PRIDE Water Quality Assessment Report: II. Chemical, Biological and Habitat Assessments

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For

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ABSTRACT

The efficient utilization of federal funds in improving the water quality and aquatic habitat of the region requires a mechanism for assessing and evaluating the impacts of the proposed and ongoing projects as well as some mechanism for prioritizing the allocation of additional funds. In order to evaluate the effectiveness of these projects it is important to provide a formal monitoring and assessment program based on sound scientific principles. This report provides an initial 10 year baseline assessment of the existing water quality conditions in the 40 county PRIDE region for the purpose of evaluating the impacts of the PRIDE programs in the region and the extent to which such programs are satisfying their stated objectives of cleaning up the region's rivers and streams. A general assessment of the associated environmental problems and programs in the region can be found in the companion reports: *PRIDE Water Quality Assessment Report I: Problems and Programs* while recommendations for additional monitoring station locations is provided in *PRIDE Water Quality Assessment Report III: Existing and Proposed Monitoring Network.*

Because of the spatial and cumulative impacts of multiple projects within a region, it is best that project impacts be evaluated on a composite or watershed basis. In using such an approach, it is important that an appropriate assessment scale be selected that maintains a balance between the ability to quantify the impacts of local projects and the ability to effectively monitor a larger number of sites. In consideration of both issues, the various projects within the PRIDE counties were evaluated both on a county basis and on an 8-digit watershed basis. In order to evaluate the water quality conditions in the PRIDE region, some type of assessment parameters are required. In general, such assessment parameters may be subdivided into chemical, biological, and habitat parameters. For this study, these parameters included measurements of pH, fecal coliform, macro-invertebrates, and general aquatic habitat.

A spatial analysis of the various pH sample locations within the region identified only a handful of sites in which the pH standard of 6 was violated. These sites tended to be concentrated McCreary, Whitley, and Pulaski counties and are reflected of the acid-bearing coal strata that lie in this area.

Unlike the pH readings, fecal coliform violations were much more spatially distributed across the region. Using an acute standard of 400c/ml, nearly all counties with any historical data show some standard violations. A simultaneous examination of both median and maximum values reveals that several counties continue to have severe pathogen problems. These include Floyd County, Harlan County, Johnson County, Letcher County, and Perry County. Other counties that have had less severe although significant problems include Bell, Breathitt, Garrard, Jessamine, and Lawrence Counties. Several counties have no historical fecal data and indicate areas where additional sampling is needed. These include: Casey, Clinton, Knott, Martin, Metcalfe, and Taylor counties. Because of the lack of and variability of the fecal data, it was hard to draw any definitive conclusions with regard to general trends. However, it does appear that general fecal levels are beginning to decrease in Bell, Harlan, Letcher, and Perry counties. An evaluation of the fecal data on a watershed basis revealed similar impacts.

As expected, the north Fork of the Kentucky River watershed and the Upper Cumberland watershed showed the most severe fecal impacts.

In an attempt to provide a historical baseline of stream habitat in the region, a statistical analyses of the Kentucky ERDAS habitat database was performed on both a county basis and a watershed basis. Generally speaking, habitat scores above 165 are indicative of good environmental conditions while scores below 135 are indicative of stressed conditions. Using these criteria and the median scores for each county, it was determined that most counties are in a fair to poor condition. General trends were difficult to determine given the sparsity of the data. However, where available, the data do tend to show a decrease in habitat scores over the last 10 years. Minimum habitat scores were obtained in Clay, Leslie, Magoffin, Menifee, Morgan, Perry, and Wolfe Counties. On a watershed basis, the most severely impacted habitats appear to be associated with the Kentucky River Basin and the Licking River Basin, however this observations may be biased on the basis of the increased biological sampling that has taken place in these two basins as part of the Kentucky Watershed Management Framework initiative.

In addition to a general habitat assessment Kentucky ERDAS database was also used to perform a macro-invertebrate assessment on both a county basis and a watershed. The macro-invertebrate data were much more comprehensive than the habitat data. Generally speaking, macro-invertebrate scores below 4 are indicative of good environmental conditions while scores above 7 are indicative of stressed conditions. Using these criteria and the median scores for each county, it was found that most counties are in a fair condition. This is also true for most of the watersheds as well. General trends are difficult to determine given the scarcity and variability of the data. In general, no overall trends were observed across the region.

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1.0 INTRODUCTION

The PRIDE (Personal Responsibility in a Desirable Environment) initiative was first announced by U.S. Congressman Harold "Hal" Rogers and Natural Resources and Environmental Protection Cabinet Secretary James Bickford in 1997. PRIDE is the first comprehensive, region-wide, local/state/federal cooperative effort designed to address the serious challenge of cleaning up the region's rivers and streams. The initiative is focusing on 40 separate counties located in the southeastern part of Kentucky that form the headwaters for the Big Sandy, Licking, Kentucky, Green and Cumberland river basins. Also included in the region are small segments of the Salt and Little Sandy river basins (see Figure 1.1). Since it's formation in 1997, PRIDE has been responsible for the funding of numerous projects in the 40 PRIDE counties, many of which focus on the elimination of straight pipes and the upgrading of wastewater treatment plants. Since 1997, PRIDE and PRIDE-related projects have received almost $70,000,000 in federal funding and the PRIDE program itself has received $26,000,000 in funding through the U.S. Department of Commerce and the National Oceanic and Atmospheric Administration in support of the continuing aquatic resources environmental initiative. These funds have been used to support various initiatives including: 1) the PRIDE community grant program, 2) the PRIDE environmental education grant program, and 3) the PRIDE septic system loan program. In addition to the $26,000,000 in direct funds to PRIDE, additional PRIDE-related projects have been funding by the U.S. Army Corps of Engineers (COE) and the U.S. Environmental Protection Agency (EPA).

