of Kentucky 31 fescue is prohibited.

Groundcover	Scientific name
Rice cutgrass	*Leersia oryzoides*
Managrass	*Glyceria striata*
Spangle grass	*Chasmanthium latifolium*
Redtop	*Agrostis alba*
Barnyard grass	*Echinochloa crus-galli*
Alsike clover	*Trifolium hybridum*
Switchgrass	*Panicum virgatum*
Annual rye	*Secale cereale*
Wild rye	*Elymus virginicus*
Deertongue grass	*Panicum clandestinum*
Panic grass	*Panicum microcarpon*

Appendix 4: Species Suitable for Revegetation of Stream Construction Sites

These are only a few botanical suggestions for planting alongside streams. Ideally, the plantings should reflect the natural vegetation of the watershed. The plants should be a natural constituent of the original streambank flora representative of the specific watershed. Exotic or nuisance plant species are never recommended.

Groundcover	Scientific Name
Rice cutgrass	*Leersia oryzoides*
Managrass	*Glyceria striata*
Spangle grass	*Chasmanthium latifolium*
Barnyard grass	*Echinochloa crusgalli*
Switchgrass	*Panicum virgatum*
Annual rye	*Secale cereale*
Wild rye	*Elymus virginicus*
Deertongue grass	*Panicum clandestinum*
Panic grass	*Panicum microcarpon*
Giant cane bamboo	*Arundinaria gigantea*
Trees	
Pin oak	*Quercus palustris*
Cherrybark oak	*Quercus pagoda*
Bur oak	*Quercus macrocarpa*
Swamp Chestnut oak	*Quercus michauxii*
Shingle oak	*Quercus imbricaria*
Northern Red oak	*Quercus rubra*
Shumard oak	*Quercus shumardii*
Red maple	*Acer rubrum*
Green ash	*Fraxinus pennsylvanica*
Sycamore	*Platanus occidentalis*
Shellbark hickory	*Carya laciniosa*
Blackgum	*Nyssa sylvatica*
American elm	*Ulmus americana*
Red elm	*Ulmus rubra*
Black walnut	*Juglans nigra*
River birch	*Betula nigra*
Buckeye	*Aesculus glabra*
Yellow poplar	*Liriodendron tulipifera*
American hornbeam	*Carpinus caroliniana*
Shrubs	
Alder	*Alnus serrulata*
Arrow-wood	*Viburnum dentatum*
American plum	*Prunus americana*
Deciduous Holly	*Ilex decidua*
Gray Dogwood	*Cornus racemosa*
Silky Dogwood	*Cornus amomum*
Spicebush	*Lindera benzoin*

Appendix 5: Sources for Obtaining Plant Materials

Many of these sources were recommended in the Landscape Restoration Handbook by Harker et al 1993.

Akinback Farm
2501 Hwy 53 South
LaGrange, KY 40031
(502) 222-5791
herbaceous perennials

Dabney Herbs
PO Box 22061
Louisville, KY 40252
(502) 893-5198
habitat restoration

Environmental Concern
PO Box P
210 W Chew Avenue
St. Michaels, MD 21663
wetland plants and seed

The EnviroTech Nursery
462 South Ludlow
Columbus, OH 43215
(614) 224-1920
herbaceous wetland plants

Jane's Native Seeds (Jane's Jungle)
1860 Kay's Branch Road
Owenton, KY 40359
(502) 484-2578 or (502) 484-2044
wetland plants and seed

LaFayette Home Nursery, Inc.
Rural Route 1
Box 1A
LaFayette, IL 61449
(309) 995-3311
wetland and prairie restoration

Nolin River Nut Tree Nursery
797 Port Wooden Road
Upton, KY 42784
(502) 369-8551
native trees and shrubs

Nurtured Gardens Nursery
8150 Lower Licking Road
Morehead, KY 40351
(606) 784-4769
wetland and stream restoration

Shooting Star Nursery
444 Bates Road
Frankfort, KY 40601
(502) 223-1679
native plants for wetland, prairie
and stream restoration

