Executive Summary

Over the past several years, the scientific community, government agencies, and the general public have become increasingly aware of the role headwater streams play in maintaining environmental quality. This awareness has lead to expanded efforts in the stewardship and management of headwater resources and increased research into critical headwater stream processes. The Clean Water Act (33 U.S.C. 1344) plays a significant role in regulating impacts to headwater streams at the national scale. Section 404 of the Act directs the U.S. Army Corps of Engineers (Corps), in cooperation with the U.S. Environmental Protection Agency (EPA), to administer the 404 Regulatory Program (404) for permitting the discharge of dredged or fill material in “waters of the United States” which, by definition, include headwater streams that are part of a tributary system encompassing navigable waters. Application requests for Nationwide permit authorization to discharge dredged or fill material in waters of the United States undergo a review that includes assessing the impact of the proposed project on the functions and values of the aquatic environment. Results of the assessment are a component of the evaluation in verifying a Nationwide permit decision.

An interagency team including members from the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), the Kentucky Division of Water (KDOW), and the Kentucky Department of Fish and Wildlife Resources (KDFWR) was assembled to address the needs for a headwater stream assessment procedure that would accommodate the 404 programmatic requirements in the eastern Kentucky Coalfield Region. The team considered a variety of methods that have been developed to assess stream quality. However, none have received wide spread use or acceptance in 404 because of a failure to satisfy one or more technical or programmatic requirements. One of the most constraining considerations for an assessment procedure to be useful within the 404 program is an ability to assess stream functions accurately and efficiently within the limited time and resources available. EPA’s Rapid Bioassessment Protocol (RBP) (Barbour *et al.*, 1999) was the assessment procedure singled out by the interagency team as having the greatest utility for the program’s needs. This protocol has undergone extensive peer review and is based on sound ecological principles. The procedure also aims to be rapid and, thus, accommodates the time and resource limitations of the 404 program. This document outlines an approach for using the RBP in a manner that assesses overall stream ecosystem integrity and also satisfies the technical and programmatic requirements of the 404 program.

The headwater stream ecosystem may be thought of as being composed of two gross compartments: 1) the abiotic compartment and 2) the biotic compartment. These two components are interdependent and interact to perform a number of ecological processes or functions within the landscape. These, often ephemeral or intermittent, streams are the key interface between the surrounding landscape and larger waterbodies. Healthy headwater streams provide habitat to relatively distinct and diverse invertebrate assemblages, and by assimilating nutrients, organic matter, and sediments, they export high quality water and provide goods and services (e.g., water supply, recreation, waste assimilation, flood control, and ecological values) important to the public interest. To assess the integrity of the stream ecosystem and, thus, its capacity to provide goods and services, one must address both the abiotic and biotic components of the system. The estimate of overall ecological integrity for the stream ecosystem would be a net result of the combined abiotic integrity and the biological integrity characterizing the entire system.

The approach recommended in this document will incorporate a body of data gathered by the Kentucky Division of Water (KDOW) (Pond & McMurray 2002, in prep) with some assistance by the Louisville District COE. In 2000, 43 sites were sampled (25 reference, 18 non-reference, or test) distributed throughout the Kentucky portion of ecoregions 68 (Southwestern Appalachians), 69 (Central Appalachians), and 70 (Western Allegheny Plateau), collectively known as the Eastern Coalfield Region. Another 13 sites (10 reference, 3 test) were collected in spring 2001 for validation purposes. Two other streams were sampled in 1998 and 1999 (CA ecoregion) and used as validation sites. All reference (least disturbed) streams were located in highly forested, undisturbed areas, whereas impaired or degraded sites ranged from slightly to severely impacted by a variety of regional land uses.

Macroinvertebrates and physical habitat data were sampled in the spring index period (mid-February to late-May) from 58 sites. These data were utilized to calibrate regional expectation criteria for benthic invertebrate communities and habitat conditions for small headwater streams (1^{st}–2^{nd} order). Sites were chosen using Arcview GIS software (e.g., topographic maps, aerial photos, and land use) and field reconnaissance. A reference site was determined adequate if it was primarily vegetated with relatively mature native forest, little or no residential development, and there were no permitted discharges (coal mining, oil/gas extraction, or sewage treatment plant). Non-reference, or test sites, were chosen to span a range of observed human impacts to the watershed, stream, or individual reach.

This data and subsequent analyses were used as a basis to compose and calibrate recommended headwater stream assessment model(s) applicable to the Eastern Kentucky Coalfield Region. The most robust form of these models includes variables representing both the biotic component and the abiotic component shown to be statistically significant for these headwater stream ecosystems and will, thus, collectively provide an index of ecological integrity. In exceptional circumstances, such as an absence of comparable biotic data or when there is a lack of time, one could rely on a less robust form of the model that includes only significant abiotic habitat parameters. Confidence in less robust forms of the model is supported by an analysis of the above referenced data, which revealed a moderately strong correlation between the integrity of the biotic communities and the habitat variables chosen to represent the abiotic component of the stream ecosystem. All of these models serve to provide an estimate of the ecological integrity of a headwater stream ecosystem relative to the reference (i.e., least disturbed) stream conditions in the same region. The output of the models range from 0 – 1, and is calibrated such that a score of 1.0 is given for stream conditions indicative of least disturbed or reference streams in the region. The models were developed with 404 program limitations in mind as well as the data requirements that may be incurred by applicants seeking a 404 permit. An effort was made to minimize the burden on the regulated public while at the same time ensuring that meaningful data was obtained. This allows for good decision making, effective administration of the 404 permitting program, and fair, reasonable, and timely responses to customers while also adequately protecting the aquatic environment.