The efficient utilization of federal funds in improving the water quality and aquatic habitat of the region requires a mechanism for assessing and evaluating the impacts of the proposed and ongoing projects as well as some mechanism for prioritizing the allocation of additional funds. In order to evaluate the effectiveness of these projects it is important to provide a formal monitoring and assessment program based on sound scientific principles. This report provides an initial 10 year baseline assessment of the existing water quality conditions in the 40 county PRIDE region for the purpose of evaluating the impacts of the PRIDE programs in the region and the extent to which such programs are satisfying their stated objectives of cleaning up the region's rivers and streams.

1.1 Physiographic Regions

The PRIDE region contains six major physiographic regions: the Eastern Coal Field, the Eastern Pennyroyal, the Inner Bluegrass, the Knobs, the Outer Blue Grass, and the Western (see Figure 1.2). Each of these regions is topographically distinct and reflects the underlying geology (see Figure 1.3). The oldest exposed rocks are limestone of Ordovician age. They contain a few layers of shale and siltstone and form the surface of the Bluegrass Region. The Devonian and Silurian rocks are exposed in the Knobs surrounding the Bluegrass Region which provide a transition to the Mountain Region in the southeast and the Pennyroyal region to the south and southwest. Surface rocks in the

Pennyroyal are of Mississippian age, mainly limestone but with some shales, siltstone, and sandstones. Pennsylvanian rocks are found at the surface in the Eastern Kentucky Coal Field which roughly corresponds to the Mountain Region. Pennyslyvanian rocks, consist mainly of sandstones, conglomerates, shale, and coal.

Soils in the region are largely influenced by the underlying geology and the associated physiographic regions. Almost all soils in Kentucky, with the exception of stream deposits, have developed under forest cover and under essentially the same climate. The various combinations of parent material, topography, and time of exposure may be expressed by dividing the region into 6 separate major soil association areas that roughly correspond to the same physiographic regions discussed earlier (see Figure 1.2). As can be seen from the figure, the dominant areas are the Eastern Pennyroyal and the Eastern Coal Fields. The Pennyroyal area is made up of the Waynesboror-Baxter-Gramon-Bedford soils series while the soils in the Eastern Coal Fields are made up of the Shelocta-Jefferson-Rarden-Weikert soil series. In general, the soils which make up the Licking and Big Sandy River basins are severely limited for the land application of wastewater.

1.2 Geographical Assessment Units

Because of the spatial and cumulative impacts of multiple projects within a region, it is best that project impacts be evaluated on a county or watershed basis. In using such an approach, it is important that an appropriate assessment scale be selected to maintain a balance between the ability to quantify the impacts of local projects and the ability to effectively monitor a larger number of sites. In consideration of both issues, the various projects within the PRIDE counties have been evaluated both on a county basis and on a watershed basis. In evaluating the projects on a watershed basis, the 8-digit HUC watersheds will be used as identified using the U.S. Geological Survey Hydrologic Unit Code (HUC) system. The HUC code is a multi-digit integer that is used to identify a particular watershed. A map of the various watershed assessment units that encompass the PRIDE region along with the associated county boundaries is shown in Figure 1.4.

In future years, additional refined assessments will be performed at the 11-digit HUC level. A map of the 11-digit HUC watersheds that encompass the PRIDE region is shown in Figure 1.5. It should be emphasized that use of the 11-digit watershed assessment scale is consistent with the Kentucky Watershed Management Framework Initiative, and will provide a strong synergism between the two programs. Previous and ongoing monitoring results from the Watershed Management Framework may be used to help support an assessment of the PRIDE projects. Use of a 11-digit HUC scale will provide the basis for the development of detailed watershed models that can be used to evaluate proposed and ongoing PRIDE projects more accurately as well as be used in the formulation of detailed watershed management plans as envisioned as part of the overall Watershed Management Framework Initiative.

1.3 Assessment Strategy

In using monitoring; physical, chemical, and bacteriological parameters of a watershed may be measured in an attempt to assess the existing baseline conditions of a stream or to assess or predict the impacts of subsequent remediation efforts or projects. As a result of the topography and terrain of eastern Kentucky, stream water quantity and quality can change dramatically over short periods of time. These changes can be due to weather effects (such as rapid changes in precipitation) or to human activities like water removals, water inputs, or intermittent pollutant inputs. As a result, it is best to monitor water quality and flow continuously. Unfortunately, implementation of a continuous water quality and flow monitoring program for the over 200 11-digit HUC watersheds within the PRIDE region would be cost-prohibitive. However, by using a general region-wide monitoring effort coupled with a detailed watershed monitoring and modeling effort, calibrated models of selected watersheds may be developed which can then be extrapolated to the remaining basins on the basis of similarity of topography, land use, soils, and the density of straight pipes and other pollutant sources. Such models can then be used to predict the impacts of aggregate projects and guide in the targeting of more detailed sampling efforts.