Southern Tier Consulting, Inc.
2677 Route 305
PO Box 30
West Clarksville, NY 14786
(800) 848-7614
wetland mitigation and habitat restoration

Stinson Rhododendron Nursery
10400 Florian Road
Louisville, KY
(502) 244-9459
native trees and shrubs

Appendix 6: Consultants for Kentucky Wetlands and Stream Ecology

ADMW Consultants
3200 Iglehart Avenue
Evansville, IN 47712
(812) 422-0214

Robert W. Colson
Auth-Colson/associates
390 Red Cedar Street
Suite P
Menomonie, WI 54751
(715) 232-8490

Hal Bryan
ECO-TECH, INC.
1208 West Main
PO Box 8
Frankfort, KY 40602-0008
(502) 695-8060

Jeff T. Drake
EMPE INC
Plaza 1 Suite 410
220 Athens Way
Nashville, TN 37228
(615) 255-9300

Mr. James Manuel Barnes, President
Environmental and GIS Consulting, Inc. (EGIS)
ATTN: Ms. Jodie Burns
314 South Main
Bentonville, AK 72712
(501) 271-9252

Ed Hartowicz
Environmental Management & Consulting CTI
500 Lake Tower #80
Lexington, KY
(606) 276-3091

John Montgomery
Fuller, Mossbarger, Scott, & May (FMSM)
1490 North Forbes Road
Lexington, KY 40511
(606) 233-0574

Steve Bickel
Fuller, Mossbarger, Scott & May (FMSM)
13005 Middletown Industrial Blvd
Suite E
Louisville, KY 40223
(502) 244-6519

Thomas Heineke, President
Heineke & Associates, Inc.
3014 Sycamore View Road
Bartlett, TN 38134
(901) 373-3289

Virgil R. Holmes
3D Environmental Services INC
781 Neeb Road #5
Cincinnati, OH 45233-4625
(513) 922-8199

Law Environmental INC
112 Townpark Drive
Kennesaw, GA 30144-5599
(404) 421-3413

This is only a partial list of consultants from the Kentucky Division of Water. Other resource agencies may have additional recommendations.

Appendix 7: References for Stream Restoration

These are only a few recommended references for stream restoration and not a comprehensive listing. This list is intended to promote healthy watershed management. Many of these references were taken from the Izaak Walton League's **A citizen's streambank restoration handbook**, 1995. Input was provided by the Louisville District Corps of Engineers.

Bioengineering for Land Reclamation & Conservation. 1980. Book written by Hugo Schiechtl recommended for stream restoration professionals. Published by University of Alberta Press, Canada. Available in libraries or specialty bookstores. (out of print)

Biohabitats. Technical and detailed information on stream restoration. Focus is on bioengineering approach to restoration for maintaining a healthy watershed. Source: Ecological Restoration and Management, Keith Bowers, 303 Allegheny Ave, Baltimore, MD, 21204, or call (410) 337-3659. (consulting fee may apply)

Biotechnical Slope Protection and Erosion Control. 1982. Book written by Donald Gray and Andrew Leiser recommended for restoration professionals. Published by Van Nostrand Reinhold Co. Available in libraries or specialty bookstores. (out of print)

Chesapeake Bay Community Action Guide, A Step-by-Step Guide to Improving the Environment in Your Neighborhood. 1994. This 94-page manual focuses on the Chesapeake Bay watershed. Includes information on storm drain stenciling, stream cleanups, reforestation, tree care, and local resources. Source: Information Center, Metropolitan Washington Council of Governments, 777 North Capitol Street, NE, Suite 300, Washington, DC 20002-4201 or call (202) 962-3256. (#94705)

A Citizen's Streambank Restoration Handbook. 1995. A 111-page grassroots guide for streambank stabilization projects using bioengineering techniques. Features installation guidelines, sample budgets, and a guide for choosing the correct techniques for your particular problem. Case studies included. Source: Izaak Walton League of America, Save Our Streams Program, 707 Conservation Lane, Gaithersburg, MD 20878-2983, or call (301) 548-0150 or (800) 284-4952. ($15)

A Classification of Natural Rivers. A 30-page article written by David Rosgen that describes stream classification for application to restoration and water resource management. Source: Catena, 1994, volume 22, pages 169 to 199.

