HABITAT QUALITY OF LEAST-IMPACTED STREAMS IN TENNESSEE

Tennessee Department of Environment and Conservation
Division of Water Pollution Control
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by

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TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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Phil Stewart	Chattanooga Environmental Assistance Center (CHEAC)
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EXECUTIVE SUMMARY

According to the Division's 2000 305(b) Report, a significant number of stream miles in Tennessee are impacted by pollutants that have criteria based on narrative statements. Most important of these causes of pollution are siltation, nutrients, habitat destruction and loss of biological integrity. Tennessee's existing water quality standards do not provide much in the way of guidance concerning how these narrative statements should be interpreted. Reference data provide a scientifically defensible method to implement the existing statewide narrative habitat criterion.

Habitat quality in streams can exacerbate or mitigate obvious sources of pollutants. It is common for Division staff to document streams where the biological integrity goal is met in spite of obvious water quality standards violations. Conversely, streams may fall very short of biological integrity goals in the absence of toxicity. Habitat quality can be the difference.

Many factors affect habitat quality. Channelization of streams is one of the most frequently encountered causes of habitat loss, especially in agricultural areas. In urbanized areas, culverting of streams and historical concrete lining of channels is significant. Downstream of mined areas, the precipitation of metals such as manganese and iron can coat substrates. In all areas of Tennessee, off-site impacts from land disturbing activities and the removal of riparian vegetation adds sediment to streams.

Degraded habitat, both in-stream and riparian, can obscure investigations on the effects of pollutants. Habitat should always be evaluated as part of any biological survey since stream biota is dependent on the availability of suitable habitat. The lack of regional habitat goals has complicated past water quality assessment activities.

The objectives for the development of regional habitat guidelines are:

1. Selecting a method that is scientifically sound and defensible, resulting in conclusions that indicate impairment in cases where it is justified but do not assign impairment in cases where the change is minor or questionable.

2. Defining a method that is easily standardized between various assessors with minimal room for individual variability.

3. Establishing a method that measures the most important components of the habitat that are most likely to affect the biological community.

4. Adjusting expectations based on natural regional variability.

5. Defining benchmarks that can be used in stream restoration activities.

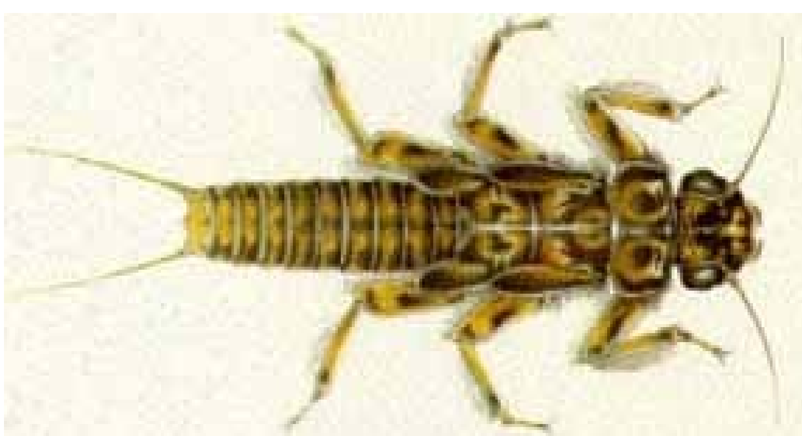
Habitat conditions that are likely to affect aquatic ecosystems are often related to the geomorphology of a region and typical land-use activities in that region. Tennessee's proposed habitat guidance is based on a numeric evaluation of habitat at reference streams in the various subregions of Tennessee. Ten components of the habitat are measured using a scoring system of 1 to 20 points for each parameter. Two different sets of scoring parameters are used dependent on steam type (high or low gradient).

The Division has been evaluating habitat at reference sites using this standardized numeric assessment approach since 1996. These reference sites were the least-impacted, yet representative, streams in each of the 25 ecological subregions across the state as established during the ecoregion project (1996-1999).

Habitat goals in each subregion were based on comparison to the median reference value. A habitat score comparable to 75% or greater of the reference condition would be considered the quality of habitat most likely to maintain biological integrity.

The use of regional habitat guidance for interpretation of narrative criterion in conjunction with numeric biocriteria will help standardize Division stream assessments and will account for regional differences in aquatic communities. Existing reference sites will be monitored in the future on a five-year rotation in conjunction with watershed monitoring. Should future watershed monitoring activities or ecoregion efforts in adjacent states uncover additional reference quality streams, these data can augment the existing databases. As appropriate, the habitat guidance can be adjusted as more data become available.

Unlike the Division's recently published studies of nutrients (Denton et al., 2001) or biocriteria (Arnwine and Denton, 2001), this is not a proposal to formalize habitat goals as water quality standards. However, the Division does intend to use this guidance informally. (For more information about the Division's intentions concerning implementation of this guidance, see Section 8.)



Many aquatic organisms, such as the stonefly, are dependent on good habitat quality.

1. INTRODUCTION

The presence of quality habitat is a critical factor in the health and diversity of the biological community. Habitat, both in-stream and riparian, can be the factor most limiting the biotic community. According to the Division's 2000 305(b) Report (Denton et al., 2000), 3,297 miles of streams have inadequate habitat to support an acceptable level of biological diversity.

Tennessee's current habitat criterion is included as part of the narrative biological criterion. Found in chapter 1200-4-3-03(3)(j), the rule states in part that "Waters shall not be modified through the addition of pollutants or through **physical alteration** to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected…" The term "physical alteration", how it should be measured, and what level of alteration is acceptable before the biotic community is affected are not defined.

The Division's proposed habitat guidance is based on a numeric evaluation of in-stream and riparian habitat parameters. Ten components of the habitat are measured using a scoring system of 1 to 20 points for each parameter. Two different scoring systems are used dependent on stream type (high or low gradient).

Habitat impacts that are likely to affect aquatic ecosystems are often related to the geomorphology of a region and typical land use activities in that region. Therefore, an ecoregional approach with habitat indices calibrated by subregion was initiated by the Division of Water Pollution Control to define habitat guidelines.

The Division has been evaluating habitat at reference sites using a standardized numeric assessment since 1996. These reference sites were the least-impacted, yet representative, streams in each of the 25 ecological subregions across the state as established during the ecoregion project (Arnwine et al., 2000).

The objectives for the development of regional habitat guidelines are:

1. Selecting a method that is scientifically sound and defensible, resulting in conclusions that indicate impairment in cases where it is justified but do not assign impairment in cases where the change is minor or questionable.

2. Defining a method that is easily standardized between various assessors with minimal room for individual variability.

3. Establishing a method that measures the most important components of the habitat that are most likely to affect the biological community.

4. Adjusting expectations based on natural regional variability.

5. Defining benchmarks that can be used in stream restoration activities

2. DATA COLLECTION

2.0 Ecoregion Delineation and Reference Site Selection

In 1986, James Omernik and Glen Griffith, U.S. EPA, delineated 76 Level III ecoregions in the contiguous United States on a map scale of 1:3,168,000. Portions of eight of these ecoregions are found in Tennessee. Due to the high diversity and complexity of these large ecoregions, it was necessary to refine and subdivide the ecoregions into smaller subregions for assessment purposes.

In 1994, Water Pollution Control (WPC) initiated an ecoregion delineation and reference site selection project in cooperation with the U. S. EPA Region IV, and James Omernik and Glen Griffith U.S. EPA. This resulted in the eight Level III ecoregions in Tennessee being divided into 25 Level IV subregions based on differences in geology, soils, vegetation, climate and physiography (Figure 1). A detailed description of each subregion can be found in *Ecoregions of Tennessee* (Griffith et al. 1997). For this report, the term "ecoregion" will refer to Level III ecoregions and the term "subregion" will refer to Level IV ecoregions.

In order to define habitat, biological, and water quality criteria on a regional basis, WPC initiated a reference stream selection and monitoring program in 1994. Reference streams of varying sizes and types were selected in each subregion thus enabling the Division to relate typical characteristics of the streams to the associated macroinvertebrate community. The list of reference streams is provided in Appendix A.

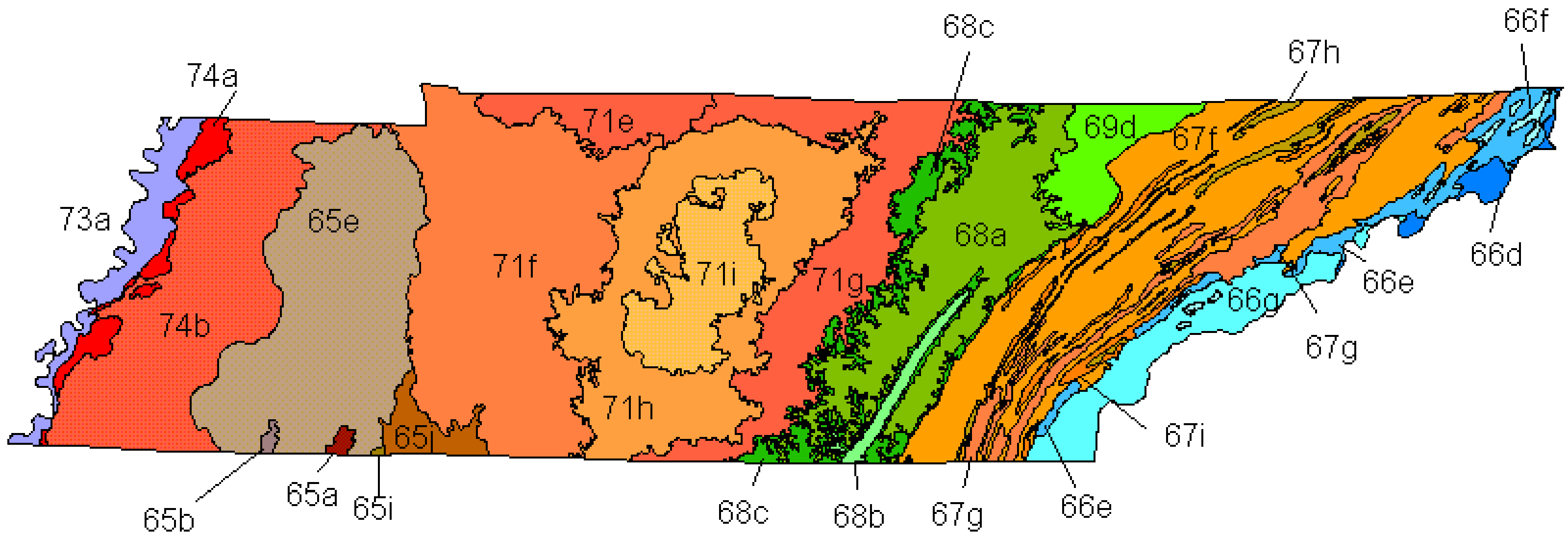
The reference streams were monitored seasonally for 3 years between 1996 and 1999. The Division's Ecoregion Project report (Arnwine et al. 2000) provides a detailed description of this study. The data generated from the reference streams monitored during this study as well as data collected from these streams since 1999 as part of the five-year watershed monitoring cycle were used in development of the regional habitat guidelines.

The pictures on the following page help illustrate the extremes in habitat type that can exist between reference streams in various regions. This variability emphasizes the benefit of different habitat goals for relatively undisturbed streams in these regions.

The Wolf River, subregion 74b (Loess Plains) in west Tennessee is considered to have extremely good habitat for the subregion. It is a typical low gradient stream with rooted undercut banks as the primary habitat. The substrate is a combination of sand and mud with a high concentration of particulate organic matter. The median reference score for this subregion is 131.

Cedar Creek, subregion 71i (Inner Nashville Basin) in middle Tennessee is typical of the region with widely scattered riffle areas separated by long expanses of bedrock. Habitat is naturally limited in these streams. Flow varies greatly between seasons. The median reference score for this region is 98.

The New River, subregion 69d (Cumberland Mountains) in east Tennessee is typical of this area's high gradient riffle streams. Diverse habitat is provided by a good riffle-run-pool sequence combined with a mix of substrate size and excellent riparian vegetation. This subregion has some of the highest habitat quality in the state with a median reference score of 183.



65a Blackland Prairie
65b Flatwoods/Alluvial Prairie Margins
65e Southeastern Plains and Hills
65i Fall Line Hills
65j Transition Hills
66d Southern Igneous Ridges and Mtns
66e Southern Sedimentary Ridges
66f Limestone Valleys and Coves
66g Southern Metasedimentary Mtns

67f Southern Limestone/Dolomite Valleys and Low Rolling Hills
67g Southern Shale Valleys
67h Southern Sandstone Ridges
67i Southern Dissected Ridges and Knobs
68a Cumberland Plateau
68b Sequatchie Valley
68c Plateau Escarpment
69d Cumberland Mountains

71e Western Pennyroyal Karst
71f Western Highland Rim
71g Eastern Highland Rim
71h Outer Nashville Basin
71i Inner Nashville Basin
73a Northern Mississippi Alluvial Plain
74a Bluff Hills
74b Loess Plains

Figure I: Level IV Ecoregions in Tennessee

2.1 Habitat Assessment Protocol

Habitat assessment data sheets finalized in EPA's *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour et. al., 1999) were used to evaluate the habitat at each site (Appendix B). Staff who conducted habitat assessments were trained in the use of the draft version of these forms during a habitat assessment and bioassessment workshop conducted by Michael Barbour, Tetra Tech Inc. in August 1994. Habitat parameters and scoring criteria in the 1999 document were compatible with the draft 1994 forms. Reference stream habitats were evaluated seasonally (spring and late summer/fall) in conjunction with macroinvertebrate sampling.

The scoring system is based on a numeric evaluation of in-stream and riparian habitat parameters that are related to overall aquatic life use. Ten components of the habitat are measured using a scoring system of 1 to 20 points for each parameter. A maximum of 200 points is possible. Habitat evaluations are made on in-stream habitat, channel morphology, bank structural features and riparian vegetation.

Two different data sheets were used dependent on the stream type in each ecoregion (Table 1). In regions 65j, 66d, 66e, 66f, 66g, 67f, 67g, 67h, 67i, 68a, 68b, 68c, 69d, 71e, 71f, 71g, 71h, 74a as well as riffle streams in 71i, the High Gradient Stream (formerly Riffle-Run) form was used to assess habitat. In regions 65a, 65b, 65e, 65i, 73a, 74b as well as non-riffle streams in 71i, the Low Gradient (formerly Glide-Pool) form was used. The data sheet selected corresponded to the semi-quantitative macroinvertebrate sample type (riffle kick or rooted bank respectively).

Table 1: Habitat Parameters

High Gradient (Riffle-Run)	Low Gradient (Glide-Pool)
Epifaunal Substrate/Available Cover	Epifaunal Substrate/Available Cover
Embeddedness	Pool Substrate Characterization
Velocity/Depth Regime	Pool Variability
Sediment Deposition	Sediment Deposition
Channel Flow Status	Channel Flow Status
Channel Alteration	Channel Alteration
Frequency of Riffles (or Bends)	Channel Sinuosity
Bank Stability	Bank Stability
Vegetative Protection	Vegetative Protection
Riparian Vegetative Zone Width	Riparian Vegetative Zone Width

2.2 Description of Habitat Parameters:

The parameters used in measuring habitat quality can be described as follows (adapted from Barbour et. al. 1999). The numbers correspond to individual parameters on the habitat assessment forms. Many parameters are the same for both high gradient and low gradient assessments. Parameters that are different between high and low gradient are designated by a letter. The habitat assessment forms can be found in Appendix B.

1. Epifaunal Substrate/Available Cover (both high and low gradient).

   Evaluates the quantity and variety of natural structures in the stream, (cobble, large rocks, fallen trees, undercut banks). A wide variety of submerged structures provide the biota with multiple niches increasing diversity. As variety of cover decreases, so does biotic diversity and the potential for recovery following disturbances.

2. a. Embeddedness (high gradient only).

   Measures the extent to which the rocks in riffle are covered by silt, sand or mud. As substrate becomes embedded, the surface area available to biota decreases. Embeddedness is a result of large-scale sediment movement and deposition.

   b. Pool Substrate Characterization (low gradient only).

   Evaluates the type and condition of substrate found in pools. A variety of loose sediment types such as gravel or sand, and rooted aquatic plants support a wider variety of organisms than a pool substrate dominated by mud or bedrock.

3. a. Velocity/Depth Combinations (high gradient only)

   Patterns of velocity and depth are important features of habitat diversity. The occurrence of a variety of velocity and depth combinations relates to the stream's ability to provide and maintain a stable aquatic environment.

   b. Pool Variability (low gradient only)

   Rates the overall mixture of pool types found in streams, according to size and depth. A stream with many pool types will support a wide variety of aquatic species. Streams with low sinuosity and monotonous pool characteristics do not have sufficient quantities and types of habitat to support a diverse biota.