The impacts of the PRIDE projects will be evaluated using both a geo-political basis (i.e. by counties) as well as a geo-hydrologic basis (i.e. by watersheds). The watershed assessment will involve a two-tier approach: 1) an annual region-wide assessment at the 8-digit HUC level, and 2) a more targeted river watershed assessment at the 11 digit HUC level rotated through each major river basin in the region over a five year rotating cycle (see Table 1.1). This approach is consistent with the National EPA watershed management approach and will directly support the goals and objectives of that program.

1.4 Kentucky Water Quality Standards

Water quality impacts within the PRIDE region will be evaluated on the basis of compliance with the Kentucky Water Quality Standards. KRS 224.10-100 requires the Kentucky Natural Resources and Environmental Protection Cabinet to develop and conduct a comprehensive program for the management of water resources and to provide for the prevention, abatement, and control of water pollution. This administrative regulation and 401 KAR 5:002, 5:026, 5:029, and 5:030 establish procedures to protect the surface waters of the Commonwealth, and thus protect water resources. This administrative regulation establishes water quality standards which consist of designated legitimate uses of the surface waters of the Commonwealth and the associated water quality criteria necessary to protect those uses. These water quality standards are minimum requirements that apply to all surface waters in the Commonwealth of Kentucky in order to maintain and protect them for designated uses.

1.5 Kentucky Water Quality Criteria

Kentucky's Water Quality Criteria are based on the designated use of the stream. Both general and separate criteria and limits for various physiochemical constituents or indicators have been developed for the following general categories: 1) Aquatic Life (both warm water and cold water habitats), 2) Water Based Recreation (both primary and secondary contact), 3 Domestic Water Supply, and 4) Outstanding State Resource Waters. In addition to water quality criteria based on these designated use categories, the Regulations also provide criteria for protection against constituent contamination from fish consumption.

1.6 Designated Uses

Kentucky lists water bodies (i.e. rivers, streams, lakes) according to specific uses in its water quality standards regulations. These uses include Warm Water Aquatic Habitat (WWAH), Cold Water Aquatic Habitat (CWAH), Domestic Water Supply (DWS), Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR), and Outstanding Resource Waters (ORW). Those waters not specifically listed are classified (by default) for use as Warm water aquatic habitat, Primary and Secondary Contact Recreation, and Domestic Water Supply.

1.7 Kentucky 305(b) Report

Section 305(b) of the Federal Water Pollution Control Act of 1972 (P.L. 92-500), as subsequently amended and commonly known as the Clean Water Act, requires that states submit to the U.S. Environmental Protection Agency (EPA) on a biennial basis a report assessing current water quality conditions. The water quality assessment of rivers and streams is based on the support of designated uses in state waters depicted on U.S. Geological Survey (USGS) 1:100,000 scale topographic maps, excluding the Mississippi River.

In evaluating the extent to which the streams in the State are supporting their designated uses, Kentucky employs four assessment classes: 1) aquatic life (which focuses on warm water aquatic habitat), 2) fish consumption (which serves as a measure of compliance with the fish consumption criteria), 3) swimming (which represents the most restrictive of the primary and secondary contact recreation designated uses), and 4) drinking water. Different assessment methods are used to determine the use support for each class. In general, the assessment methods employ both physiochemical and biological data.