Biotic Integrity

Thirty-one (31) macroinvertebrate biological attributes (biometrics) were calculated and evaluated for discrimination efficiency, sensitivity, redundancy, and variability. Effort was given to include metrics covering a wide scope of ecological attributes (e.g., structure, tolerance, habit, and function). Five metrics (**taxa richness, EPT richness, mHBI, %Ephemeroptera, and %Chironomidae+Oligochaeta**) were selected for use in a Macroinvertebrate Bioassessment Index (MBI). Data analysis also revealed that the output of the MBI model using family level taxonomy and sampling only the riffle habitats was highly correlated with the output derived from using genus and species level taxonomy and sampling multiple habitats. The use of family level taxonomy and the sampling of a single habitat would reduce the time and effort required to glean useful data in certain situations (e.g., pre-application consultations and project/mitigation site screening) and also eliminate noise and improve the quality of data submitted with 404 applications. The approach recommended by the interagency team incorporates the MBI model to serve as the indicator for the integrity of the biotic component for the overall headwater stream ecosystem within the reference domain.

Abiotic Integrity

The assessment protocol was validated in selected sites with catchment areas ranging from 50 to 2000 acres. Reference and test stream data sets did not differ significantly in mean catchment area, riffle substrate size, stream width, elevation, slope, and distance-to-source (Mann-Whitney, $p>0.1$). In contrast, the two data sets differed significantly in mean riffle embeddedness, riparian width, canopy score, conductivity, and temperature ($p<0.01$). Both stepwise discriminant function analysis (DFA) and principal components analysis (PCA) showed that **conductivity**, **riparian width**, **canopy**, and **embeddedness** best separated reference (least disturbed) and test (degraded) sites. In addition, cluster analyses and box and whisker plots also indicated that EPA **RBP habitat scores** successfully distinguished reference from test sites. These physical habitat parameters which proved to provide the best discriminatory power between least disturbed streams and those that were degraded serve as the variables used to assess for the abiotic integrity of the stream ecosystem.

The recommended assessment procedure includes a characterization, assessment, and analysis component. The characterization is largely embodied by the current requirements of the EPAs RBP and involves using a checklist and describing the physical characteristics of the headwater stream ecosystem and the surrounding landscape. However, for 404 purposes one must also include a characterization of the proposed project and its potential consequences on the aquatic environment. Assessment involves the application of the developed models and the calculation of ecological integrity indices for a defined headwater stream ecosystem under existing (i.e., preproject) conditions, and if appropriate, predicted (postproject) conditions. Analysis involves the application of the assessment results to the following: 1) description of the potential impacts of a proposed project, 2) description of the actual impacts of a completed project, 3) identification of ways to avoid and minimize impact of a proposed project, 4) determination of the least damaging alternative for a proposed project, 5) determination of compensatory mitigation needs for a proposed project, 6) determination of restoration potential for headwater streams, 7) development of design criteria for stream restoration projects, 8) planning, monitoring and managing stream mitigation or restoration projects, 9) evaluation of performance standards or success criteria for headwater stream mitigation efforts, 10) comparison of stream management alternatives or results, 11) determination of appropriate in-lieu-fee ratios, and 12) identifying priorities for in-lieu-fee mitigation projects.

The strengths of the recommended approach are that it promotes an ecosystem approach based on accepted methodologies and real data calibrated to the existing gradient of conditions found within a specific region. In addition, it takes advantage of information and data that is currently being supplied by applicants to the 404 program and thus imparts little additional burden to the regulated public. The limitations of the assessment procedure should also be identified at the outset. In order for the MBI scores to be effective, adherence to sampling procedures and sample index period is important. Recommended time frames for sampling headwater streams ranges from mid-February to late-May. Samples collected before or after these dates may give inaccurate results and caution should be used when interpreting benthic data. In addition, the tool may only be applied to headwater streams in the region from which the reference data was collected. In addition to these ecological integrity assessment models, one should also take into consideration sound geomorphological principles when assessing for stable stream morphology. The last potential limitation is that the ecological integrity indices developed under this approach do not assign value to stream ecosystems. The ecological integrity indices derived from the models may serve as a type of environmental "currency" and can be used to estimate a stream's functional capacity or relative quality. They may also predict the amount of loss or gain of stream function(s). However, they cannot be used to assign the value of benefits, goods, and services resulting from a proposed project. This requires other methods designed specifically for the purpose of assigning value, and is beyond the scope or intent of the stream assessment protocol.