4. Sediment Deposition (high and low gradient)

   Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

5. Channel Flow Status (high and low gradient)

When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions.

6. Channel Alteration (high and low gradient)

Is a measure of large-scale changes in the shape of the stream channel. Altered streams generally have less habitat than do naturally meandering streams. Scouring is often associated with channel alteration.

7. a. Frequency of Riffles or Bends (high gradient only)

Riffles provide high-quality habitat and diverse fauna. Bends protect the stream from excessive erosion and flooding. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream.

b. Channel Sinuosity (low gradient only)

A high degree of sinuosity provides diverse habitat and the stream is better able to handle surges in flow. Bends protect the stream from excessive erosion and flooding.

8. Bank Stability (high and low gradient)

Measures whether the stream banks are eroded or have the potential for erosion. Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks and are therefore considered to be unstable. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and vegetative food sources.

9. Bank Vegetative Protection (high and low gradient)

This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of in-stream scouring and stream shading. This parameter also defines the native vegetation for the region and stream type.

10. Riparian Vegetative Zone Width (high and low gradient)

Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and a food source to the stream.

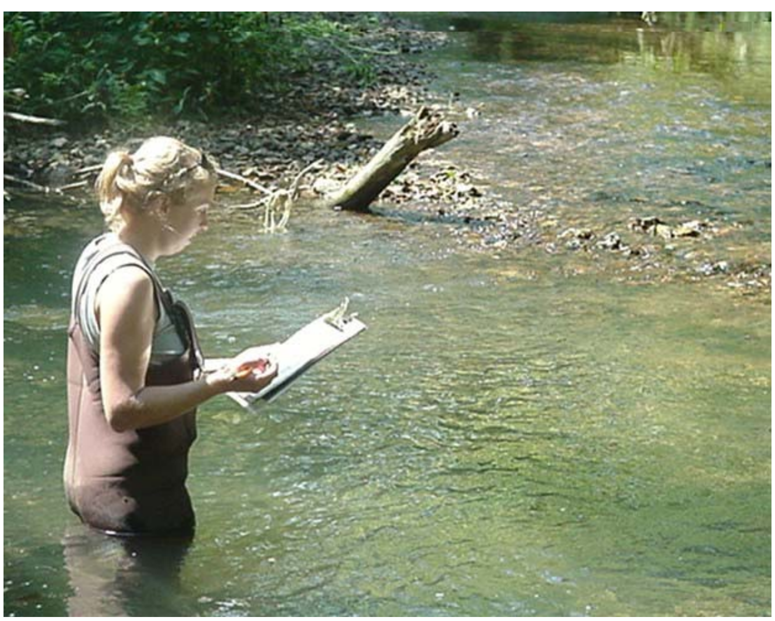
2.3 Quality Assurance

One of the major concerns of habitat assessment is the danger of assessment bias due to the inherent subjectivity of the evaluation process. The proposed habitat assessment method helps reduce subjectivity since specific guidelines are used for each category. For example 0 - 25% embeddedness is scored as optimal condition. However, these are visual estimates rather than an actual measurement. Also, a five-point spread is possible in each category (optimal, sub-optimal, marginal, poor). For example within the optimal category for embeddedness, the site can be given a score of 16-20.

Several measures were taken to reduce the potential for bias in the reference database as well as evaluate the consistency of assessments. First, all persons performing habitat evaluations were trained in the field on the use of the scoring system. Second, several different investigators (an average of 8) from at least two different offices assessed sites in each subregion. This helped make sure that an individual assessor was not over or under rating a site.

Third, the majority of sites were evaluated by a minimum of two investigators during each sampling trip. Staff scored sites independently then averaged results, or scored the sites as a team, arbitrating differences. This helped insure that individuals were not missing key factors and were using the same set of standards for the evaluation process.

To test for consistency of habitat evaluations between investigators, re-assessment by a different staff member (or team of members) was conducted within one month of the original assessment periodically throughout the study. A total of 25 sites representing 12 subregions were re-evaluated in this manner. On average, there was only 8% difference between the two assessments. A paired t-test of all 25 sites demonstrated no significant difference between the assessments ($p = 0.3$).



Kim Sparks, Aquatic Biology, TDH evaluates the bottom substrate. Staff from different offices assessed habitat to test consistency of the method between investigators. Photo provided by Aquatic Biology, TDH.

3. PICTORIAL SUMMARY OF TYPICAL STREAM TYPES BY ECOLOGICAL SUBREGION

Tennessee is a diverse state with many stream types represented. The pictures and brief summaries in this section illustrate the dominant stream types in each ecoregion.

Within the **Southeastern Plains (65**), the Transition Hills (65j) consistently had the highest habitat scores. The relatively high gradient cobble-bottom streams in this area are atypical of the rest of the ecoregion. The Blackland Prairie (65a) covers a very small area in Tennessee that narrowed the reference stream possibilities. As a result, habitat scores were lower in this subregion than in the surrounding regions. Habitat scores from Tennessee's 65a reference sites will be compared to data from other states that have larger areas in 65a to determine if values are typical. The majority of streams in this region run through the Southeastern Plains and Hills (65e).

Right Fork Whites Creek, a reference stream in the Transition Hills (65j). Typical streams in this subregion are high gradient with riffle habitat. Photo provided by Amy Fritz, JEAC, TDEC.

Thompson Creek (non-reference) is typical of the low gradient streams found in the Southeastern Plains and Hills (65e). This is the largest subregion within the Southeastern Plains ecoregion. Photo provided by Aquatic Biology Section, TDH.

Within the **Blue Ridge Mountains (66)**, the Southern Igneous Ridges and Mountains (66d) had the highest and most consistent habitat scores. As expected, the greatest variability and lowest scores were observed in the Limestone Valleys and Coves (66f) subregion, which is generally the most developed in the Blue Ridge Mountains.

The Little River, a reference stream in the Southern Metasedimentary Mountains (66g) of the Blue Ridge. Photo provided by Aquatic Biology, TDH.

The Copper Basin area was originally included in subregion 66g, the Southern Metasedimentary Mountains (Griffith et al. 1997). Subsequent ecoregion delineation work conducted by Omernik and Griffith in North Carolina may result in this area becoming a distinct subregion called the Broad Basins (66j). Caution should be used in comparing streams in the Copper Basin to 66g guidelines until reference data in the Copper Basin area can be collected and compared for similarity to 66g reference data. However, a habitat assessment conducted by Division personnel at a watershed reference station on North Potato Creek yielded a score of 153 that would fall within expectations for 2nd and 3rd order streams based on the 66g reference database.

Watershed reference site on a recovering section of North Potato Creek, located in the proposed 66j Broad Basins subregion. Photo provided by Dan Murray, Mining Section, TDEC

Quality reference streams were difficult to find within the **Ridge and Valley (67**) ecoregion. Due to a combination of animal operations and urban development, many streams in the valley regions were impacted by removal of riparian vegetation, channelization, sedimentation and erosion.

Typical stream in the Ridge and Valley (ecoregion 67). Removal of riparian vegetation resulted in erosion and sedimentation making riffles non-useable to benthos. Loss of canopy and native vegetation reduces the diversity of niches available for colonization, removes food supplies for biota and promotes algal growth.

A non-reference stream in the same watershed as the above photo supports a healthy benthic community. A protective riparian zone with native vegetation has been left intact. Riffles are relatively free of sedimentation. Canopy cover keeps temperatures down and suppresses algal growth. A diverse assemblage of niches and multiple food sources are available to the benthos.

Photos provided by Kim Sparks, Aquatic Biology Section, TDH.

In the **Southwestern Appalachians (68)**, streams in the heavily agriculturalized Sequatchie Valley (68b) had relatively low habitat scores. All three subregions in the Southwestern Appalachians demonstrated a significant difference (Fishers PLSD) between fall and spring habitat scores. This is primarily a function of flow regime as many of the streams in this ecoregion have significantly reduced flow in the dry seasons.

Typical habitat impaired stream in the Sequatchie Valley (68b).

Reference stream in the Sequatchie Valley. Although this site has inadequate riparian vegetation, it was one of the least impaired in the region. Photos provided by Tammy Hutchinson, CHEAC, TDEC.

The **Central Appalachians (69)** is represented by a single subregion in Tennessee, the Cumberland Mountains (69d). During the spring, reference streams in this region have some of the highest habitat scores in the state. Fall scores are significantly lower primarily due to a substantial reduction in flows that make habitat unavailable to the aquatic community. Biological communities in this region have adapted to the extreme flow fluctuation.

Large tracts of land in this subregion are owned by lumber and coal companies. Siltation and habitat destruction are a result of historical mining and forestry activities that did not use proper management practices.

No Business Branch, a reference stream in the Cumberland Mountains subregion (69d). The majority of instream habitat is provided by a mixture of boulder, cobble and gravel substrate. Due to the seasonality of the flow, rooted banks are generally not available for colonization by macroinvertebrates. Photo provided by Aquatic Biology Section, TDH.

Distinct differences can be seen in habitat scores among the five subregions in the **Interior Plateau, (71)**. Streams in the Eastern Highland Rim (71g) provide some of the most diverse habitats in the Interior Plateau ecoregion The Inner Nashville Basin (71i) has significantly lower scores than other subregions. Streams in this region naturally have poor habitat due to bedrock substrates and extreme seasonal flow variations.

Flat Creek, a reference stream in the habitat rich Eastern Highland Rim (71g). Photo provided by Jimmy Smith, NEAC, TDEC.

Example of a non-reference stream in the Inner Nashville Basin (71i). The bedrock substrate provides minimal habitat for aquatic life. Photo provided by Aquatic Biology Section, TDH.

The **Mississippi Alluvial Plain (73)** had some of the lowest habitat scores in the state. This is primarily an agricultural area with the majority of streams receiving impacts from channelization, loss of riparian vegetation, sedimentation and erosion. Reference stream selection was limited to those streams having the most stable habitat or widest riparian zone since all were impaired to some extent. Communications with biologists in adjacent states indicate this is a widespread problem in the ecoregion. When available, data from adjacent states will be compared to determine if these sites are similar to what is best attainable in the ecoregion.

The Mississippi Alluvial Plain was assessed as a single subregion (73a, Northern Mississippi Alluvial Plain) for development of habitat guidelines. However, according to Glen Griffith, USDA-NRCS, the entire Mississippi Alluvial Plains ecoregion is currently being sub-delineated. A second subregion, the Pleistocene Valley Trains (73d) is being proposed in the Dyer County area. This may result in separate subregional criteria once reference streams in this area can be targeted. Also, as a result of this current delineation process, the name of 73a may be changed to the Mississippi River Meander Belts.

The Obion River test site at mile 20.4 is typical of large streams in the Mississippi Alluvial Plain. Streams in this region are generally channelized with steep, eroding banks and shifting sand substrate providing little habitat. Photo provided by Aquatic Biology Section, TDH

The **Mississippi Valley Loess Plains (74)** is comprised of two distinct subregions in Tennessee. In the Bluff Hills (74a), streams are relatively high gradient with riffle habitat and a predominately gravel substrate. They tend to have lower habitat scores than the Loess Plains (74b) streams. The 74b streams are lower gradient with a sandy substrate. Both subregions are exposed to a great deal of human impact resulting in sedimentation and loss of riparian vegetation.

Sugar Creek, a reference site in the Bluff Hills Subregion (74a). Photo provided by Aquatic Biology Section, TDH.

Powell Creek, a reference site in the Loess Plains subregion (74b). Photo provided by Amy Fritz, JEAC, TDEC.

4.0 DISTRIBUTION OF HABITAT SCORES

4.0 Seasonal Variation

Five subregions: 68a, 68b, 68c, 69d and 71i demonstrated significant seasonal variation in habitat composition (Fisher's PLSD). Habitat quality was generally reduced in the late summer/fall season (Figure 2). This was primarily a function of reduced flow providing less available habitat for macroinvertebrate colonization. Separate guidelines based on season were developed for each of these 5 regions.

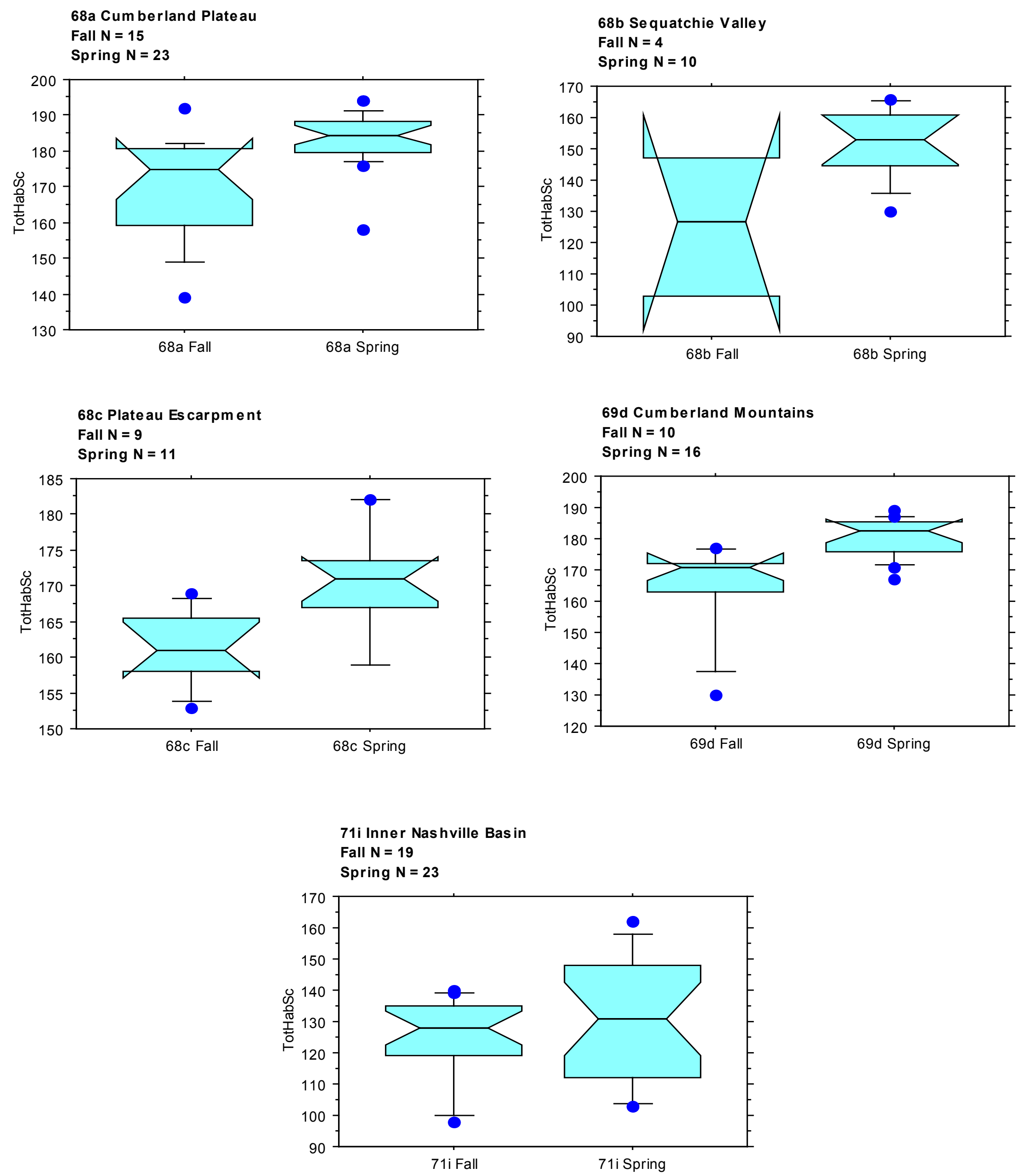


Figure 2: Distribution of reference habitat scores in subregions that demonstrated significant seasonal variation.

4.1 Differences Between Size Classes

Several different size classes, defined by stream order, were assessed in each subregion (Table 2). Habitat scores were grouped by stream size in each subregion to determine if scores varied significantly or whether it was appropriate to use one scoring system regardless of size. Fisher's Protected Least Significant Difference was used to determine significance.

There was no significant difference between streams of varying size in the majority of subregions. Subregion 71f (Western Highland Rim) is illustrated in Figure 3 as an example of an area with similar habitat values among variously sized streams. In these regions it would be appropriate to use the same scoring system for all streams that fit the orders included in the reference data base. Caution should be used in evaluating streams outside the specified classes, however. For example, if first order streams were not included in the reference database for the subregion, the individual parameters of channel flow status and epifaunal substrate should be reviewed to see if a low habitat score is indicative of stream size rather than habitat degradation.