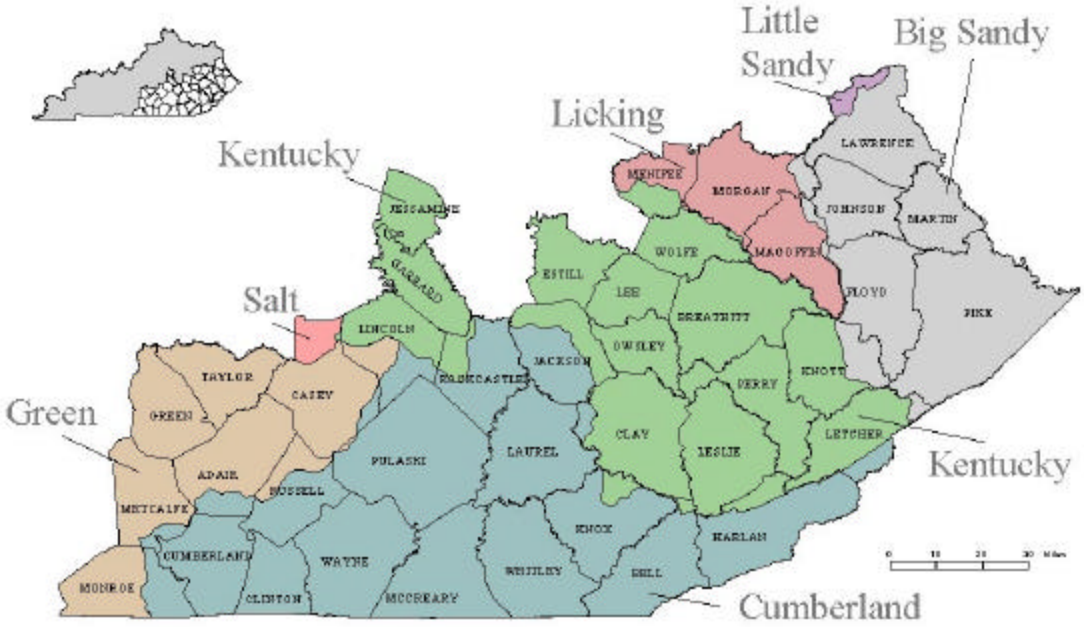

Figure 1.1 Counties and Major River Basins Located Within the PRIDE Region

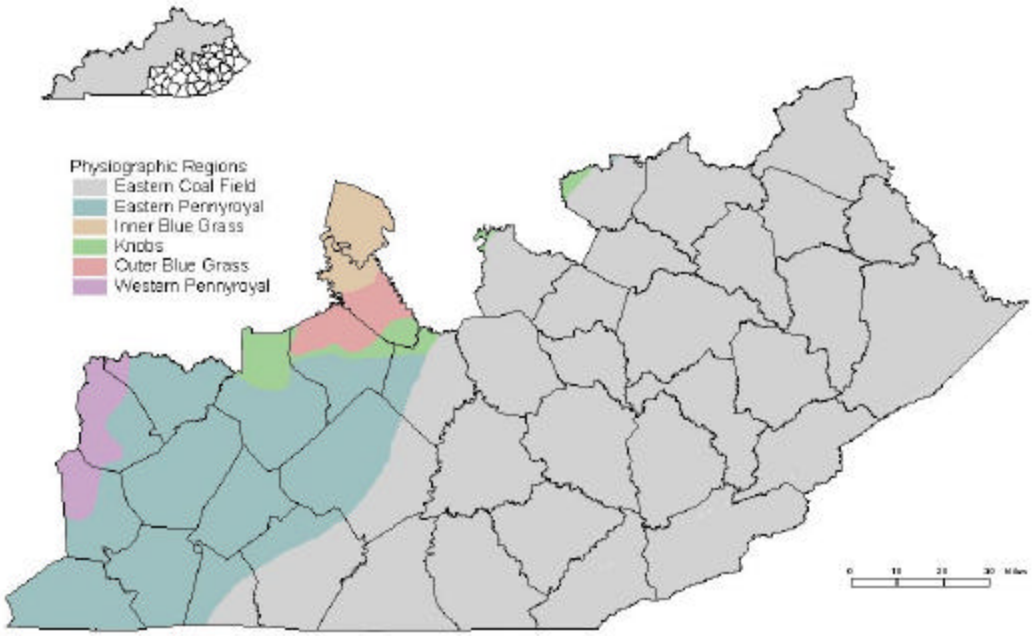

Figure 1.2 Physiographic Regions within the 40-County PRIDE area.