Clean Water in Your Watershed: A Citizens Guide to Watershed Protection. 1993. A 90-page citizen's guide to designing and completing a watershed restoration project. Source: The Terrene Institute, 1717 K St, Suite 801, NW, Washington, DC 20006-1504, or call (202) 833-8317. ($19.95)

Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors. 1992. This resource manual encourages the use of economic concepts as part of the effort to protect and promote greenways. Source: Rivers, Trails, and Conservation Assistance Program, PO Box 37127, Washington, DC, 20013, or call (202) 343-3780. (free)

Fish and Fisheries Management in Lakes and Reservoirs. 1993. A 322-page technical guide for developing lake management strategies to protect fish. Source: The Terrene Institute, 1717 K St, Suite 801, NW, Washington, DC 20006-1504, or call (202) 833-8317. ($35)

Greenways: A Guide to Planning, Design and Development. 1993. A 351-page step by step guide to envisioning, funding, implementing and managing a greenways project. Source: Island Press, Box 7, Covelo, CA 95428 or call (800) 828-1302. (ISBN # 1-55963-137-6) ($45)

Greenways for America. 1990. A planning manual for communities that has many examples of river corridor projects and a good bibliography. Source: The Johns Hopkins University Press, Hampden Station, Baltimore, MD, 21211, or call (410) 516-6956. ($24.95)

Guidelines for Bank Stabilization Projects in the Riverine Environments of King County. 1993. A 195-page manual developed to help scientists and engineers with the design of bank stabilization projects for river and streambank protection. A step-by-step approach starting with assessment of problems to planning, design, and implementation. Although geared to the Northwest, principles can be applied to other areas. Source: King County Department of Public Works, Surface Water Management Division, 700 Fifth Ave, Suite 2200, Seattle, WA 98104, or call (206) 296-6519. ($21.65)

Guidelines for Streambank Restoration. 1994. A 52-page booklet on understanding and correcting streambank erosion problems. The book focuses on bioengineering techniques as advised by Robbin B. Sotir & Associates. Source: Georgia Soil and Water Conservation Commission, (706) 542-3065.

How Greenways Work, A Handbook on Ecology. [NO DATE] This is a pamphlet published by the National Park Service and the Quebec-Labrador Foundation's Atlantic Center for the Environment. Available for $2.75 from the Government Printing Office: Superintendent of Documents, GPO, Washington, D.C., 20402, (202) 783-3238, Stock #024-005-01118-8.

Lake Smarts. 1994. A 228-page "how to" handbook covering lake management problems form algae to undesirable fish. Source: The Terrene Institute, 1717 K St, Suite 801, NW, Washington, DC, 20006-1504, or call (202) 833-8317. ($21.95)

Landscape Restoration Handbook. 1993. Technical reference on ecological restoration and recommendations for native plant species in broad ecological regions. Written by Donald Harker, Sherri Evans, Marc Evans, and Kay Harker; published by Lewis Publishers. (ISBN # 0-87371-952-2)

Riparian Forest Buffers. 1992. A six page article describing riparian buffers with recommended sizes, and benefits of buffer zones. Source: Oklahoma State University Cooperative Extension Service, OSU Extension Facts #5034, Division of Agricultural Sciences and Natural Resources, OSU, OK. (free)

Riparian Forest Buffers. 1991. A 20-page guide to the function and design of riparian forest buffers for protection and enhancement of water resources. Source: USDA Forest Service, Forest Resources Management, PO Box 6775, Radnor, PA, 19087-8775, or call (610) 975-4111. ($2.00)

Rosgen, David. 1996. Applied River Morphology. Wildland Hydrology, Colorado.

Soil Bioengineering for Upland Slope Protection and Erosion Reduction. 1992. This is a 53-page document on basic principles of soil bioengineering, vegetative components, and techniques published by the USDA, Natural Resources Conservation Service. Source: Consolidated Forms and Distribution Center, 3222 Hubbard Road, Landover, Maryland, 20785. Ask for Engineering Field Handbook (EFH), Part 650, Chapter 18 (EFH-1B).