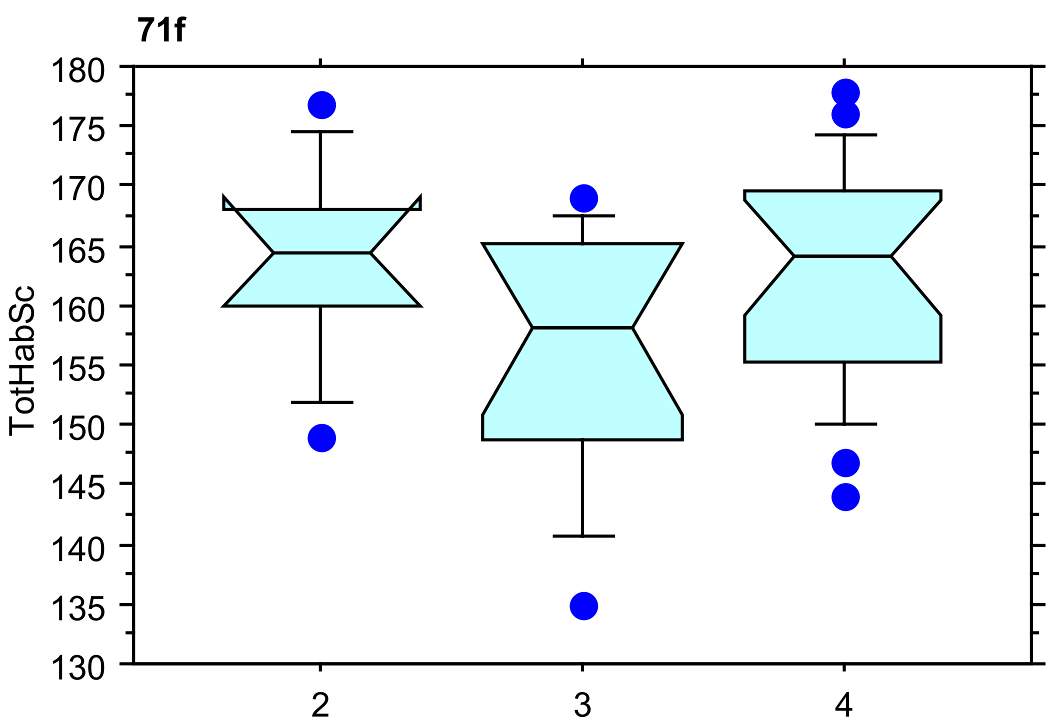


Figure 3: Distribution of reference habitat scores by stream size in the Western Highland Rim (71f).

Four subregions, 65e, 65j, 66g, and 68a, did exhibit a significant habitat difference between stream size based on total scores (Figure 4). Therefore, separate guidelines were established for two groups based on size within these regions (Table 2). First order streams were only monitored in the 4 subregions. Therefore headwater streams in other subregions should be evaluated with caution. The individual parameters of channel flow status and epifaunal substrate may naturally be lower in these streams.

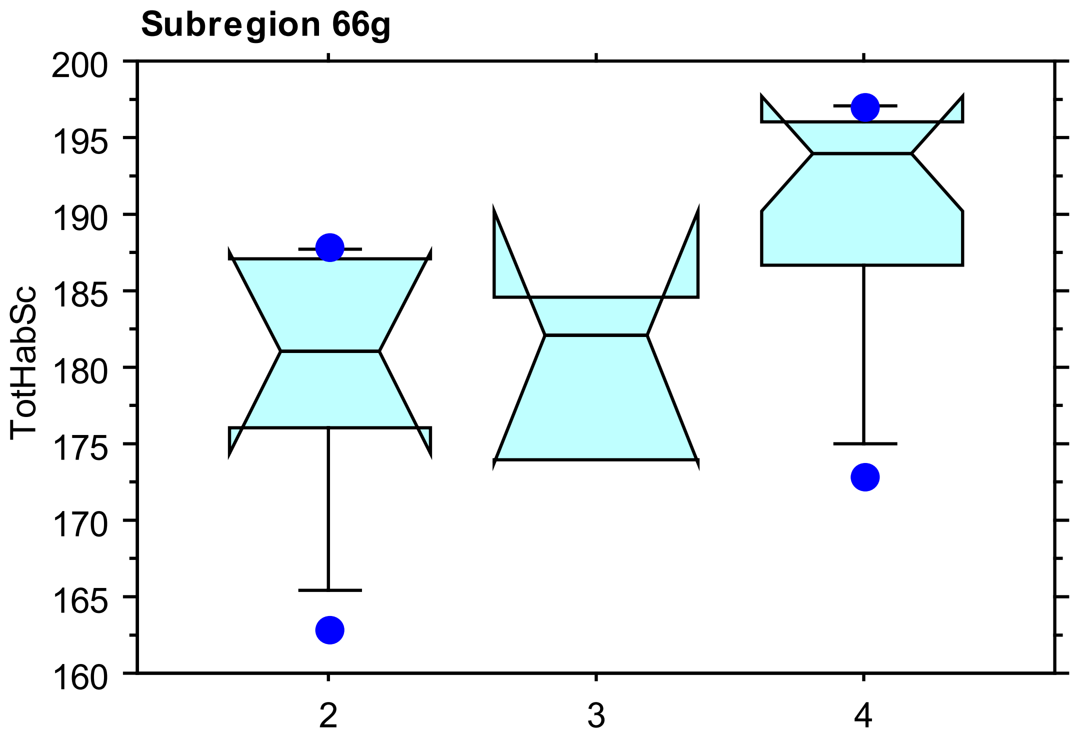


Figure 4: Distribution of reference habitat scores by stream size in the Southern Metasedimentary Mountains (66g)

4.2 Subregional Expectations of Habitat Scores

Reference condition was defined as the median habitat score for each subregion. Goals were then set at ≥75 percent of reference condition (Table 2). Habitat scores that are at least 75 percent similar to reference condition have the potential to support an acceptable level of biota (Plafkin et. al., 1989). Figure 5 shows the reference data distribution.

Table 2: Summary statistics and proposed habitat goals by subregion including divisions by season and stream order where significant.

Subregion	Order	Sites	N	Assessors	Mn	S.D.	Min.	Max.	Median	**Goal**
65a	2	2	7	4	88	26	71	151	82	**62**
65b	3	1	8	5	132	16	122	162	123	**92**
65e	2	1	8	6	170	13	144	181	175	**131**
65e	3	4	28	6	149	19	122	185	146	**110**
65i	2	1	5	3	127	5	119	131	131	**98**
65j	2,	3	21	5	180	9	163	195	179	**134**
65j	3	1	7	5	170	12	151	190	169	**127**
66d	1,2,4	5	21	6	194	5	181	199	194	**146**
66e	2,3,4	5	20	7	188	11	158	200	191	**143**
66f	3,4	4	13	11	182	11	165	197	184	**138**
66g	2,3	3	11	11	180	8	163	188	181	**136**
66g	4	2	15	11	190	8	173	197	194	**146**
67f	2,3,4,5	10	43	13	177	11	156	196	175	**131**
67g	1,2,3,4	4	12	10	155	9	138	167	156	**117**
67h	1,2,	3	12	11	161	16	130	180	168	**126**
67i	3	1	3	7	155	8	149	164	152	**114**
68a Fall	3,4,5	5	15	8	170	14	139	192	176	**132**
68a Spirng	2	1	1	2	158	0	158	158	158	**118**
68a Spring	3,4,5	7	23	13	185	5	176	194	185	**139**
68b Fall		2	4	5	125	26	96	151	127	**95**
68b Spring		3	11	3	152	11	130	166	153	**115**
68c Fall		3	9	7	162	5	153	169	161	**121**
68c Spring		4	11	7	170	8	159	182	171	**128**
69d Fall		5	10	5	165	15	130	177	171	**128**
69d Spring		4	16	6	181	6	167	189	183	**137**
71e		2	21	5	149	9	135	164	150	**112**
71f		5	42	9	161	10	135	178	164	**123**
71g		3	16	6	165	10	148	181	164	**123**
71h		3	28	12	153	13	125	172	156	**117**
71i Fall	3,4	6	22	9	125	13	98	140	128	**96**
71i Spring	3,4	6	23	9	132	20	103	162	131	**98**
73a		4	17	8	126	19	96	161	125	**94**
74a		3	13	11	120	14	99	143	118	**88**
74b		3	22	10	133	11	112	156	131	**98**

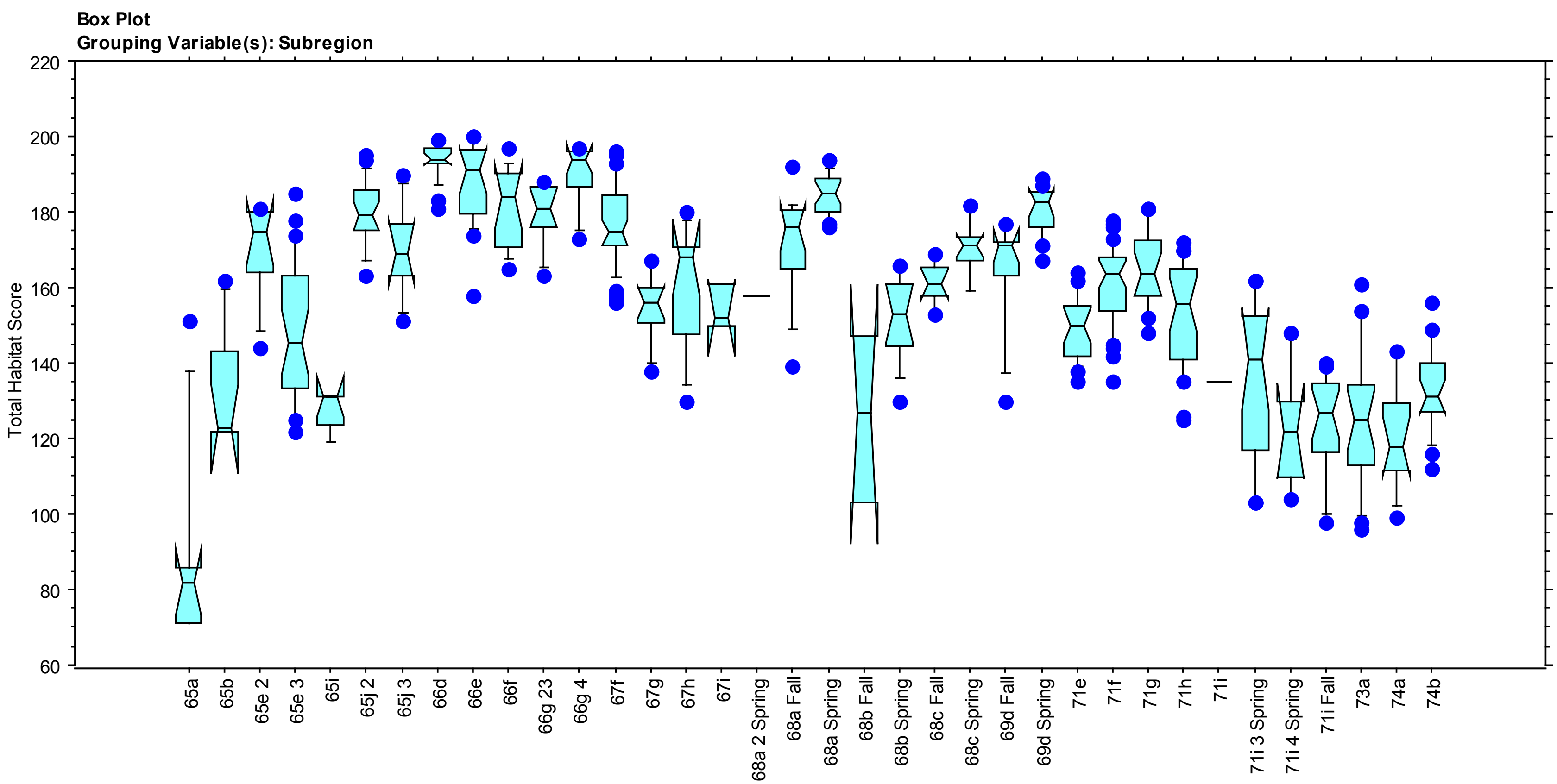
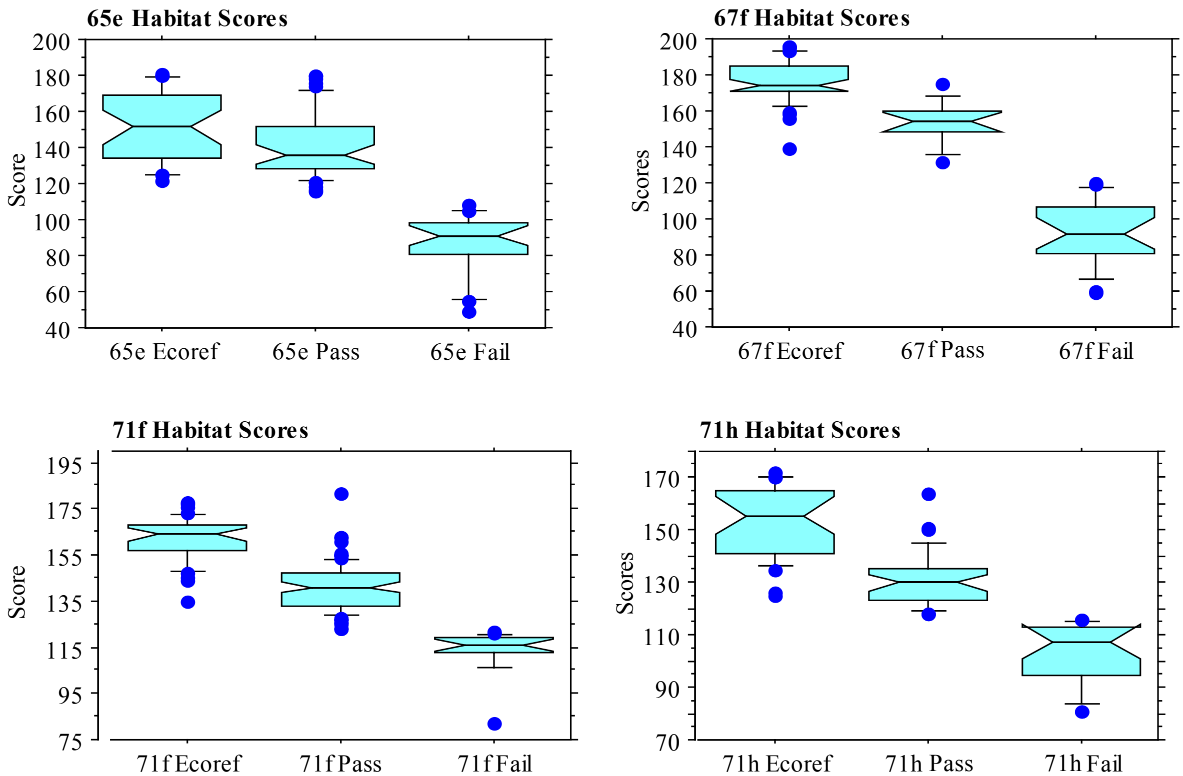


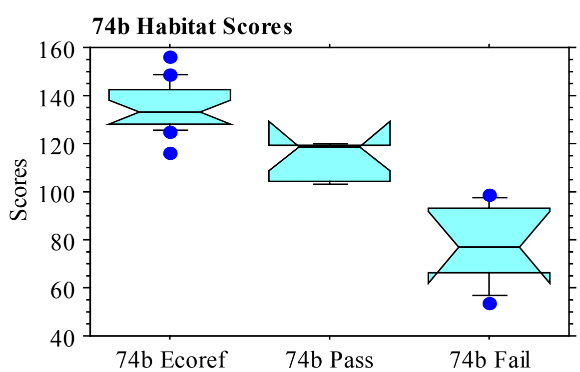
Figure 5: Distribution of reference habitat scores by ecological subregions in Tennessee. Subregions are split by season, and stream size where significant. Multiple assessments are represented. Information on number of sites and number of observations at each site can be found in Table 2.

5. CALIBRATION OF PROPOSED HABITAT GOALS

5.0 Comparison of Proposed Habitat Goals to Test Sites

The proposed habitat goals were compared to 296 test sites at streams in 5 subregions across the state to determine responsiveness of the metric (Figure 6). Thirty-two percent of the sites failed to meet acceptable habitat goals. The majority of sites that failed to meet the proposed goals had been evaluated by Division biologists as having degraded habitat during the original assessment.