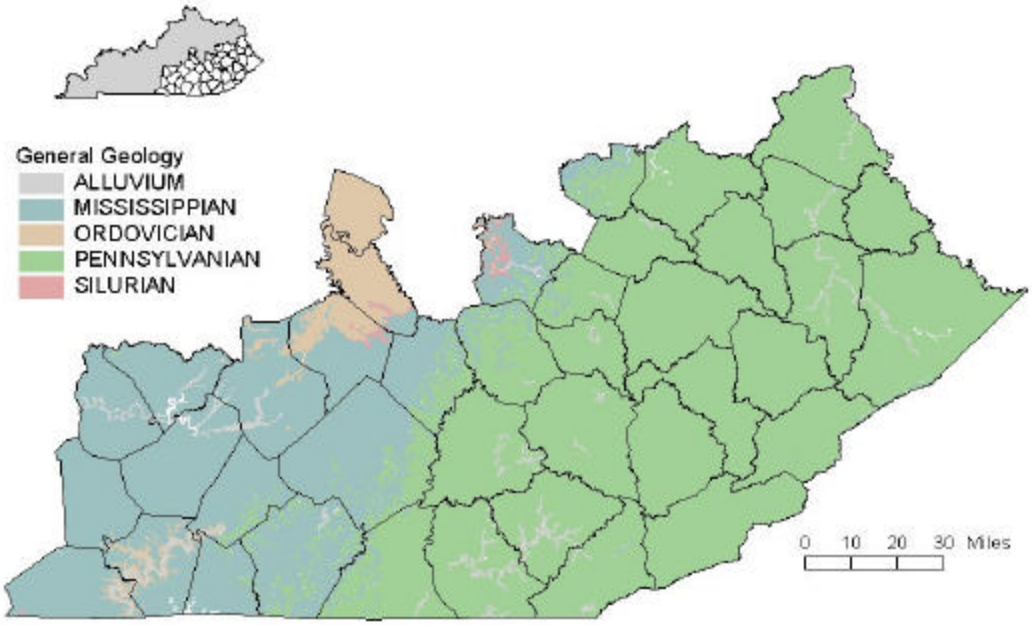

Figure 1.3 General Geologic Map of the PRIDE Region

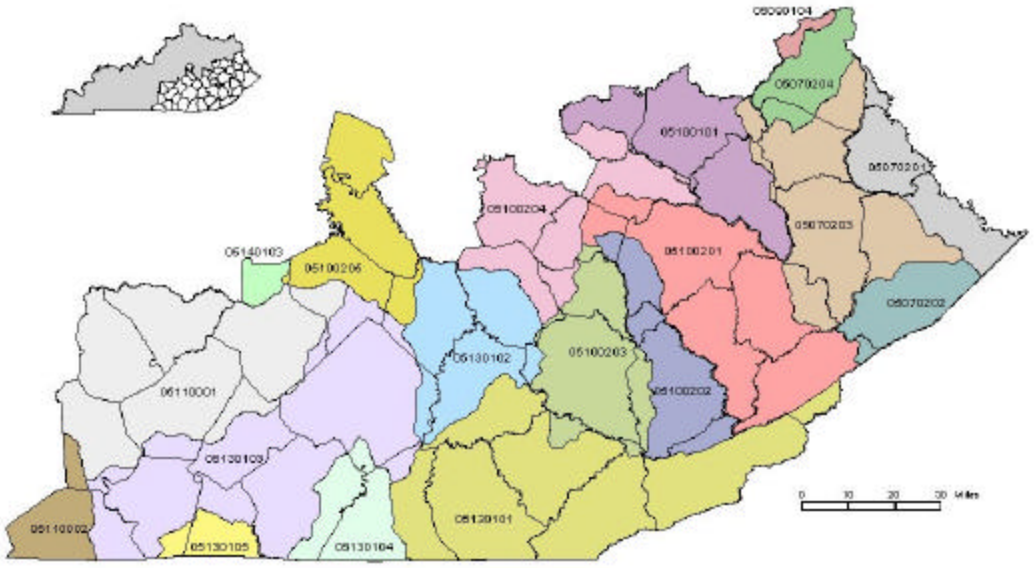

Figure 1.4 8-Digit Watersheds Located Within the PRIDE Region (with County Lines)

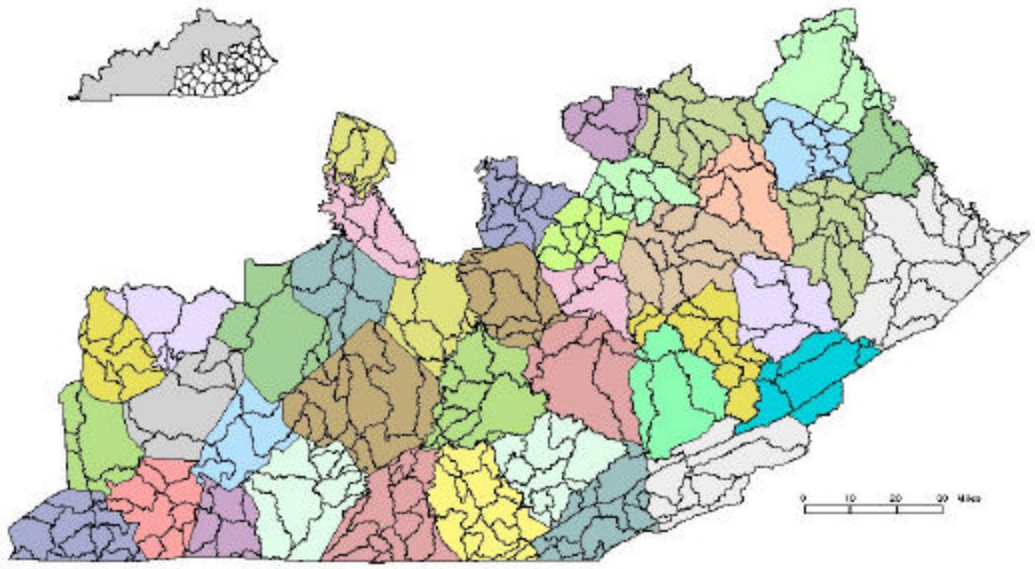

Figure 1.5 11-Digit Watersheds Within the PRIDE Region (with Counties in Color)

Figure 1.5 11-Digit Watersheds Within the PRIDE Region (with Counties in Color)

Based on a stream's designated use, the stream may be classified as 1) fully supporting, 2) partially supporting, or 3) not supporting. Overall use support of a particular stream is determined by following EPA guidelines that define fully supporting as fully supporting all uses for which data are available. If a segment supports one use but not another, it is listed as not supporting. For instance, if a segment supports a warm water aquatic habitat use but not a primary contact recreation use, it is listed as not supporting. A segment is listed as partially supporting if any assessed use falls into that category even if another use was fully supported. Many waterbodies are assessed for only one use because data were not available to assess other uses. Those streams within the PRIDE area that did not meet the criteria for one or more of their assessment classes (generally their designated use) in 1998 are shown in Figure 1.6. A summary of each of the assessment classes are discussed in the following sections.

1.7.1 Aquatic Life Use Support

Aquatic Life use support is evaluated using both water quality and biological data. The utilized data are categorized as either "monitored" or "evaluated." Monitored data are derived from site specific ambient surveys, targeted watershed sites, and a probabilistic macroinvertebrate network. Evaluated data are from other sources such as questionnaires to regional field personnel or from ambient surveys that were conducted more than five years ago. The criteria for assessing these data to determine use support are explained below. In areas where both chemical and biological data were available, the biological data were generally the determinant factor for establishing WAH use support status.