Stream Habitat Improvement Handbook. 1992. A 29-page technical handbook on how to correct or improve habitat deficiencies with in-stream structure design. Includes information on streambank protection, diagrams, and color pictures. Source: US Forest Service, Southern Region, 1720 Peachtree Road, NW, Atlanta, GA, 30367-9102, or call (404) 347-4082. (free...Technical Publication R8-TP-16)

Streambank Protection Guidelines for Landowners and Local Governments. 1983. A 62-page book on streambank erosion and protection. Also lists Natural Resources Conservation Service Plant Material Centers across the country. Source: National Technical Information Service, US Commerce, 5285 Port Royal Road, Springfield, VA, 22161, or call (703) 487-4650. (#ADA193023) ($19.50)

A Streambank Stabilization and Management Guide for Pennsylvania Landowners. 1986. A 79-page technical guide to streambank management, protection, and stabilization. Lists additional information sources. This book is an excellent primer on diagnosing streambank problems and choosing solutions for specific situations. Source: State Bookstore, PO Box 1365, Harrisburg, PA, 17105. ($3.15)

Streamside Habitats in Southern Forested Wetlands: Their Role and Implications for Management. 1988. Article recommending riparian buffer zone sizes written by R.J. Howard, and J.A. Allen. Source: Hook, D.D. and R. Lea (eds). Proceedings of the Symposium: The Forested Wetlands of the Southern United States. Southeastern Forest Experiment Station, Asheville, NC.

Watershed Restoration Sourcebook. 1991. A 267-page collection of papers presented at the conference, "Restoring Our Home River: Water Quality and Habitat in the Anacostia." Source: Information Center, Metropolitan Washington Council of Governments, 777 North Capitol Street, NE, Suite 300, Washington, DC, 20002-4201, or call (202) 962-3256 (#92701) ($35)

Willow Planting for Riparian Habitat Improvement. 1984. A 21-page technical guide designed for field personnel who wish to plant willows and easily obtainable low cost vegetation to improve stream side habitat. Source: National Technical Information Service, US Commerce, 5285 Port Royal Road, Springfield, VA, 22161, or call (703) 487-4650. (Technical Note #363) ($17.50)

Restoration Periodicals:

Erosion Control. The official bi-monthly journal of the International Erosion Control Association. Source: Forester Communications, Inc, PO Box 3877, Santa Barbara, CA, 93130-9988, or fax your subscription to (805) 899-3350.

Nonpoint Source News Notes. A bi-monthly bulletin on topics such as the control of nonpoint source pollution, articles on successful projects and the ecological management and restoration of watersheds. Source: The Terrene Institute, 1717 K Street, NW, Suite 801, Washington, DC 20006, or call (202) 833-8317.

Land & Water. A magazine covering topics such as erosion control, bioengineering techniques, landscaping and other issues that relate to watershed management. Source: Land and Water, PO Box 1197, Fort Dodge, IA, 50501-9925. (1 year subscription $20)

Stream Notes. A quarterly publication to exchange technical ideas among scientists working with wildland stream systems. Source: Stream Systems Technology Center, USDA Forest Service, Rocky Mountain Station, 240 West Prospect, Fort Collins, CO, 80525, or call 970-498-1731.

Watershed Protection Techniques. A quarterly bulletin on urban watershed restoration and protection tools. A good source of technical information. Source: Center for Watershed Protection, 8630 Fenton St, Suite 910, Silver Spring, MD, 20910, or call (301) 589-1890. ($34 per year individual; $54 for organizations)

Videos:

SOS for America's Streams. 1990. A 28-minute VHS video on recognizing stream pollution problems, conducting a biological monitoring project, and adopting a stream. Source: Izaak Walton League of America, Save Our Streams (SOS) Program, 707 Conservation Lane, Gaithersburg, MD, 20878-2983, or call (301) 548-0150, or (800) 284-4952. ($20)
Crow Creek Stabilization. 1991. A 7-minute video demonstrating bioengineering techniques used to control streambank erosion. Source: Robin B. Sotir & Associates. To obtain this video, call (404) 424-0719.