Descriptive Statistics

	Mean	Std. Dev.	Count	Minimum	Maximum	Median
65e Ecoref	152.1	19.1	34	122.0	181.0	151.5
65e Pass	140.8	17.6	50	116.0	180.0	136.0
65e Fail	87.2	15.8	25	49.0	108.0	91.0
67f Ecoref	176.2	12.1	43	139.0	196.0	174.0
67f Pass	153.5	11.7	12	132.0	175.0	154.0
67f Fail	92.6	18.0	21	59.0	120.0	92.0
71f Ecoref	161.7	9.7	38	135.0	178.0	164.0
71f Pass	141.1	9.9	101	123.0	182.0	141.0
71f Fail	113.6	8.7	21	82.0	122.0	116.0
71h Ecoref	152.9	13.3	28	125.0	172.0	155.5
71h Pass	130.9	10.7	33	118.0	164.0	130.0
71h Fail	103.7	11.8	20	81.0	116.0	107.5
74b Ecoref	135.5	10.1	19	116.0	156.0	133.0
74b Pass	113.2	8.4	5	103.0	120.0	119.0
74b Fail	78.1	16.0	8	54.0	99.0	77.0

Figure 6: Comparison of proposed habitat goals to test sites in selected subregions. Ecoref represents the distribution of reference data, Pass represents sites that passed proposed habitat critera and Fail represents sites that failed to meet proposed habitat goals.

5.1 Comparison of Proposed Habitat Goals to Randomly Selected Sites in the Inner Nashville Basin (71i)

A probabilistic monitoring project was conducted during 2000 in the Inner Nashville Basin (TDEC 2000). Fifty streams were randomly selected. Habitat was assessed once each quarter at each randomly selected site. Four of the streams monitored as part of the probabilistic monitoring study proved to be as good or better than the established reference streams in this region. Data from these streams were included in determination of habitat goals. Due to decreased flows, statistically different seasonal variation was measured between the Winter/Spring and the Summer/Fall quarters.

Typical streams in this region have bedrock substrates providing limited benthic habitat in natural conditions. The Inner Nashville Basin is experiencing heavy population growth that results in many streams being impacted from urban development, habitat destruction, riparian loss and/or livestock access. Although they were the best attainable in the region, all of the reference streams had some level of impact. The naturally limited habitat coupled with the unavoidable impairment at the reference sites yielded a relatively low acceptable score of 98 for the winter/spring season and a score of 96 in the summer/fall season. Although these numbers are similar, there was significant variability between individual scores as measured by Fisher's PLSD. Statistically significant seasonal variation was also measured in the macroinvertebrate community (Arnwine and Denton, 2001).

Eighty percent of the randomly selected sites met the proposed habitat goals in the winter/spring season (Table 3). Only 61 percent passed in the summer/fall even though the expected habitat score had been adjusted for this season based on reference data. Six percent of the streams that failed to meet the spring guidelines, passed in the fall when goals were lower. Fifty-four percent of the streams passed the proposed habitat goals for all seasons.

Table 3: Comparison of randomly selected streams in the Inner Nashville Basin to proposed habitat goals

Station ID	Winter/Spring	Met Goal	Summer/Fall	Met Goal
ALEXA004.0BE	122	YES	66	NO
BARTO017.6WS	70	NO	66	NO
BRADL003.8RU	116	YES	108	YES
BROCK006.0ML	150	YES	138	YES
BUSH002.2RU	132	YES	126	YES
CEDAR002.2MY	124	YES	84	NO
CEDAR004.6WS	152	YES	135	YES
CEDAR011.8WS	103	YES	110	YES
CHRIS000.7RU	124	YES	106	YES
CLEM000.4BE	131	YES	Dry	NA
CRIPP003.0RU	142	YES	142	YES

Station ID	Winter/Spring	Met Goal	Summer/Fall	Met Goal
CROOK000.2MY	108	YES	116	YES
DAVIS000.2BE	108	YES	54	NO
EFSTO026.6RU	106	YES	113	YES
EROCK020.8BE	126	YES	73	NO
FALL003.0BE	128	YES	90	NO
FALL003.6RU	107	YES	132	YES
FALL018.8WS	130	YES	109	YES
FLORI002.4WS	70	NO	79	NO
HARPE076.0WI	139	YES	104	YES
HENRY001.5RU	102	YES	90	NO
HURRI002.0RU	94	NO	99	YES
HURRI004.2BE	111	YES	54	NO
JOHNS000.4WS	85	NO	109	YES
LFLAT003.6MY	136	YES	96	YES
LITTL001.8WS	98	YES	114	YES
LSINK001.0BE	90	NO	52	NO
LYTLE000.6RU	118	YES	128	YES
MCKNI001.2RU	109	YES	146	YES
MILL012.4DA	130	YES	116	YES
MILL021.2DA	150	YES	110	NO
NFORK007.7BE	143	YES	88	NO
NFORK016.4BE	116	YES	Dry	NA
OVERA009.4RU	123	YES	108	YES
RICH000.5ML	133	YES	54	NO
SINKI001.2BE	140	YES	98	YES
SINKI004.0WS	52	NO	Dry	NA
SINKI008.9BE	108	YES	66	NO
SPENC005.0WS	126	YES	102	YES
SPRIN004.4WS	115	YES	128	YES
SPRIN016.0WS	110	YES	116	YES
SPRIN027.0WS	74	NO	84	NO
STEWA018.2RU	110	YES	116	YES
SUGGS007.7WS	80	NO	104	YES
THICK002.0ML	134	YES	80	NO
WALLA000.8WI	108	YES	43	NO
WEAKL005.2BE	106	YES	Dry	NA
WFSTO013.6RU	132	YES	122	YES
WFSTO023.2RU	120	YES	109	YES
WILSO005.2BE	96	NO	64	NO

5.2 Comparison of Proposed Habitat Goals with Proposed Biological and Nutrient Criteria at Randomly Selected Sites in the Inner Nashville Basin (71i).

The Division is in the process of proposing biological and nutrient criteria derived from reference stream data. A comparison was made of the proposed criteria and the habitat goals to the sites monitored as part of the 71i Probabilistic Monitoring Project (Table 4).

Fifty-four percent of the sites met the habitat guidelines in all seasons. Only two creeks (Florida and Johnson) failed to meet the habitat guidelines for the region while passing both the proposed nutrient and biological criteria. All the other sites that did not meet habitat goals failed to meet at least one other proposed limit.

The biotic integrity at three sites (FLORI002.4WS, JOHNS000.4WS, and SPRING027.0WS) appeared intact despite the low habitat scores. This testifies to the adaptability of the macroinvertebrate community in this harsh subregion. However, the biota at these three sites are threatened since riparian loss was the primary habitat problem in each case. This leaves no buffer between the stream and run-off from any future disturbances in the surrounding watershed.

Table 4: Comparison of proposed habitat goals with proposed biological and nutrient criteria at randomly selected sites in the Inner Nashville Basin

Site	Habitat Spring	Biology Spring	Fall	Biology Fall	Phosp s	NO2 & NO
ALEXA004.0BE	Pass	**Fail**	**Fail**	NA	Pass	Pass
BARTO017.6WS	**Fail**	**Fail**	**Fail**	**Fail**	Pass	Pass
BRADL003.8RU	Pass	Pass	Pass	Pass	Pass	Pass
BROCK006.0ML	Pass	**Fail**	Pass	Pass	Pass	**Fail**
BUSH002.2RU	Pass	Pass	Pass	Pass	Pass	Pass
CEDAR002.2MY	Pass	**Fail**	**Fail**	NA	Pass	Pass
CEDAR004.6WS	Pass	Pass	Pass	Pass	Pass	Pass
CEDAR011.8WS	Pass	Pass	Pass	Pass	Pass	**Fail**
CHRIS000.7RU	Pass	**Fail**	Pass	Pass	Pass	**Fail**
CLEM000.4BE	Pass	**Fail**	NA	NA	Pass	**Fail**
CRIPP003.0RU	Pass	**Fail**	Pass	Pass	Pass	Pass
CROOK000.2MY	Pass	**Fail**	Pass	NA	Pass	Pass
DAVIS000.2BE	Pass	**Fail**	**Fail**	NA	Pass	Pass
EFSTO026.6RU	Pass	Pass	Pass	Pass	Pass	Pass
EROCK020.8BE	Pass	Pass	**Fail**	NA	Pass	**Fail**
FALL003.0BE	Pass	**Fail**	**Fail**	Pass	Pass	Pass
FALL003.6RU	Pass	Pass	Pass	Pass	Pass	Pass
FALL018.8WS	Pass	Pass	Pass	**Fail**	**Fail**	Pass
FLORI002.4WS	**Fail**	Pass	**Fail**	Pass	Pass	Pass
HARPE076.0WI	Pass	Pass	Pass	Pass	**Fail**	Pass
HENRY001.5RU	Pass	**Fail**	**Fail**	NA	Pass	Pass

Site	Habitat Spring	Biology Spring	Habitat Fall	Biology Fall	Phosphorus	NO2 & NO3
HURRI002.0RU	**Fail**	**Fail**	Pass	NA	Pass	Pass
HURRI004.2BE	Pass	**Fail**	**Fail**	NA	Pass	Pass
JOHNS000.4WS	**Fail**	Pass	Pass	NA	Pass	Pass
LFLAT003.6MY	Pass	Pass	Pass	NA	Pass	Pass
LITTL001.8WS	Pass	Pass	Pass	**Fail**	Pass	Pass
LSINK001.0BE	**Fail**	**Fail**	**Fail**	NA	Pass	Pass
LYTLE000.6RU	Pass	**Fail**	Pass	Pass	Pass	Pass
MCKNI001.2RU	Pass	**Fail**	Pass	**Fail**	Pass	Pass
MILL012.4DA	Pass	**Fail**	Pass	**Fail**	**Fail**	Pass
MILL021.2DA	Pass	**Fail**	**Fail**	**Fail**	Pass	Pass
NFORK007.7BE	Pass	**Fail**	**Fail**	NA	Pass	**Fail**
NFORK016.4BE	Pass	**Fail**	NA	NA	Pass	**Fail**
OVERA009.4RU	Pass	Pass	Pass	Pass	Pass	**Fail**
RICH000.5ML	Pass	**Fail**	**Fail**	NA	Pass	Pass
SINKI001.2BE	Pass	**Fail**	Pass	NA	Pass	Pass
SINKI004.0WS	**Fail**	**Fail**	NA	NA	**Fail**	Pass
SINKI008.9BE	Pass	**Fail**	**Fail**	NA	Pass	Pass
SPENC005.0WS	Pass	**Fail**	Pass	Pass	**Fail**	**Fail**
SPRIN004.4WS	Pass	Pass	Pass	Pass	**Fail**	Pass
SPRIN016.0WS	Pass	Pass	Pass	**Fail**	**Fail**	Pass
SPRIN027.0WS	**Fail**	Pass	**Fail**	**Fail**	**Fail**	Pass
STEWA018.2RU	Pass	**Fail**	Pass	**Fail**	Pass	**Fail**
SUGGS007.7WS	**Fail**	**Fail**	Pass	**Fail**	Pass	Pass
THICK002.0ML	Pass	**Fail**	**Fail**	NA	Pass	Pass
WALLA000.8WI	Pass	Pass	**Fail**	NA	Pass	Pass
WEAKL005.2BE	Pass	**Fail**	NA	NA	Pass	**Fail**
WFSTO013.6RU	Pass	**Fail**	Pass	**Fail**	Pass	Pass
WFSTO023.2RU	Pass	**Fail**	Pass	Pass	Pass	**Fail**
WILSO005.2BE	**Fail**	**Fail**	**Fail**	Pass	Pass	**Fail**

In subregion 71i, biological integrity proved the most responsive of the proposed criteria to pollution (Figure 7). This is to be expected since the benthic community is exposed to continuous stream conditions that may not be captured in periodic grab samples for nutrients. Although good habitat is essential to the continuance of biological integrity, it is only one factor. Biota are responsive to synergistic effects of all components of the stream. Habitat is not a sensitive metric in this subregion due to the naturally poor habitat availability and the lack of unimpaired reference sites.

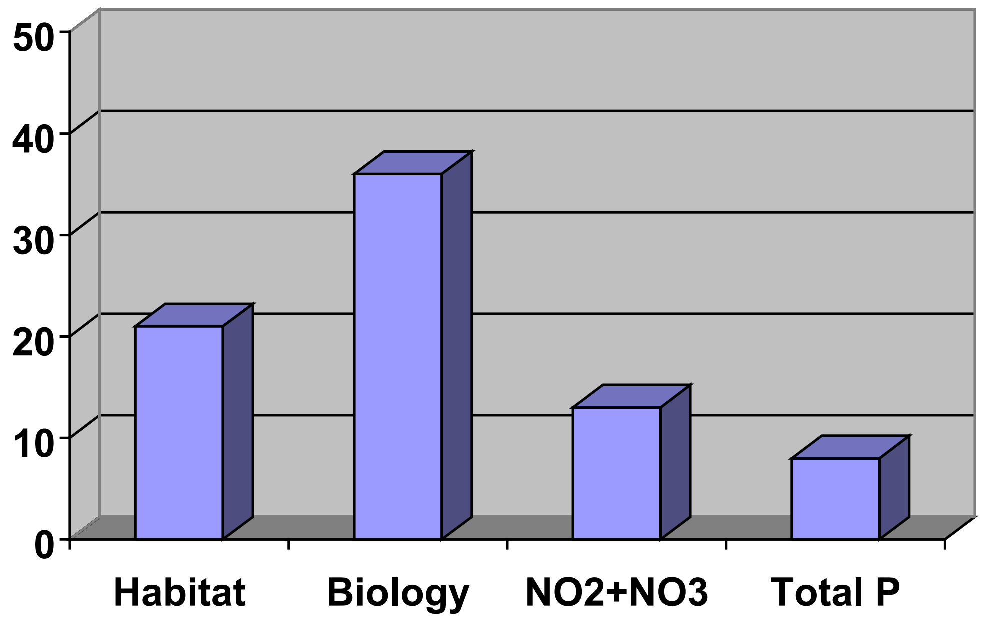


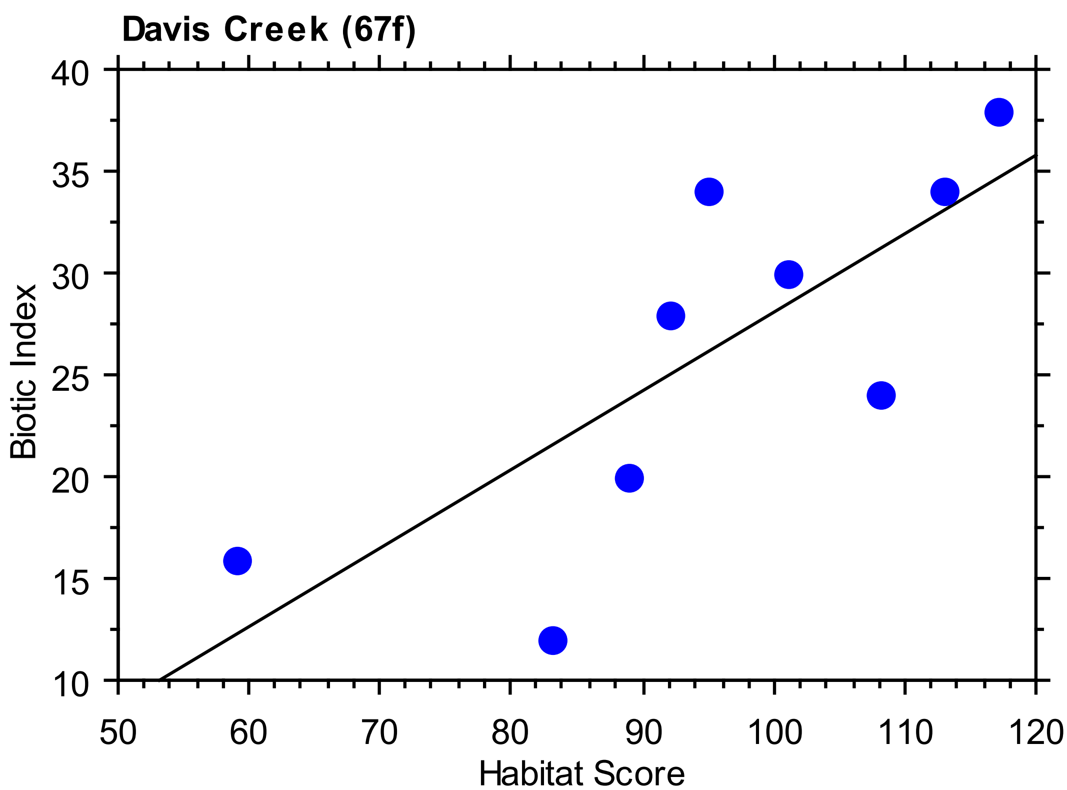
Figure 7: Number of sites failing to meet proposed habitat guidelines, biocriteria or nutrient criteria at 71i probabilistic monitoring stations. Based on a single (spring) assessment of 50 randomly selected sites.