Physical and chemical parameters and criteria used by the Kentucky Division of Water to determine use support status are shown in Table 1.2. A stream is designated as

fully supporting the Aquatic Life use when criteria for dissolved oxygen, un-ionized ammonia, temperature, and pH were not met in 10 percent or less of the samples collected. Partial support is indicated if any one criterion for these parameters was not met 11-25 percent of the time. The segment is not supporting if any one of these criteria was not met more than 25 percent of the time. Data for mercury, cadmium, copper, lead, and zinc are analyzed for violations of acute criteria listed in state water quality standards using the 1998 monitoring data. The segment fully supports its use if all criteria are met at stations with quarterly or less frequent sampling or if only one violation occurs at stations with monthly sampling. Partial support is indicated if any one criterion is not met more than once but in less than 10 percent of the samples. A segment is not supporting if criteria are exceeded in greater than 10 percent of the samples. The assessment criteria are closely linked to the way state water quality criteria were developed. Aquatic life is considered to be protected if, on the average, the acute criteria are not exceeded more than once every three years.

1.7.2 Swimming Use Support

Fecal coliform and pH data are used to indicate the degree of support for Primary Contact Recreation (swimming) use. The swimming use is considered fully supported if the criterion in Table 1.2 is met in 90 percent or more of the measurements, partially supported if the criterion was met in 89-75 percent of the measurements, and not supported if the criterion was met less than 75 percent of the time. Streams with pH below 6.0 units were judged to not support swimming use.

1.7.3 Fish Consumption Use Support

Fish consumption is a category that, in conjunction with aquatic life use, assesses attainment of the fishable goal of the Clean Water Act. Assessment of the fishable goal was separated into these two categories in 1992 because a fish consumption advisory does not preclude attainment of the aquatic life use and vice versa. Separating fish consumption and aquatic life uses gives a clearer picture of actual water quality conditions. The following criteria are used to assess support for the fish consumption use:

* Fully Supporting: No fish advisories or bans in effect.

* Partially Supporting: “Restricted consumption” fish advisory or ban in effect for general population or a sub-population that could be at potentially greater risk (e.g., pregnant women, children). Restricted consumption is defined as limits on the number of meals consumed per unit time for one or more fish species.

* Not supporting: “No consumption” fish advisory or ban in effect for general population, or a sub-population that could potentially be at greater risk, for one or more fish species; commercial fishing ban in effect.

1.7.4. Drinking Water Use Support

For purposes of assessing drinking water use, federal EPA Phase II/Phase V finished water results are compared to established maximum contaminant levels (MCLs). Although not a quantitative measurement of ambient water quality, it highlights water in which certain pollutants are high enough to exceed drinking water criteria even after conventional treatment by the drinking water plant. Lacking in-stream data, EPA's 1998 305(b) report guidance recommends using the finished water data for assessing drinking water use. Because of the importance of this data, each individual watershed assessment summary includes a separate table that provides the locations of each water sources and water withdrawl point.

Figure 1.6. Streams in PRIDE Region Not Meeting their Designated Use

Table 1.1. Watershed Assessment Cycle

Watersheds	**Assessment Year**
Kentucky	2000-2001
Licking/Salt	2001-2002
Upper Cumberland	2002-2003
Green	2003-2004
Big/Little Sandy	2004-2005

Table 1.2. Physical and Chemical Parameters and Criteria Used to Determine Use Support Status At Fixed Stations

Parameter	Criterion [a]
Dissolved Oxygen	4.0 mg/l
Temperature	30^{o}C
pH	6 to 9 units
Un-ionized Ammonia-N	0.05 mg/1
Mercury	2.4 ug/1

Cadmium	$e^{(1.28 \ln x - 3.828)b}$
Copper	$e^{(.9422 \ln x - 1.464)b}$
Lead	$e^{(1.273 \ln x - 1.460)b}$
Zinc	$e^{(.8473 \ln x + .8604)b}$
Fecal Coliform Bacteria	400 colonies/100 ml (May 1 thru Oct 1)

[a] from Ky Water Quality Standards
[b] x = hardness in mg/1 as $CaCO_3$

Table 1.3. Miles of Streams Not Meeting Their Designated Use

COUNTY	MILES
ADAIR	0.00
BELL	68.06
BREATHITT	42.09
CASEY	0.00
CLAY	6.32
CLINTON	0.94
CUMBERLAND	0.00
ESTILL	4.33
FLOYD	101.88
GARRARD	30.56
GREEN	0.54
HARLAN	124.59
JACKSON	11.03
JESSAMINE	25.33
JOHNSON	26.79
KNOTT	54.37
KNOX	6.21
LAUREL	44.54
LAWRENCE	30.90
LEE	0.00
LESLIE	63.23
LETCHER	101.84
LINCOLN	3.96
MAGOFFIN	38.93

MARTIN	24.90
MCCREARY	57.31
MENIFEE	1.13
METCALFEE	0.00
MONROE	0.00
MORGAN	13.94
OWSLEY	2.02
PERRY	106.28
PIKE	93.05
PULASKI	7.93
ROCKCASTLE	16.86
RUSSELL	0.00
TAYLOR	4.10
WAYNE	0.00
WHITLEY	10.69
WOLFE	34.55

2.0 ENVIRONMENTAL ASSESSMENT

2.1 Assessment Parameters

In order to evaluate the water quality conditions in the PRIDE region, some type of assessment parameters are required. In general, such assessment parameters may be subdivided into chemical, biological, and habitat parameters. Each parameter is discussed in the following sections.