Environmental Films. A list of environmental and rental/purchase fees. Source: The National Audiovisual Center, Information Services Section, 8700 Edgeworth Drive, Capitol Heights, MD, 20743-3701, or call (302) 763-1896.

Web Sites: These are just a few web sites on stream restoration:

Kentucky Division of Water -- Water Quality Certification Section
http://water.nr.state.ky.us/dow/dwwqc.htm
stream restoration references; wetland mitigation guidelines
links to Corps, EPA, National Wetlands Inventory (USFWS) and Ky. Dept. Fish & Wildlife Resouces....plus stream restoration sites, such as
http://www.westec-inc.com/pages/servicesdept/stream.html

Best Management Practices for Nonpoint Source Pollution Control
http://h2osparc.wq.ncsu.edu/info/bmps.html
BMPs for boats, marinas, roads, construction, septic systems, forestry, streambanks, streambeds, habitat degradation, stormwater, mining, etc.
Simple and easy to install BMPs for erosion and sediment control.

Stream Corridor Restoration HANDBOOK
http://www.usda.gov/stream_restoration/
An Interagency Partnership of Corps, EPA, NRCS, USFWS, etc........

Habitat Restoration Glossaries
http://www.habitat-restoration.com/gloss.htm
Summary: 1. Download Soils and Soil Science Glossary
2. Aquatic and Fisheries Management Glossary.
3. Download Stream and Watershed Restoration Glossary.
4. Download Wetland Restoration Glossary

Ecological Restoration
http://www.epa.gov/OWOW/watershed/wsb3.html
Summary: Ecological restoration is now being recognized as an important tool that can produce additional improvements in the quality of our water resources to support diverse, productive communities of plants and animals that provide significant ecological and social benefits.

Effects of Channelization.
http://www.ies.wisc.edu/research/ies900/kimchannelization.htm
Restoration of channelized streams to enhance fish habitat: A case study in Oregon.
Kim White; IES 900; May 14, 1996

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Harker, D. S. Evans, M. Evans, K. Harker. 1993. Landscape Restoration Handbook. Lewis Publishers.

Howard, R.J. and J.A. Allen. 1988. Streamside habitats in southern forested wetlands: Their role and implications for management. IN: Hook, D.D., and R. Lea (eds). Proceedings of the Symposium: The Forested Wetlands of the Southern United States. Southereastern Forest Experiment Station, Ashville, North Carolina.

Izaak Walton League of America. 1995. A citizen's Streambank Restoration Handbook. Karen Firehock and Jacqueline Doherty authors. A publication of the Save Our Streams Program. Gaithersburg, Maryland.

KY Division of Water. 1996. KY Report to Congress on Water Quality. 305B Report. Kentucky Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Frankfort, Kentucky.

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Oklahoma State University Cooperative Extension Service. 1992. Riparian Forest Buffers. OSU Extension Facts #5034, Division of Agricultural Sciences and Natural Resources, OSU, Oklahoma.

Rosgen, David. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Seehorn, M.E. 1992. Stream habitat improvement handbook. USDA Forest Service, Southern Region, Atlanta, Georgia.

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Scott Paper Company. 1988. Best management practices: wetland. Mobile, Alabama: Southeast Timberlands Division.

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U.S. Bureau of Land Management. 1979. Floodplain management, Section 7221. Washington: U.S. Bureau Land Management Manual.

US Department of Agriculture. 1980. Policy on fish and wildlife. Washington: U.S. Department of Agriculture Secretary's Memorandum No. 2019.

USDA Forest Service. 1991. Riparian Forest Buffers. Technical Document #NA-PR-07-91. Stock #001-001-00657-2. Forest Resources Management. Radnor, Pennsylvania.

US Fish and Wildlife Service. 1988. Forest habitat management plan for Boque Chito National Wildlife Refuge.