Spring Creek is typical of Inner Nashville Basin streams where urban development, loss of streamside vegetation and agricultural run-off result in stressed biological communities. Photo courtesy of Aquatic Biology, TDH.

5.3 Comparison of Proposed Habitat Goals With Proposed Biological and Nutrient Criteria at Test Sites in 67f

In 2000, a TMDL survey was conducted at 9 sites in the Davis Creek sub-watershed of the Powell River in the Southern Limestone/Dolomite Valleys and Low Rolling Hills, (Subregion 67f). This creek is on the 1998 303(d) list due to impacts from pathogens, nutrients and siltation, primarily as a result of intense dairy operations.

Habitat was assessed and semi-quantitative macroinvertebrate samples were collected in October. Figure 8 illustrates a clear correlation between habitat scores and biological integrity. Davis Creek is typical of many streams in 67f, a region where reduced riparian zones, high erosion, sedimentation and nutrient loading from animal operations is wide-spread.



$R^2 = 0.592$

Figure 8: Correlation between habitat scores and the proposed Tennessee Biotic Index scores at 9 sites in the Davis Creek watershed, Subregion 67f. Based on single assessments at each site conducted in October.

Davis Creek, (subregion 67f) test site demonstrating poor habitat quality (eroded banks, lack of riparian habitat). Biological integrity at this site was compromised.

Davis Creek site where an adequate riparian zone provided better habitat and reduced erosion and nutrient run-off. Biological integrity was maintained at this location. Photos provided by Aquatic Biology, TDH.

6. RECOMMENDATIONS

Degraded habitat is one of the major stressors of aquatic populations and can obscure the effects of other types of pollution. Therefore, habitat assessments consistent with this guidance should be conducted as part of any biological survey. Assessed habitat scores can then be compared to regional habitat goals.

Unlike biological and nutrient criteria, habitat goals are not confined to streams contained within a single subregion (or group of regions). Habitat is reach-specific and can therefore be compared to the goals for whichever subregion the assessed reach is in. However, the goals should not be used to evaluate dissimilar waters such as lakes, wetlands or large rivers.

Table 5 defines the habitat goals for each subregion in Tennessee. Based on 75 percent of the median habitat scores, these goals represent the minimum habitat score that would be expected to sustain biological integrity, minimize erosion, maintain water quality and protect the stream from disturbances in the watershed. Scores are differentiated by season for the five subregions that had significant seasonal differences in habitat scores. Additionally, four subregions, Southeastern Plains and Hills (65e), Transition Hills (65j), Southern Sedimentary Mountains (66g) and Cumberland Plateau (68a) exhibited a statistically significant difference between size classes. Therefore, separate habitat goals were developed based on stream order in these regions.

Occasionally, a single component of the habitat (such as sedimentation) will cause the biological integrity of a stream to be compromised even though the total habitat score meets regional expectations. Therefore, in instances where biological monitoring indicates stress to the aquatic community but the total habitat score is satisfactory, each individual scoring parameter should be reviewed to determine if habitat is a factor in the loss of biological integrity. Table 6 provides scoring guidelines for individual habitat parameters by subregion, season and stream size.

Another instance where evaluating individual parameter scores may be useful is in dry conditions or when assessing first order streams (if first order streams were not included in the reference database for that region). If channel flow status is the only parameter scoring below expectations, habitat is probably comparable to reference conditions. An exception would be when performing assessments downstream of impoundments where minimum flow requirements are not being maintained.

Regional expectations for each parameter were determined in the same manner as goals were defined for the total habitat score. Parameter scores for each assessment were pooled by subregion. The median score was calculated from this data set. Then, 75% of the median was established as the minimum score for each parameter. Table 6 defines what would be considered an acceptable value for each component of the habitat to maintain a healthy benthic community.

Table 5: Guidelines for maintaining protective habitat by subregion.

Subregion	Ref Stream Order*	Habitat Form	Season	Minimum Score
65a	2	Low Gradient	Jan. – Dec.	62
65b	3	Low Gradient	Jan. – Dec.	92
65e	2,	Low Gradient	Jan. – Dec.	131
65e	3	Low Gradient	Jan. – Dec	110
65i	2	Low Gradient	Jan. – Dec.	98
65j	2,3	High Gradient	Jan. – Dec.	134
66d	1,2,4	High Gradient	Jan. – Dec.	146
66e	2,3,4	High Gradient	Jan. – Dec.	143
66f	3,4	High Gradient	Jan. – Dec.	138
66g	2,3,	High Gradient	Jan. – Dec.	136
66g	4	High Gradient	Jan. – Dec.	146
67f	2,3,4,5	High Gradient	Jan. – Dec.	131
67g	1,2,3,4	High Gradient	Jan. – Dec.	117
67h	1,2,	High Gradient	Jan. – Dec.	126
67i	3	High Gradient	Jan. – Dec.	114
68a	2	High Gradient	Jan. - June	118
68a	3,4,5	High Gradient	Jan. - June	139
68a	3,4,5	High Gradient	July – Dec.	132
68b	2,3	High Gradient	Jan. - June	115
68b	2,3	High Gradient	July – Dec.	95
68c	1,2	High Gradient	Jan. - June	128
68c	1,2	High Gradient	July – Dec.	121
69d	2,3	High Gradient	Jan. - June	137
69d	2,3	High Gradient	July – Dec.	128
71e	3	High Gradient	Jan. – Dec.	112
71f	2,3,4	High Gradient	Jan. – Dec.	123
71g	3,4	High Gradient	Jan. – Dec.	123
71h	3,4	High Gradient	Jan. – Dec.	117
71i	3,4	High/Low Grad.	Jan. - June	98
71i	3,4	High/Low Grad.	Jan. – Dec.	96
73a	3,4	Low Gradient	Jan. – Dec.	94
74a	2	High Gradient	Jan. – Dec.	88
74b	2,4	Low Gradient	Jan. – Dec.	98

Table 6: Goals for individual habitat parameters by subregion.

High Gradient (Riffle-Run) Streams											
Region	**Season***	**Epifaunal Substrate**	**Embedded.**	**Velocity/ Depth**	**Sediment Deposition**	**Channel Flow**	**Channel Alteration**	**Frequency Riffles**	**Bank Stability**	**Bank Vege on**	**Riparian Zone**
65j 2	All	13	14	13	13	11	14	14	15	15	15
65J 3	All	11	14	12	12	11	14	14	14	15	15
66d	All	15	15	15	14	14	15	15	15	15	15
66e	All	14	14	15	14	15	15	15	15	15	15
66f	All	13	14	12	14	14	15	14	15	15	14
66g 2,3	All	12	14	12	14	13	14	14	15	15	14
66g 4	All	14	15	14	15	14	15	15	15	15	15
67f	All	14	14	14	12	13	15	14	14	14	14
67g	All	12	12	11	11	13	12	12	10	13	10
67h	All	10	13	12	11	11	13	14	14	14	14
67i	All	10	12	8	11	13	12	10	14	14	12
68a	Fall	12	12	13	14	10	14	12	15	15	15
68a 2	Spring	10	11	14	10	13	14	14	11	11	10
68a 3,4,5	Spring	14	14	14	14	14	14	13	15	15	15
68b	Fall	9	9	9	6	8	12	12	10	11	9
68b	Spring	11	12	11	10	13	13	12	10	11	9
68c	Fall	10	12	12	11	8	15	13	13	14	14
68c	Spring	11	12	14	12	14	15	14	13	15	14
69d	Fall	10	13	12	13	6	15	14	14	15	15
69d	Spring	13	14	14	14	12	14	14	14	15	14
71e	All	12	11	11	10	12	12	12	10	12	10
71f	All	12	13	11	11	11	14	13	13	14	12
71g	All	12	12	12	12	12	13	13	14	12	12
71h	All	12	13	12	11	12	12	13	13	11	9
71i	Fall	10	10	4	10	10	13	6	12	12	9
71i	Spring	10	11	9	8	12	12	8	12	13	10
74a	All	8	11	7	8	6	12	10	9	9	10

Low Gradient (Glide-Pool) Streams											
Region	**Season***	**Epifaunal Substrate**	**Pool Substrate Character**	**Pool Variability**	**diment Deposition**	**Channel Flow Status**	**Channel Alteration**	**Channel Sinuosity**	**Bank Stability**	**Bank Vegetative Protection**	**Riparian Vegetative**
65a	All	4	5	8	9	8	9	4	6	10	3
65b	All	11	7	8	9	8	12	11	12	14	15
65e 2	All	14	11	8	12	15	14	11	15	15	12
65e 3	All	10	8	8	11	12	14	11	12	14	14
65i	All	10	9	9	8	6	14	8	6	6	15
71i	Fall	10	6	6	10	10	14	8	12	12	10
71i	Spring	8	5	5	7	14	12	9	9	11	8
73a	All	8	4	4	8	10	14	8	8	14	14
74b	All	7	7	7	8	11	13	8	10	15	15

* Spring = January through June
Fall = July through December

7. CONCLUSIONS

The Division of Water Pollution Control used reference data collected from each of 25 ecological subregions between 1996 and 2001 to define regional habitat conditions. Habitat goals were based on 75% of the median reference score for each subregion.

Tennessee's proposed habitat guidelines are based on a numeric evaluation of instream and riparian habitat parameters that are related to overall aquatic life use. Ten components of the habitat are measured using a scoring system of 1 to 20 points for each parameter. Two different scoring guidelines are used dependent on stream type in the ecoregion (riffle or non-riffle).

Five subregions; 68a, 68b, 68c, 69d and 71i demonstrated significant seasonal variation in habitat composition. Habitat quality was generally reduced in the late summer/fall season. This was primarily a function of reduced flow providing less available habitat for macroinvertebrate colonization. Separate habitat goals based on season were proposed for each of these five regions.

Four subregions, 65e, 65j, 66g and 68a had statistically different scores based on stream order. Two separate habitat goals were calculated in each of these regions grouped by stream size.

The proposed habitat guidelines were compared to historic test sites at streams in various subregions to determine responsiveness of the metric. The majority of sites that failed to meet the proposed goals had been previously evaluated by WPC biologists as having degraded habitat during the original assessments.

Additionally, the habitat guidelines were compared to 50 randomly selected sites in the Inner Nashville Basin (subregion 71i). Fifty-four percent of the sites met the habitat guidelines in all seasons. Only two creeks failed to meet the habitat guidelines for the region while meeting goals for both nutrients and biology. All the other sites failed to meet at least one other proposed limit.

The habitat goals were also compared to nine sites in an impaired watershed in subregion 67f. A direct correlation was observed between habitat scores and biological integrity.

Once established, the use of regional habitat guidelines in conjunction with numeric biocriteria will help standardize Division stream assessments and will account for regional differences in aquatic communities. Existing reference sites will be monitored in the future on a five-year rotation in conjunction with watershed monitoring. Should future watershed monitoring activities or ecoregion efforts in adjacent states uncover additional reference quality streams, these data can augment the existing databases. Habitat guidelines can be adjusted in future triennial reviews as more data become available.

8. HABITAT GUIDANCE IMPLEMENTATION QUESTIONS AND ANSWERS

Why has the Division published this guidance?

Experience gained while assessing streams and implementing the narrative biological integrity criterion has emphasized that adequate habitat is critical to a stream's ability to meet clean water goals. Additionally, we have learned that the proper amounts and types of habitat should be different in the various regions of the state. Without a sense of the appropriate habitat requirements for each region, the Division has difficulty differentiating between impacts caused by habitat loss and those caused by other pollutants. With this guidance document, the Division is formalizing a standardized approach based on a comparison of test sites to the range of habitat scores from least impacted reference streams.

What is the statutory basis for regulating habitat quality?

The Tennessee Water Quality Control Act defines pollution as something that alters any one of five properties of water to the extent that the designated uses are affected [TCA 69-3-103(22)]. In addition to the chemical, bacteriological, and radiological quality of waters, biological and physical alterations are also specifically identified. The Act indicates that these alterations cannot take place without permission from the state of Tennessee [TCA 69-3-108 (1)].

Removal or changes in stream habitat is a physical alteration that directly impacts biological integrity. Tennessee's water quality standards state that habitat should not be altered to the degree that biological integrity is negatively impacted.

What are common examples of habitat alteration activities that negatively impact biological integrity in Tennessee?

According to the 2000 305(b) Report, channelization is the largest single source of habitat alterations in Tennessee (as measured by the number of impacted stream miles). Vegetation removal and levee construction is often associated with channelization and also impact water quality by increasing scour and stream temperatures and by separating a stream from its floodplain and associated wetlands (respectively).

In urban areas, culverting of streams is a frequent source of impacts, as is construction activities in floodplains. Some urban streams were concrete-lined in the years before an effective permitting program was in operation. Also in urban areas, headwaters are often eliminated in preparing land for development. Downstream of dams, flow alteration can negatively impact the habitat available to biota.

In streams impacted by habitat alterations, siltation is the specific pollutant most frequently associated with reduced biological integrity. Common sources of silt include erosion from land development, agriculture, and abandoned mine sites. In the Cumberland Mountains, streams impacted by historical mining activities can have habitats coated by precipitated metals such as manganese (black coating) or iron (orange coating). Overgrowth of algae and bacteria in areas of nutrient enrichment can also impact habitat.

Are habitat alterations included in the exemptions found in the Water Quality Control Act?

The Water Quality Control Act generally exempts agricultural and forestry activities from regulation, unless a discreet conveyance of pollutants is created [TCA 69-3-120 (g)]. However, it is generally held that habitat alteration is not the type of ordinary activity intended to be included in the agricultural or forestry exemptions found in the Act. As a practical matter, the Division does not intend to use its regulatory authority to require restoration of historically altered streams. Certainly, we will be supportive of voluntary efforts to restore habitat in these streams.

The Division's regulatory authority will be used in those cases where it has come to the Division's attention that recent habitat alterations have occurred either without a permit or in violation of the provisions of an existing permit.

Why is the Division not proposing to formalize the habitat goals as numeric water quality standards at this time?

Habitat quality is evaluated by use of a standardized form developed by EPA according to the procedure found in EPA guidance. Because Division staff have been trained in the proper use of the form, we are confident that our habitat assessments have been performed consistently. However, we are aware that habitat assessments, like any generally qualitative assessment, may provide opportunity for variability between assessors. Because we cannot fully account for this variability, we would prefer to use these numbers as general guidance rather than as promulgated criteria.

How does the Division intend to use the habitat goals?

Our primary in-house use of the guidance will be as an aid to interpreting biological data. If the habitat goal is not met in a stream that has evidence of biological impairment, we will consider habitat alteration to be one of the causes of impacts.

Additionally, it is our opinion that the habitat goals will be invaluable to the sister agencies that help install best management practices in impacted streams. The goals can provide targets for habitat improvement.

Will the habitat goals be incorporated into permit requirements?

It is not very likely that habitat goals will be directly incorporated as permit requirements. However, in those permits that require in-stream biological monitoring, it is very likely that habitat monitoring would also be required.

Additionally, the habitat goal concept could be an important part of future enforcement actions where an entity is being required to restore a stream segment that has been altered.

Do habitat goals based on the reference condition establish an unattainable standard?

As reference streams had to be both least-impacted <u>and</u> representative, most do not represent pristine conditions. It might be argued by some that the Division should have established a higher habitat goal in ecoregions where even the reference streams have been substantially altered.

Additionally, the regional goal is based on a 75% or greater similarity to the median habitat value. Thus, a test stream does not have to be just like the reference streams in order to meet the goal.

Why did the Division base the habitat goals on a 75% or greater similarity to the median reference score instead of on the 90th percentile as was proposed with the nutrient criteria?

Since 1992, the Division has been assessing habitat in accordance with EPA guidance developed in 1989. This guidance defines habitat that is at least 75% comparable to the reference condition as being capable of supporting a healthy biotic community.

The median value of the reference database for each subregion was used to determine reference condition. The median was determined to be a fair representation of habitat quality in each subregion since it represents the central tendency without being influenced by outliers.