2.1.1 Chemical Parameters

The 1998 Kentucky 303(d) Report identified pH impairment as one of the most significant causes of stream impairment in the 40 county PRIDE area. As a result, baseline pH data were obtained for the entire 40 county PRIDE region. A map of the monitoring stations used in developing this assessment is shown in Figure 2.1. The state of Kentucky uses pH readings to assess whether a stream is meeting it's designated use for aquatic life and primary contact (i.e. swimming). Streams meeting these designated uses must have pH reading between 6 and 9. Since all streams in Kentucky not specifically listed are classified by default for use as aquatic life and primary contact, this parameter provides a basis for making a general assessment of the streams in the PRIDE region.

2.1.2 Habitat Assessment Parameters

The quality of the in-stream and riparian habitat influences the structure and function of the aquatic community in a stream. The presence of a degraded habitat can

sometimes obscure investigations on the effects of toxicity and/or pollution. The assessments performed by most water resource agencies and/or volunteer organizations like Kentucky Watershed Watch, include a general description of the site, a physical characterization and water quality assessment, and a visual assessment of in-stream and riparian habitat quality. Together, these data provide a comprehensive and integrated picture of the biological condition of a stream system. By taking habitat assessments at the same location over several years, a general trend can be developed about the increased impairment or restoration of a particular stream reach. A map of the habitat assessment sites used in developing this report is shown in Figure 2.2

Habitat assessments in Eastern Kentucky are conducted by the Kentucky Division of Water, the U.S. Fish and Wildlife Service, and the U.S. Forest Service using the Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (www.epa.gove/owow/monitoring/rbp/.) . This protocol is used to develop a composite habitat assessment score by summing individual assessment scores for ten separate categories. The individual assessment categories include: 1) epifaunal substrate and available cover, 2) embeddedness, 3) velocity and depth regime, 4) sediment deposition, 5) channel flow status, 6) channel alteration, 7) frequency of riffles or bends, 8) bank stability, 9) vegetative cover, and 10) riparian vegetative zone width. A single score is assigned to each assessment category on the following basis: Optimal [16-20], Suboptimal [11-15], Marginal [10-6], and Poor [0-5]. Scores for each assessment category are assigned using narrative assessment sheets that provide numerical correlations between the assessment scores and the narrative descriptions. The final composite habitat assessment score (CHS) can be used to assess the degree of designated use support using Table 2.1.

Table 2.1. Habitat Criteria for Assessment of Warmwater Aquatic Habitat (WAH) Use Support

Fully Supporting	Threatened	Partially Supporting	Not Supporting
CHS > 166	165 > CHS > 161	160 > CHS > 136	135 > CHS

2.1.3 Biological Parameters

Four major types of biological data are frequently used in making biological assessments. These include algae, fish, macroinvertebrates, and bacteria. Due to the relative ease in making such assessments and due to the greater data available across the region, macro-invertebrate and bacteriological data have been used as the primary biological assessment metrics for the PRIDE region. Each of these indicators are discussed below.

2.1.3.1 Macroinvertebrate Parameters.

Macroinvertebrate assemblages are good indicators of localized ecosystem conditions. Because many benthic macroinvertebrates have limited migration patterns or a sessile mode of life, they are particularly well-suited for assessing site-specific impacts

(upstream-downstream studies). Macroinvertebrates integrate the effects of short-term environmental variations. Most species have a complex life cycle of approximately one year or more. Sensitive life stages will respond quickly to stress; the overall community will respond more slowly.

Benthic macroinvertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects. Sampling is relatively easy, requires few people and inexpensive gear, and has minimal detrimental effect on the resident biota.

Degraded conditions can often be detected by an experienced biologist with only a cursory examination of the benthic macroinvertebrate assemblage. Macro-invertebrates are relatively easy to identify to family; many "intolerant" taxa can be identified to lower taxonomic levels with ease.

Macroinvertebrates may be collected from both artificial substrates and all available natural habitats. A macroinvertebrate bioassessment index (MBI) is generally calculated from several other indices, including, at a minimum: 1) taxa richness, 2) total number of individuals, 3) Hilsenhoff Biotic Index (HBI) and 4) percent Community Similarity Index. Additional metrics can also be used depending on factors such as ecoregion and type of impact. In using macroninvertebrate evaluations in making designated use assessments, the Kentucky Division of Water considers stream reaches to fully support the WAH use if information reflected no alterations in community structure or functional compositions for the available habitats and if habitat conditions were relatively undisturbed. A reach is considered partially supporting uses when information reveals that community structure was slightly altered, that functional feeding components were noticeably influenced, or if available habitats reflected some alterations and/or reductions. Reaches were considered not supporting uses if information reflected sustained alterations or deletions in community structure, taxa richness and functional feeding types, or if available habitats were severely reduced or eliminated. These conditions may be expressed in terms of the sub-indices as shown in Table 2.2.

Table 2.2.
Biological Criteria for Assessment of
Warmwater Aquatic Habitat (WAH) Use Support

Fully Supporting	Partially Supporting	Not Supporting
Macroinvertebrate Bioassessment Index (MBI) excellent or good, high EPT, sensitive species present.	MBI classification of fair, EPT lower than expected in relation to available habitat, reduction in RA of sensitive taxa. Some alterations of functional groups evident.	MBI classification of poor, EPT low, TNI of tolerant taxa very high. Most functional groups missing from community.