Seventy-five percent of the median reference score represents an attainable goal since reference sites were selected to be representative of the subregion. This means that many of the sites were exposed to land-use practices that were prevalent in the region.

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APPENDIX A

HABITAT SCORES FOR ECOREGION REFERENCE SITES

1995-2001

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO65A01	UNNAMED TRIB TO MUDDY CR	85	9/18/96	DHA,PAD-LAB
ECO65A01	UNNAMED TRIB TO MUDDY CR	86	4/14/97	PAD-LAB
ECO65A01	UNNAMED TRIB TO MUDDY CR	82	9/8/97	PAD,PDS-LAB
ECO65A01	UNNAMED TRIB TO MUDDY CR	151	6/2/98	AJF-JEAC
ECO65A03	WARDLOW CREEK	71	9/20/96	DHA,PAD-LAB
ECO65A03	WARDLOW CREEK	71	4/15/97	PAD,PDS-LAB
ECO65A03	WARDLOW CREEK	71	9/9/97	PAD,PDS-LAB
ECO65B04	CYPRESS CREEK	122	9/16/96	PAD-LAB
ECO65B04	CYPRESS CREEK	122	12/2/96	PAD-LAB
ECO65B04	CYPRESS CREEK	122	4/14/97	PAD,PDS-LAB
ECO65B04	CYPRESS CREEK	122	9/8/97	PAD-LAB
ECO65B04	CYPRESS CREEK	154	4/23/98	AJF,GSO-JEAC
ECO65B04	CYPRESS CREEK	132	9/2/98	AJF,GSO-JEAC
ECO65B04	CYPRESS CREEK	162	4/7/99	AJF-JEAC
ECO65B04	CYPRESS CREEK	123	9/2/99	AJF/GSO-JEAC
ECO65E04	BLUNT CREEK	134	4/17/97	PAD,PDS-LAB
ECO65E04	BLUNT CREEK	128	10/7/97	PAD,PDS-LAB
ECO65E04	BLUNT CREEK	133	4/22/98	AJF,GSO-JEAC
ECO65E04	BLUNT CREEK	134	9/9/98	AJF,GSO-JEAC
ECO65E04	BLUNT CREEK	136	4/19/99	AJF-JEAC
ECO65E06	GRIFFEN CREEK	125	4/16/97	PAD,PDS-LAB
ECO65E06	GRIFFEN CREEK	125	9/10/97	PAD,PDS-LAB
ECO65E06	GRIFFEN CREEK	147	4/22/98	GSO,AJF-JEAC
ECO65E06	GRIFFEN CREEK	130	9/9/98	GSO,AJF-JEAC
ECO65E06	GRIFFEN CREEK	125	4/19/99	AJF-JEAC
ECO65E08	HARRIS CREEK	140	8/22/96	AJF,GSO-JEAC
ECO65E08	HARRIS CREEK	122	9/20/96	DHA,PAD-LAB
ECO65E08	HARRIS CREEK	143	5/5/97	GSO-JEAC
ECO65E08	HARRIS CREEK	144	8/15/97	AJF-JEAC
ECO65E08	HARRIS CREEK	151	6/2/98	AJF-JEAC
ECO65E08	HARRIS CREEK	163	9/11/98	GSO,AJF-JEAC
ECO65E08	HARRIS CREEK	154	3/24/99	AJF-JEAC
ECO65E08	HARRIS CREEK	163	9/11/99	GSO-JEAC
ECO65E10	MARSHALL CREEK	180	8/9/96	AJF,AMR-JEAC
ECO65E10	MARSHALL CREEK	144	9/16/96	DHA,PAD-LAB
ECO65E10	MARSHALL CREEK	180	4/17/97	AJF,GSO-JEAC
ECO65E10	MARSHALL CREEK	181	8/14/97	AJF-JEAC
ECO65E10	MARSHALL CREEK	179	4/23/98	AJF,GSO-JEAC
ECO65E10	MARSHALL CREEK	159	9/2/98	AJF,GSO-JEAC
ECO65E10	MARSHALL CREEK	169	4/7/99	AJF-JEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO65E10	MARSHALL CREEK	162	6/28/01	AJF-JEAC
ECO65E11	WEST FORK SPRING CREEK	174	8/15/96	AJF,PCP-JEAC
ECO65E11	WEST FORK SPRING CREEK	143	9/16/96	DHA-LAB
ECO65E11	WEST FORK SPRING CREEK	152	4/17/97	GSO-JEAC
ECO65E11	WEST FORK SPRING CREEK	173	8/14/97	AJF-JEAC
ECO65E11	WEST FORK SPRING CREEK	168	4/23/98	AJF,GSO-JEAC
ECO65E11	WEST FORK SPRING CREEK	163	9/2/98	AJF,GSO-JEAC
ECO65E11	WEST FORK SPRING CREEK	171	4/7/99	AJF-JEAC
ECO65E11	WEST FORK SPRING CREEK	185	4/29/99	AJF,GSO-JEAC
ECO65I02	BATTLES CREEK	131	9/18/96	DHA,PAD-LAB
ECO65I02	BATTLES CREEK	131	12/2/96	PAD/DKW-LAB
ECO65I02	BATTLES CREEK	131	4/15/97	PAD,PDS-LAB
ECO65I02	BATTLES CREEK	119	10/7/97	PAD-LAB
ECO65I02	BATTLES CREEK	125	10/7/97	PDS-LAB
ECO65J04	POMPEYS BRANCH	181	8/29/96	JIB-CO
ECO65J04	POMPEYS BRANCH	184	8/29/96	AJF,PCP-JEAC
ECO65J04	POMPEYS BRANCH	178	5/2/97	AJF-JEAC
ECO65J04	POMPEYS BRANCH	186	8/21/97	AJF-JEAC
ECO65J04	POMPEYS BRANCH	195	4/29/98	AJF,GSO-JEAC
ECO65J04	POMPEYS BRANCH	176	9/17/98	GSO -JEAC
ECO65J04	POMPEYS BRANCH	176	9/17/98	AJF-JEAC
ECO65J04	POMPEYS BRANCH	180	4/20/99	AJF,SKRS-JEAC
ECO65J05	DRY CREEK	151	8/29/96	JIB-CO
ECO65J05	DRY CREEK	174	8/29/96	AJF,PCP-JEAC
ECO65J05	DRY CREEK	166	5/2/97	AJF-JEAC
ECO65J05	DRY CREEK	190	8/21/97	AJF-JEAC
ECO65J05	DRY CREEK	178	9/17/98	AFJ,GSO-JEAC
ECO65J05	DRY CREEK	169	4/20/99	AJF,SKRS-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	163	8/29/96	JIB-CO
ECO65J06	RIGHT FORK WHITES CREEK	179	8/29/96	AJF,JIB-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	167	5/2/97	AJF-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	190	8/22/97	AJF-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	176	4/28/98	AJF,GSO-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	184	9/17/98	AJF,GSO-JEAC
ECO65J06	RIGHT FORK WHITES CREEK	186	4/29/99	AJF,GSO-JEAC
ECO65J11	UNAMED TRIB RT FRK WHITES CK	167	5/2/97	AJF-JEAC
ECO65J11	UNAMED TRIB RT FRK WHITES CK	194	8/22/97	AJF-JEAC
ECO65J11	UNAMED TRIB RT FRK WHITES CK	189	4/29/98	AJF,GSO-JEAC
ECO65J11	UNAMED TRIB RT FRK WHITES CK	176	9/17/98	AJF,GSO-JEAC
ECO66D01	BLACK BRANCH	183	8/18/95	BTB-JCEAC
ECO66D01	BLACK BRANCH	197	4/25/97	BTB-JCEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO66D01	BLACK BRANCH	198	9/26/97	TDR,RGC-JCEAC
ECO66D01	BLACK BRANCH	193	5/15/98	WDH-JCEAC
ECO66D01	BLACK BRANCH	197	10/7/98	TAR,WDH-JCEAC
ECO66D01	BLACK BRANCH	198	4/19/99	TAR,WDH-JCEAC
ECO66D03	LAUREL FORK	195	10/2/96	BTB,TAR-JCEAC
ECO66D03	LAUREL FORK	196	4/25/97	BTB-JCEAC
ECO66D03	LAUREL FORK	197	9/15/97	BTB,TAR-JCEAC
ECO66D03	LAUREL FORK	181	4/13/98	WDH,RLT-JCEAC
ECO66D03	LAUREL FORK	194	10/9/98	WDH,TAR-JCEAC
ECO66D03	LAUREL FORK	194	4/19/99	TAR,WDH-JCEAC
ECO66D05	DOE RIVER	194	6/23/97	TAR-JCEAC
ECO66D05	DOE RIVER	199	11/5/97	TAR,RGC-JCEAC
ECO66D05	DOE RIVER	194	5/15/98	WDH-JCEAC
ECO66D05	DOE RIVER	194	9/15/98	TAR,RLT-JCEAC
ECO66D05	DOE RIVER	194	4/22/99	RGC,TAR-JCEAC
ECO66D06	TUMBLING CREEK	190	11/7/97	TAR,RGC-JCEAC
ECO66D07	LITTLE STONY CREEK	199	11/5/97	TAR,RGC-JCEAC
ECO66E04	GENTRY CREEK	195	11/6/97	TAR,RGC-JCEAC
ECO666E09	CLARK CREEK	177	8/25/95	BTB-JCEAC
ECO66E09	CLARK CREEK	194	5/5/97	BTB-JCEAC
ECO66E09	CLARK CREEK	191	8/22/97	BTB,TAR-JCEAC
ECO66E09	CLARK CREEK	158	5/13/98	WDH-JCEAC
ECO66E09	CLARK CREEK	199	4/7/99	TAR,WDH-JCEAC
ECO66E11	LOWER HIGGINS CREEK	190	8/22/95	BTB-JCEAC
ECO66E11	LOWER HIGGINS CREEK	193	9/15/96	TAR/RLT-JCEAC
ECO66E11	LOWER HIGGINS CREEK	195	5/23/97	BTB-JCEAC
ECO66E11	LOWER HIGGINS CREEK	198	8/21/97	BTB-JCEAC
ECO66E11	LOWER HIGGENS CREEK	191	8/22/97	TAR-JCEAC
ECO66E11	LOWER HIGGINS CREEK	198	4/2/98	WDH,RLT-JCEAC
ECO66E11	LOWER HIGGINS CREEK	200	9/10/98	TAR,RLT-JCEAC
ECO66E11	LOWER HIGGINS CREEK	200	6/9/99	WDH,RGC-JCEAC
ECO66E17	DOUBLE BRANCH	179	4/9/96	JEB-KEAC
ECO66E17	DOUBLE BRANCH	178	9/30/97	PES,AEW-KEAC
ECO66E18	GEE CREEK	174	4/9/96	GDR-CHEAC
ECO66E18	GEE CREEK	190	9/10/96	GDR/TYH-CHEAC
ECO66E18	GEE CREEK	188	4/14/97	GDR-CHEAC
ECO66F06	ABRAMS CREEK	171	3/27/96	JEB-KEAC
ECO66F06	ABRAMS CREEK	177	9/3/96	KEAC
ECO66F06	ABRAMS CREEK	165	9/4/96	PDS,PAD-LAB
ECO66F06	ABRAMS CREEK	170	5/20/97	JEB,PES-KEAC
ECO66F06	ABRAMS CREEK	185	9/30/97	PES,AEW-KEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO66F06	ABRAMS CREEK	184	4/13/98	PES,JCP-KEAC
ECO66F06	ABRAMS CREEK	191	8/28/98	PES,JCP-KEAC
ECO66F06	ABRAMS CREEK	184	4/22/99	JEB,JCP-KEAC
ECO66F07	BEAVERDAM CREEK	168	9/10/96	APM,KJS-LAB
ECO66F07	BEAVERDAM CREEK	192	10/2/96	JCEAC
ECO66F07	BEAVERDAM CREEK	197	6/10/97	BTB,TAR-JCEAC
ECO66F07	BEAVERDAM CREEK	190	10/13/97	TAR,WDH-JCEAC
ECO66F08	STONY CREEK	190	11/7/97	TAR,RGC-JCEAC
ECO66G04	MID PRONG LITTLE PIGEON R	194	4/22/96	JEB-KEAC
ECO66G04	MID PRONG LITTLE PIGEON R	197	9/4/96	JEB,PES-KEAC
ECO66G04	MID PRONG LITTLE PIGEON R	194	10/2/97	PES,AEW-KEAC
ECO66G05	LITTLE RIVER	197	4/22/96	JEB-KEAC
ECO66G05	LITTLE RIVER	195	9/4/96	JEB,PES-KEAC
ECO66G05	LITTLE RIVER	196	5/20/97	JEB,PES-KEAC
ECO66G05	LITTLE RIVER	195	10/2/97	PES,AEW-KEAC
ECO66G05	LITTLE RIVER	196	4/13/98	PES,JCP-KEAC
ECO66G05	LITTLE RIVER	193	9/11/98	JEB,JCP-KEAC
ECO66G05	LITTLE RIVER	196	4/22/99	JEB,JCP-KEAC
ECO66G07	CITICO CREEK	176	4/22/96	JEB-KEAC
ECO66G07	CITICO CREEK	173	10/1/97	PES,AEW-KEAC
ECO66G07	CITICO CREEK	189	4/16/98	PES,JCP-KEAC
ECO66G07	CITICO CREEK	175	9/10/98	JEB,KMJ-KEAC
ECO66G07	CITICO CREEK	186	4/8/99	PES,AJM-KEAC
ECO66G09	NORTH RIVER	186	10/1/97	PES,AEW-KEAC
ECO66G09	NORTH RIVER	167	5/18/98	CLD-CHEAC
ECO66G09	NORTH RIVER	181	9/10/98	JEB,KMJ-KEAC
ECO66G09	NORTH RIVER	183	4/8/99	PES,AJM-KEAC
ECO66G12	SHEEDS CREEK	179	4/24/96	KEAC
ECO66G12	SHEEDS CREEK	187	9/12/96	GDR-CHEAC
ECO66G12	SHEEDS CREEK	188	4/15/97	GDR-CHEAC
ECO66G12	SHEEDS CREEK	163	9/8/97	GDR-CHEAC
ECO66G12	SHEEDS CREEK	187	5/13/98	GDR-CHEAC
ECO66G12	SHEEDS CREEK	175	8/31/98	KJS,JCA-LAB
ECO66G12	SHEEDS CREEK	181	4/26/99	JCA,APM-LAB
ECO6701	BIG CREEK	164	5/29/98	RLT,WDH-JCEAC
ECO6701	BIG CREEK	163	9/22/98	TAR,WDH-JCEAC
ECO6701	BIG CREEK	177	4/16/99	TAR,SKV-JCEAC
ECO6702	FISHER CREEK	156	11/17/95	BTB,TAR-JCEAC
ECO6702	FISHER CREEK	176	6/18/97	TAR-JCEAC
ECO6702	FISHER CREEK	167	8/26/97	BTB-JCEAC
ECO6702	FISHER CREEK	172	9/22/98	TAR,WDH-JCEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO6702	FISHER CREEK	172	4/16/99	TAR,SKV-JCEAC
ECO6707	POSSUM CREEK	193	5/13/98	WDH,RLT-JCEAC
ECO6707	POSSUM CREEK	173	9/14/98	TAR,WDH-JCEAC
ECO6707	POSSUM CREEK	173	4/22/99	RGC,RLT-JCEAC
ECO67F06	CLEAR CREEK	176	5/5/98	PES,AEW-KEAC
ECO67F06	CLEAR CREEK	139	8/31/98	JEB-KEAC
ECO67F06	CLEAR CREEK	174	4/20/99	JEB,KMJ-KEAC
ECO67F13	WHITE CREEK	164	6/6/95	JCEAC
ECO67F13	WHITE CREEK	186	4/8/96	KEAC
ECO67F13	WHITE CREEK	181	9/5/96	PDS,PAD-LAB
ECO67F13	WHITE CREEK	183	5/5/97	JEB,PES-KEAC
ECO67F13	WHITE CREEK	182	9/11/97	JEB,PES-KEAC
ECO67F13	WHITE CREEK	187	5/6/98	JEB,NRH-KEAC
ECO67F13	WHITE CREEK	173	8/31/98	JEB-KEAC
ECO67F13	WHITE CREEK	187	4/20/99	JEB,KMJ-KEAC
ECO67F14	POWELL RIVER	159	4/8/96	JEB-KEAC
ECO67F14	POWELL RIVER	174	9/20/96	BTB,JKH-JCEAC
ECO67F14	POWELL RIVER	174	10/3/96	JCEAC
ECO67F14	POWELL RIVER	174	10/2/97	TAR,WDH-JCEAC
ECO67F14	POWELL RIVER	166	3/31/98	WDH,RLT-JCEAC
ECO67F14	POWELL RIVER	186	9/1/98	TAR,WDH-JCEAC
ECO67F14	POWELL RIVER	158	9/28/00	PAD,PDS-LAB
ECO67F16	HARDY CREEK	183	7/1/98	WDH,TAR-JCEAC
ECO67F16	HARDY CREEK	182	9/24/98	TAR,WDH-JCEAC
ECO67F16	HARDY CREEK	196	4/1/99	TAR,WDH-JCEAC
ECO67F17	BIG WAR CREEK	171	11/22/95	BTB,TAR-JCEAC
ECO67F17	BIG WAR CREEK	180	9/25/96	BTB,TAR-JCEAC
ECO67F17	BIG WAR CREEK	192	6/13/97	BTB,TAR-JCEAC
ECO67F17	BIG WAR CREEK	171	6/27/97	TAR-JCEAC
ECO67F17	BIG WAR CREEK	193	9/12/97	TAR,JEB-JCEAC
ECO67F17	BIG WAR CREEK	193	5/28/98	WDH,RCT-JCEAC
ECO67F17	BIG WAR CREEK	195	10/2/98	WDH,TAR-JCEAC
ECO67F17	BIG WAR CREEK	196	5/28/99	TAR,WDH-JCEAC
ECO67F23	MARTIN CREEK	168	7/1/98	TAR-JCEAC
ECO67F23	MARTIN CREEK	173	9/24/98	TAR,WDH-JCEAC
ECO67F23	MARTIN CREEK	175	4/1/99	TAR,WDH-JCEAC
ECO67G01	LITTLE CHUCKY CREEK	167	10/2/96	JCEAC
ECO67G01	LITTLE CHUCKY CREEK	159	5/12/97	TAR-JCEAC
ECO67G01	LITTLE CHUCKY CREEK	165	8/22/97	BTB-JCEAC
ECO67G01	LITTLE CHUCKY CREEK	154	5/14/98	WDH-JCEAC
ECO67G01	LITTLE CHUCKY CREEK	161	9/3/98	TAR,WDH-JCEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO67G01	LITTLE CHUCKY CREEK	158	5/25/99	TAR,CAB-JCEAC
ECO67G05	BENT CREEK	141	4/25/96	JEB-KEAC
ECO67G05	BENT CREEK	138	9/9/96	JEB,PES-KEAC
ECO67G05	BENT CREEK	154	5/22/97	JEB,AJM-KEAC
ECO67G05	BENT CREEK	151	9/23/97	JEB-KEAC
ECO67G08	BRYMER CREEK	150	5/21/97	TYH-CHEAC
ECO67G09	HARRIS CREEK	158	10/9/97	CLD-CHEAC
ECO67H04	BLACKBURN CREEK	136	4/10/96	CHEAC
ECO67H04	BLACKBURN CREEK	130	9/4/96	GDR
ECO67H04	BLACKBURN CREEK	143	2/6/97	GDR
ECO67H04	BLACKBURN CREEK	167	10/2/97	CLD,GDR-CHEAC
ECO67H06	LAUREL CREEK	171	4/10/96	KEAC
ECO67H06	LAUREL CREEK	169	9/11/96	JEB,PES-KEAC
ECO67H06	LAUREL CREEK	170	5/1/97	JEB,PES-KEAC
ECO67H06	LAUREL CREEK	166	9/29/97	APM,PDS-LAB
ECO67H08	PARKER BRANCH CREEK	152	9/12/96	APM,KJS-LAB
ECO67H08	PARKER BRANCH CREEK	169	10/3/96	JCEAC
ECO67H08	PARKER BRANCH CREEK	177	4/30/97	TAR-JCEAC
ECO67H08	PARKER BRANCH CREEK	180	10/9/97	TAR,WDH-JCEAC
ECO67I12	MILL CREEK	164	9/19/96	KEAC
ECO67I12	MILL CREEK	149	4/16/97	JEB,PES-KEAC
ECO67I12	MILL CREEK	152	9/22/97	PAD,KJS-LAB
ECO68A01	ROCK CREEK	178	4/17/96	KEAC
ECO68A01	ROCK CREEK	178	9/13/96	KEAC
ECO68A01	ROCK CREEK	180	5/7/97	JEB,AEW-KEAC
ECO68A01	ROCK CREEK	182	9/26/97	PES,AEW-KEAC
ECO68A01	ROCK CREEK	187	5/8/98	PES,AEW-KEAC
ECO68A01	ROCK CREEK	173	9/17/98	JEB,JCP-KEAC
ECO68A01	ROCK CREEK	181	4/12/99	PES,AJM-KEAC
ECO68A03	LAUREL FORK STATION CAMP	180	4/17/96	KEAC
ECO68A03	LAUREL FORK STATION CAMP	178	9/13/96	KEAC
ECO68A03	LAUREL FORK STATION CAMP	188	5/14/97	JEB,PES-KEAC
ECO68A03	LAUREL FORK STATION CAMP	192	9/26/97	PES,AEW-KEAC
ECO68A03	LAUREL FORK STATION CAMP	185	5/18/98	JEB,KMJ-KEAC
ECO68A03	LAUREL FORK STATION CAMP	156	9/17/98	JEB,JCP-KEAC
ECO68A03	LAUREL FORK STATION CAMP	191	4/12/99	PES,AJM-KEAC
ECO68A08	CLEAR CREEK	179	4/17/96	KEAC
ECO68A08	CLEAR CREEK	175	9/12/96	KEAC
ECO68A08	CLEAR CREEK	177	6/26/97	JEB-KEAC
ECO68A08	CLEAR CREEK	163	9/22/97	JEB,PES-KEAC
ECO68A08	CLEAR CREEK	183	5/22/98	JEB,SLD-KEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO68A08	CLEAR CREEK	181	9/2/98	JEB,KMJ-KEAC
ECO68A08	CLEAR CREEK	190	4/26/99	PES,AEW-KEAC
ECO68A13	PINEY RIVER	158	5/3/99	DRL,PAD-LAB
ECO68A20	MULLENS CREEK	176	4/15/96	CHEAC
ECO68A20	MULLENS CREEK	170	9/11/96	GDR-CHEAC
ECO68A20	MULLENS CREEK	189	5/27/97	GDR-CHEAC
ECO68A20	MULLENS CREEK	158	9/30/97	GDR-CHEAC
ECO68A20	MULLENS CREEK	184	5/4/98	GDR-CHEAC
ECO68A20	MULLENS CREEK	179	4/26/99	JCA,APM-LAB
ECO68A26	DADDY'S CREEK	179	9/5/97	JEB,PES-KEAC
ECO68A26	DADDY'S CREEK	191	5/22/98	JEB,SLD-KEAC
ECO68A26	DADDY'S CREEK	182	9/2/98	JEB,KMJ-KEAC
ECO68A26	DADDY'S CREEK	194	4/26/99	PES,AEW-KEAC
ECO68A27	ISLAND CREEK	187	3/30/98	JEB,KMJ-KEAC
ECO68A27	ISLAND CREEK	139	9/2/98	JEB,KMJ-KEAC
ECO68A27	ISLAND CREEK	182	4/26/99	PES,AEW-KEAC
ECO68A28	ROCK CREEK	194	3/30/98	JEB,KMJ-KEAC
ECO68A28	ROCK CREEK	149	9/16/98	JEB,KMJ-KEAC
ECO68A28	ROCK CREEK	188	5/3/99	JEB,AWB-KEAC
ECO68B01	CRYSTAL CREEK	130	4/16/96	CHEAC
ECO68B01	CRYSTAL CREEK	165	5/7/97	GDR-CHEAC
ECO68B01	CRYSTAL CREEK	150	5/6/98	GDR-CHEAC
ECO68B01	CRYSTAL CREEK	166	5/3/99	DRL,PAD-LAB
ECO68B02	MCWILLIAMS CREEK	131	4/16/96	CHEAC
ECO68B02	MCWILLIAMS CREEK	110	9/4/96	CHEAC
ECO68B02	MCWILLIAMS CREEK	155	5/19/97	GDR-CHEAC
ECO68B02	MCWILLIAMS CREEK	153	5/12/98	GDR-CHEAC
ECO68B02	MCWILLIAMS CREEK	149	5/3/99	DRL,PAD-LAB
ECO68B09	MILL CREEK	151	9/19/96	GDR-CHEAC
ECO68B09	MILL CREEK	140	4/16/97	GDR-CHEAC
ECO68B09	MILL CREEK	143	9/23/97	CLD-CHEAC
ECO68B09	MILL CREEK	163	5/5/98	GDR-CHEAC
ECO68B09	MILL CREEK	96	9/8/98	DRL,DHA-LAB
ECO68B09	MILL CREEK	143	5/3/99	DRL,PAD-LAB
ECO68C12	ELLIS GAP	155	4/29/96	CHEAC
ECO68C12	ELLIS GAP	170	6/3/97	TYH-CHEAC
ECO68C13	MUD CREEK	159	5/1/96	LAB
ECO68C13	MUD CREEK	161	8/22/96	APM,PAD-LAB
ECO68C13	MUD CREEK	171	4/16/97	DRM,APM-LAB
ECO68C13	MUD CREEK	155	9/3/97	DRM-LAB
ECO68C13	MUD CREEK	169	11/12/97	APM,KJS-LAB

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO68C13	MUD CREEK	172	2/10/98	APM,DRL-LAB
ECO68C15	CROW CREEK	171	5/6/96	LAB
ECO68C15	CROW CREEK	165	8/22/96	PAD,APM-LAB
ECO68C15	CROW CREEK	159	9/6/96	APM,DHA-LAB
ECO68C15	CROW CREEK	167	4/16/97	DRM-LAB
ECO68C15	CROW CREEK	153	9/3/97	DRM-LAB
ECO68C15	CROW CREEK	167	11/12/97	APM,KJS-LAB
ECO68C15	CROW CREEK	167	2/10/98	APM,DRL-LAB
ECO68C15	CROW CREEK	159	4/14/98	APM,JCA-LAB
ECO68C15	CROW CREEK	161	8/31/98	APM,LAH-LAB
ECO68C15	CROW CREEK	182	4/28/99	APM,JCA-LAB
ECO68C20	CROW CREEK	174	4/14/98	APM,JCA-LAB
ECO68C20	CROW CREEK	164	8/31/98	APM,LAH-LAB
ECO68C20	CROW CREEK	182	4/28/99	APM,JCA-LAB
ECO69D01	NO BUSINESS BRANCH	186	4/29/96	JEB-KEAC
ECO69D01	NO BUSINESS BRANCH	172	9/10/96	JEB,PES-KEAC
ECO69D01	NO BUSINESS BRANCH	176	4/25/97	JEB,PES-KEAC
ECO69D01	NO BUSINESS BRANCH	176	10/3/97	JEB-KEAC
ECO69D01	NO BUSINESS BRANCH	187	4/2/98	JEB,JCP-KEAC
ECO69D01	NO BUSINESS BRANCH	170	9/1/98	JEB,JCP-KEAC
ECO69D01	NO BUSINESS BRANCH	185	4/9/99	JEB,JCP-KEAC
ECO69D03	FLAT FORK	186	4/29/96	KEAC
ECO69D03	FLAT FORK	177	9/12/96	KEAC
ECO69D03	FLAT FORK	176	4/17/97	PES-KEAC
ECO69D03	FLAT FORK	189	3/30/98	JEB,KMJ-KEAC
ECO69D03	FLAT FORK	130	9/2/98	JEB,KMJ-KEAC
ECO69D03	FLAT FORK	182	4/30/99	PES,MJA,KEAC
ECO69D04	STINKING CREEK	167	4/29/96	KEAC
ECO69D04	STINKING CREEK	163	9/10/96	JEB,PES-KEAC
ECO69D04	STINKING CREEK	171	5/16/97	JEB,PES-KEAC
ECO69D04	STINKING CREEK	172	10/3/97	JEB-KEAC
ECO69D04	STINKING CREEK	176	4/2/98	JEB,JCP-KEAC
ECO69D04	STINKING CREEK	168	9/1/98	JEB,JCA-KEAC
ECO69D04	STINKING CREEK	183	4/9/99	JEB,JCP-KEAC
ECO69D05	NEW RIVER	183	4/6/98	JEB,AEW-KEAC
ECO69D05	NEW RIVER	145	9/16/98	JEB,KMJ-KEAC
ECO69D05	NEW RIVER	183	4/30/99	PES,MJA-KEAC
ECO69D06	ROUND ROCK CREEK	180	4/6/98	JEB,AEW-KEAC
ECO69D06	ROUND ROCK CREEK	172	9/16/98	JEB,KMJ-KEAC
ECO69D06	ROUND ROCK CREEK	181	4/9/99	JEB,JCP-KEAC
ECO71E09	BUZZARD CREEK	164	7/8/96	DLH,RWK-NEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO71E09	BUZZARD CREEK	150	8/19/96	AMG,AMM-NEAC
ECO71E09	BUZZARD CREEK	140	10/1/96	AMG,AMM-NEAC
ECO71E09	BUZZARD CREEK	142	5/19/97	JRS,AMG-NEAC
ECO71E09	BUZZARD CREEK	135	10/16/97	JRS-NEAC
ECO71E09	BUZZARD CREEK	161	5/12/98	RWK,JRS-NEAC
ECO71E09	BUZZARD CREEK	145	8/26/98	RWK-NEAC
ECO71E09	BUZZARD CREEK	155	5/4/99	RWK-NEAC
ECO71E09	BUZZARD CREEK	138	11/27/00	NEAC
ECO71E09	BUZZARD CREEK	155	5/3/01	NEAC
ECO71E14	PASSENGER CREEK	155	6/6/97	RWK-NEAC
ECO71E14	PASSENGER CREEK	143	9/4/97	JRS,AMG-NEAC
ECO71E14	PASSENGER CREEK	154	5/12/98	RWK,JRS-NEAC
ECO71E14	PASSENGER CREEK	162	8/26/98	RWK-NEAC
ECO71E14	PASSENGER CREEK	159	5/4/99	RWK-NEAC
ECO71E14	PASSENGER CREEK	142	11/27/00	NEAC
ECO71E14	PASSENGER CREEK	142	5/3/01	NEAC
ECO71F12	SOUTH HARPETH RIVER	158	6/18/95	DLH,JRS-NEAC
ECO71F12	SOUTH HARPETH RIVER	157	8/28/96	PDS-LAB
ECO71F12	SOUTH HARPETH RIVER	150	9/25/96	JRS,AMG-NEAC
ECO71F12	SOUTH HARPETH RIVER	135	4/22/97	AMG,AMM-NEAC
ECO71F12	SOUTH HARPETH RIVER	159	4/22/98	AMG-NEAC
ECO71F12	SOUTH HARPETH RIVER	165	9/9/98	RWK,JRS-NEAC
ECO71F12	SOUTH HARPETH RIVER	154	11/9/98	AMG,JRS-NEAC
ECO71F12	SOUTH HARPETH RIVER	167	5/10/99	JRS,RWK-NEAC
ECO71F16	WOLF CREEK	169	5/29/98	TCW,JRS-NEAC
ECO71F16	WOLF CREEK	165	9/9/98	RWK,JRS-NEAC
ECO71F16	WOLF CREEK	145	11/9/98	JRS,AMG-NEAC
ECO71F16	WOLF CREEK	166	5/10/99	JRS,RWK-NEAC
ECO71F16	WOLF CREEK	142	5/2/00	NEAC
ECO71F19	BRUSH CREEK	173	7/15/96	DLH,RWK-NEAC
ECO71F19	BRUSH CREEK	144	8/28/96	AMG-NEAC
ECO71F19	BRUSH CREEK	176	10/4/96	AMM-NEAC
ECO71F19	BRUSH CREEK	147	5/14/97	JRS,AMG-NEAC
ECO71F19	BRUSH CREEK	163	9/3/97	RWK-NEAC
ECO71F19	BRUSH CREEK	163	5/11/98	RWK,JRS-NEAC
ECO71F19	BRUSH CREEK	166	9/21/98	JRS-NEAC
ECO71F19	BRUSH CREEK	171	6/7/99	JRS,AMG-NEAC
ECO71F19	BRUSH CREEK	168	8/24/99	NEAC
ECO71F19	BRUSH CREEK	156	6/5/00	NEAC
ECO71F27	SWANEGAN BRANCH	159	7/11/96	DLH,RWK-NEAC
ECO71F27	SWANEGAN BRANCH	161	8/28/96	AMG-NEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO71F27	SWANEGAN BRANCH	177	10/7/96	AMG,AMM-NEAC
ECO71F27	SWANEGAN BRANCH	164	4/21/97	JRS-NEAC
ECO71F27	SWANEGAN BRANCH	149	9/11/97	JRS,AMG-NEAC
ECO71F27	SWANEGAN BRANCH	165	5/5/98	RWK,JTK-NEAC
ECO71F27	SWANEGAN BRANCH	167	9/21/98	JRS-NEAC
ECO71F27	SWANEGAN BRANCH	169	6/7/99	JRS,AMG-NEAC
ECO71F28	LITTLE SWAN CREEK	172	6/27/96	DLH,JRS-NEAC
ECO71F28	LITTLE SWAN CREEK	164	8/28/96	AMG-NEAC
ECO71F28	LITTLE SWAN CREEK	178	10/4/96	RWK-NEAC
ECO71F28	LITTLE SWAN CREEK	158	5/14/97	RWK,WCO-NEAC
ECO71F28	LITTLE SWAN CREEK	165	9/3/97	RWK-NEAC
ECO71F28	LITTLE SWAN CREEK	168	5/5/98	RWK,JTR-NEAC
ECO71F28	LITTLE SWAN CREEK	153	9/21/98	JRS-NEAC
ECO71F28	LITTLE SWAN CREEK	162	6/7/99	JRS,AMG-NEAC
ECO71F28	LITTLE SWAN CREEK	169	8/24/99	NEAC
ECO71F28	LITTLE SWAN CREEK	152	6/5/00	NEAC
ECO71G03	FLAT CREEK	181	4/28/98	NEAC
ECO71G03	FLAT CREEK	172	9/14/98	JRS,AMG-NEAC
ECO71G03	FLAT CREEK	181	6/16/99	JRS,AMG-NEAC
ECO71G03	FLAT CREEK	173	5/8/01	JRS-NEAC
ECO71G04	SPRING CREEK	161	4/28/98	NEAC
ECO71G04	SPRING CREEK	152	9/14/98	JRS,AMG-NEAC
ECO71G04	SPRING CREEK	161	6/16/99	JRS,AMG-NEAC
ECO71G04	SPRING CREEK	148	5/8/01	JRS-NEAC
ECO71G10	HURRICANE CREEK	158	7/18/96	DLH,JRS-NEAC
ECO71G10	HURRICANE CREEK	179	9/4/96	AMG-NEAC
ECO71G10	HURRICANE CREEK	164	9/30/96	AMG,MLR-NEAC
ECO71G10	HURRICANE CREEK	165	5/1/97	AMG-NEAC
ECO71G10	HURRICANE CREEK	163	10/10/97	RWK-NEAC
ECO71G10	HURRICANE CREEK	170	4/23/98	AMG-NEAC
ECO71G10	HURRICANE CREEK	157	9/8/98	JRS,AMG-NEAC
ECO71G10	HURRICANE CREEK	158	6/8/99	JRS-NEAC
ECO71H03	FLYNN CREEK	165	7/17/96	DLH,RWK-NEAC
ECO71H03	FLYNN CREEK	159	8/27/96	APM,DRL-LAB
ECO71H03	FLYNN CREEK	157	10/14/96	JRS,AMG-NEAC
ECO71H03	FLYNN CREEK	170	5/6/97	AMG,RWK-NEAC
ECO71H03	FLYNN CREEK	170	8/20/97	RWK-NEAC
ECO71H03	FLYNN CREEK	165	5/4/98	JRS-NEAC
ECO71H03	FLYNN CREEK	165	9/17/98	AMG-NEAC
ECO71H03	FLYNN CREEK	156	6/2/99	JRS,RLH-NEAC
ECO71H03	FLYNN CREEK	150	5/8/01	JRS-NEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO71H06	CLEAR FORK	165	7/10/96	RWK,DLH-NEAC
ECO71H06	CLEAR FORK	170	8/19/96	RWK,MCR-NEAC
ECO71H06	CLEAR FORK	141	10/16/96	TCW-NEAC
ECO71H06	CLEAR FORK	172	11/12/96	RWK,AER-NEAC
ECO71H06	CLEAR FORK	157	8/21/97	AMG,JRS-NEAC
ECO71H06	CLEAR FORK	153	4/13/98	JRS-NEAC
ECO71H06	CLEAR FORK	144	8/31/98	AMG-NEAC
ECO71H06	CLEAR FORK	149	6/11/99	RWK-NEAC
ECO71H09	CARSON FORK	141	7/10/96	DLH-NEAC
ECO71H09	CARSON FORK	157	8/19/96	MLR,RWK-NEAC
ECO71H09	CARSON FORK	155	9/19/96	MLR,RWK-NEAC
ECO71H09	CARSON FORK	126	10/16/96	TCW-NEAC
ECO71H09	CARSON FORK	151	11/12/96	RWK,AER-NEAC
ECO71H09	CARSON FORK	164	4/30/97	RWK-NEAC
ECO71H09	CARSON FORK	139	8/19/97	RWK-NEAC
ECO71H09	CARSON FORK	135	4/13/98	NEAC
ECO71H09	CARSON FORK	140	8/19/98	ARC
ECO71H09	CARSON FORK	125	8/31/98	AMG-NEAC
ECO71H09	CARSON FORK	140	6/11/99	RWK-NEAC
ECO71H09	CARSON FORK	140	8/19/99	NEAC
ECO71I03	STEWART CREEK	140	7/26/96	RWK,JRS-NEAC
ECO71I03	STEWART CREEK	129	9/4/96	DKW,KJS-LAB
ECO71I03	STEWART CREEK	134	9/5/96	DHA,KJS-LAB
ECO71I03	STEWART CREEK	119	9/26/96	AMG,JRS-NEAC
ECO71I03	STEWART CREEK	139	4/23/97	AMG,AMM-NEAC
ECO71I03	STEWART CREEK	127	10/1/97	AMG-NEAC
ECO71I09	WEST FORK STONES RIVER	121	7/18/96	NEAC
ECO71I09	WEST FORK STONES RIVER	131	9/4/96	DKW,KJS-NEAC
ECO71I09	WEST FORK STONES RIVER	124	10/8/96	AMM,AMG-NEAC
ECO71I09	WEST FORK STONES RIVER	130	4/23/97	AMG-NEAC
ECO71I09	WEST FORK STONES RIVER	114	10/1/97	AMG-NEAC
ECO71I09	WEST FORK STONES RIVER	125	5/19/98	RWK,JRS-NEAC
ECO71I09	WEST FORK STONES RIVER	143	9/1/98	RWK-NEAC
ECO71I09	WEST FORK STONES RIVER	117	6/3/99	RWK-NEAC
ECO71I09	WEST FORK STONES RIVER	169	1/11/00	DRL-LAB
ECO71I09	WEST FORK STONES RIVER	148	4/19/00	DRL,PDS-LAB
ECO71I10	FLAT CREEK	135	7/18/96	DLH,JRS-NEAC
ECO71I10	FLAT CREEK	131	9/4/96	AMG-NEAC
ECO71I10	FLAT CREEK	98	10/15/96	NEAC
ECO71I10	FLAT CREEK	165	5/1/97	RWK-NEAC
ECO71I10	FLAT CREEK	128	10/9/97	RWK,JRS-NEAC

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO71I10	FLAT CREEK	154	5/19/98	JRS,RWK-NEAC
ECO71I10	FLAT CREEK	113	6/8/99	JRS,RWK-NEAC
ECO71I10	FLAT CREEK	128	1/25/00	JCA,DHA-LAB
ECO71I10	FLAT CREEK	159	4/12/00	JCA,JKW-LAB
ECO71I12	CEDAR CREEK	162	1/3/00	KJS,DHA-LAB
ECO71I12	CEDAR CREEK	142	4/19/00	PAD-LAB
ECO71I12	CEDAR CREEK	135	7/19/00	KJS-LAB
ECO71I12	CEDAR CREEK	135	11/1/00	KJS,BGL-LAB
ECO71I12	CEDAR CREEK	157	5/7/01	JRS-NEAC
ECO71I13	FALL CREEK	104	1/6/00	DHA-LAB
ECO71I13	FALL CREEK	110	5/1/00	KJS,DRL-LAB
ECO71I13	FALL CREEK	126	7/20/00	KJS,PDS-LAB
ECO71I13	FALL CREEK	139	10/31/00	KJS,JRS-LAB
ECO71I13	FALL CREEK	119	5/7/01	JRS-NEAC
ECO71I14	LITTLE FLAT CREEK	131	1/25/00	JCA,DHA-LAB
ECO71I14	LITTLE FLAT CREEK	141	4/11/00	JCA-LAB
ECO71I14	LITTLE FLAT CREEK	103	5/9/01	JRS-LAB
ECO71I15	HARPETH RIVER	130	1/24/00	JCA,DHA-LAB
ECO71I15	HARPETH RIVER	148	5/3/00	JCA,DRL-LAB
ECO71I15	HARPETH RIVER	108	7/13/00	JCA,PAD-LAB
ECO71I15	HARPETH RIVER	100	10/31/00	PAD,DRL-LAB
ECO71I15	HARPETH RIVER	125	5/9/01	JRS-LAB
ECO73A01	COLD CREEK	130	5/2/96	RBM,LEH-MEAC
ECO73A01	COLD CREEK	125	8/15/96	DHA,KJS-LAB
ECO73A01	COLD CREEK	105	4/21/97	APM-KJS,LAB
ECO73A01	COLD CREEK	98	8/26/97	PAD,KJS-LAB
ECO73A02	MIDDLE FORK FORKED DEER R	118	4/24/97	APM,KJS-LAB
ECO73A02	MIDDLE FORK FORKED DEER R	96	8/27/97	PAD,KJS-LAB
ECO73A02	MIDDLE FORK FORKED DEER R	114	5/27/98	KJS,PDS-LAB
ECO73A02	MIDDLE FORK FORKED DEER R	110	8/25/98	KJS,DRL-LAB
ECO73A02	MIDDLE FORK FORKED DEER R	122	4/21/99	KJS,PAD-LAB
ECO73A03	COLD CREEK	128	4/24/97	APM,KJS-LAB
ECO73A03	COLD CREEK	130	8/26/97	PAD,KJS-LAB
ECO73A03	COLD CREEK	122	5/26/98	KJS,PDS-LAB
ECO73A03	COLD CREEK	147	8/25/98	KJS,DRL-LAB
ECO73A03	COLD CREEK	126	4/20/99	KJS,PAD-LAB
ECO73A04	BAYOU DU CHIEN	154	5/28/98	KJS,PDS-LAB
ECO73A04	BAYOU DU CHIEN	161	8/19/98	APM,JCA-LAB
ECO73A04	BAYOU DU CHIEN	154	4/21/99	KJS,PAD-LAB
ECO74A06	SUGAR CREEK	142	4/16/96	LEH,RBM-MEAC
ECO74A06	SUGAR CREEK	99	8/14/96	DHA,KJS-LAB

StationID	StreamName	Habitat Score	Collection Date	Field Assessors
ECO74A06	SUGAR CREEK	113	4/22/97	KJS,APM-LAB
ECO74A06	SUGAR CREEK	118	8/25/97	PAD,KJS-LAB
ECO74A06	SUGAR CREEK	112	4/27/98	KJS,PDS-LAB
ECO74A06	SUGAR CREEK	119	8/24/98	KJS,DRL-LAB
ECO74A06	SUGAR CREEK	103	4/19/99	KJS,PAD-LAB
ECO74A08	PAW PAW CREEK	143	9/19/96	AJF,RDO-JEAC
ECO74A08	PAW PAW CREEK	114	4/22/97	AJF-JEAC
ECO74A08	PAW PAW CREEK	130	8/7/97	AJF,JBC-JEAC
ECO74A08	PAW PAW CREEK	110	4/21/98	APM,DRL-LAB
ECO74A08	PAW PAW CREEK	129	8/18/98	APM,JCA-LAB
ECO74A08	PAW PAW CREEK	124	4/13/99	APM,JCA-LAB
ECO74B01	TERRAPIN CREEK	143	9/11/96	AJF,MBM-JEAC
ECO74B01	TERRAPIN CREEK	137	5/6/97	GSO-JEAC
ECO74B01	TERRAPIN CREEK	149	8/20/97	AJF-JEAC
ECO74B01	TERRAPIN CREEK	127	4/20/98	APM,DRL-LAB
ECO74B01	TERRAPIN CREEK	130	4/20/98	APM,DRL-LAB
ECO74B01	TERRAPIN CREEK	139	8/20/98	APM,JCA-LAB
ECO74B01	TERRAPIN CREEK	146	4/14/99	APM,JCA-LAB
ECO74B04	POWELL CREEK	129	9/11/96	AJF,MBW-LAB
ECO74B04	POWELL CREEK	127	5/6/97	GSO-JEAC
ECO74B04	POWELL CREEK	125	8/20/97	AJF-JEAC
ECO74B04	POWELL CREEK	112	4/20/98	APM,DRL-LAB
ECO74B04	POWELL CREEK	116	4/20/98	APM,DRL-LAB
ECO74B04	POWELL CREEK	119	8/19/98	APM,JCA-LAB
ECO74B04	POWELL CREEK	131	8/19/98	APM,JCA-LAB
ECO74B04	POWELL CREEK	129	4/14/99	APM,JCA-LAB
ECO74B12	WOLF RIVER	156	5/16/96	RBM,LEH-MEAC
ECO74B12	WOLF RIVER	140	8/13/96	DHA,KJS-LAB
ECO74B12	WOLF RIVER	128	4/27/97	APM,KJS-LAB
ECO74B12	WOLF RIVER	140	8/25/97	DHA,KJS-LAB
ECO74B12	WOLF RIVER	133	4/27/98	KJS,JCA-LAB
ECO74B12	WOLF RIVER	149	8/24/98	KJS,DRL-LAB
ECO74B12	WOLF RIVER	131	4/19/99	KJS,PAD-LAB

APPENDIX B

HABITAT ASSESSMENT FORMS

HABITAT ASSESSMENT DATA SHEET- HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #_______________ RIVER MILE______	STREAM CLASS	
LAT_____________________ LONG___________	RIVER BASIN	
STORET#	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE_______ TIME_______ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new-fall and not transient)	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the from of new-fall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; availability less than desirable; substrate frequently disturbed or removed	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 76% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow) (Slow is<0.3m/s deep is >0.5m)	Only 3 of the 4 regimes present (if fast-shallow is missing score lower than regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low)	Dominated by 1 velocity/depth regime (usually slow-deep)
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low –gradient streams) of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills> 75% of the available channel; or 25 % of channel substrate is exposed.	Waters fills 25-75 % of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT DATA SHEET- HIGH GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures, present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5-7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >35.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank) **Note: determine left or right side by facing downstream.**	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60 % of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded area; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protective (score each bank) **Note: determine left or right side by facing downstream**	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns or crops) have not impacted zone	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

TOTAL SCORE ________________

Adapted from Appendix A-1 Habitat Assessment and Physiochemical Characterization Field Data Sheets – Form, EPA 841-B-99-002

HABITAT ASSESSMENT DATA SHEET- LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________________ RIVER MILE_______	STREAM CLASS	
LAT______________________ LONG____________	RIVER BASIN	
STORET#	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE________ TIME________ AM PM	REASON FOR SURVEY

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient)	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the from of new-fall, but not yet prepared for colonization (may rate at high end of scale)	10-30% mix of stable habitat; availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation present.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Pool Variabilitly	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low – gradient streams) of the bottom affected by sediment deposition	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills> 75% of the available channel; or 25 % of channel substrate is exposed.	Waters fills 25-75 % of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

HABITAT ASSESSMENT DATA SHEET- LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present	Channelization may be extensive; embankments or shoring structures, present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Channel Sinuosity	The bends in the stream increase the stream length 3-4 times longer than if it was in a straight line. (Note – channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2-3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank) **Note: determine left or right side by facing downstream.**	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60 % of bank in reach has areas of erosion; high erosion potential during floods	Unstable; many eroded area; “raw” areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protective (score each bank) **Note: determine left or right side by facing downstream.**	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e. parking lots, roadbeds, clear-cuts, lawns or crops) have not impacted zone	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE____(LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE____(RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

TOTAL SCORE ________________

Adapted from Appendix A-1 Habitat Assessment and Physiochemical Characterization Field Data Sheets – Form, EPA 841-B-99-002

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To reach your local
ENVIRONMENTAL ASSISTANCE CENTER
Call 1-888-891-8332 OR 1-888-891-TDEC

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