EPT = Ephenmeroptera, Plecoptera, Trichoptera, RA = Relative Abundance, TNI = Total Number of Individuals

As an alternative to use of the composite MBI score, some states such as North Carolina only use the Hilsenhoff Biotic Index (HBI) for making designated use assessments. Such assignments can be made using the values shown in Table 2.3

Table 2.3.
HBI Criteria for Assessment of
Warmwater Aquatic Habitat (WAH) Use Support

Fully Supporting	Partially Supporting	Not Supporting
HBI < 4	7 > HBI > 4	HBI > 7

In the current report, the HBI was used as the principal metric for assessing the conditions of the streams in the PRIDE region. A map of the macro-invertebrate sites used in developing this assessment is shown in Figure 2.3.

2.1.3.2 Bacteriological Parameters

Pathogen impairment in a stream is normally inferred through the use of the presence of indicator bacteria such as fecal coliform. Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. They aid in the digestion of food. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being Escherichia coli. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals.

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

Membrane filtration is the method of choice for the analysis of fecal coliforms in water. Samples to be tested are passed through a membrane filter of particular pore size (generally 0.45 micron). The microorganisms present in the water remain on the filter surface. When the filter is placed in a sterile petri dish and saturated with an appropriate medium, growth of the desired organisms is encouraged, while that of other organisms is suppressed. Each cell develops into a discrete colony which can be counted directly and the results calculated as microbial density. Thus the results of a fecal coliform test are reported in units of the number of colonies per 100 ml of sample. The state water quality chronic limit is calculated on the basis of a geometric mean of at least five samples over a 30 day period. For swimming the limit is fewer than 200 colonies/100 mL; for fishing

and boating, fewer than 1000 colonies/100 mL; and for domestic water supply fewer than 2000 colonies/100 mL.

The state of Kentucky uses fecal coliform to assess whether a stream is meeting it's designated use for primary contact (i.e. swimming). Streams meeting this designated use must have an acute (single sample) fecal coliform count below 400 per 100 mL. Since all streams in Kentucky not specifically listed are classified by default for use as primary contact, fecal coliform counts provide a basis for making a general assessment of the streams in the PRIDE region. As a result, baseline fecal coliform data were obtained for all of the 40 counties in the PRIDE Region. A map of the monitoring stations used in developing this assessment is shown in Figure 2.4.

2.2 Assessment Data

Ten years of water quality data were collected from various sources for use in developing a baseline water quality assessment for the PRIDE Region. These data were obtained from the following sources: 1) PRIDE supported Watershed Watch Data, 2) Kentucky Division of Water ambient and TMDL data, 3) the U.S. Forest Service, 4) the U.S. Fish and Wildlife Service, and 5) USGS water quality data. A brief description of each of the data are provided in the following sections.

2.2.1 PRIDE Watershed Watch Data

As part of the PRIDE educational grants program, PRIDE has awarded several educational grants to support volunteer sampling efforts across the PRIDE area. These grants have been awarded to five separate volunteer groups associated with the Kentucky Watershed Watch Program. The volunteer groups have been organized around 6-digit river basins and include: The Kentucky River Watershed Watch Group, The Licking River Watershed Watch Group, The Big Sandy Watershed Watch Group, The Upper Cumberland Watershed Watch Group, and the Upper Green Watershed Watch Group. A map of the five different sample regions is shown in Figure 2.5. Sampling is performed for basic physiochemical data such as flow, pH, temperature, conductivity, herbecides/pesticides, fecal coliforms, nutrients and metals. In addition, several groups are sampling for habitat and macroinvertebrates. Each group performs sampling at multiple sites for multiple events. Locations of the various sample sites are shown in Figure 2.5.

2.2.2 DOW Ambient Stream Data

The State of Kentucky currently operates an ambient monitoring network that has been augmented through relationships with other state and federal agencies. A map of historical DOW monitoring sites is shown in Figure 2.6.

2.2.3 US Fish and Wildlife

The U.S. Fish and Wildlife collects habitat and macro-invertebrate data as part of

various focused watershed studies. The locations of these stations is shown in Figures 2.2 and 2.3.

2.2.4 US Forest Service

The U.S. Forest Service collects habitat and macro-invertebrate data as part of various focused watershed studies. The locations of these stations is shown in Figures 2.2 and 2.3.

2.2.5 USGS Sampling Data

The USGS also collects water quality data as part of various focused watershed studies. The locations of USGS water quality sampling sites across the region are shown in Figure 2.7.

2.2.6 DOW TMDL Study Data

In addition to annual ambient data, the Kentucky Division of Water has also conducted detailed monitoring activities associated with the development of TMDLs in various regions of the state. Two such studies performed in the PRIDE region are discussed in the following sections. The locations of the sample sites in both studies are shown in Figure 2.8 and 2.9.

2.3 Assessment Analysis

Because of the spatial and cumulative impacts of multiple projects within a region, it is best that project impacts be evaluated on a composite or watershed basis. In using such an approach, it is important that an appropriate assessment scale be selected that maintains a balance between the ability to quantify the impacts of local projects and the ability to effectively monitor a larger number of sites. In consideration of both issues, the various projects within the PRIDE counties were evaluated both on a county basis and on an 8-digit watershed basis. Maps of the 18 8-digit watersheds along with their adjacent or included counties and the associated pH, fecal coliform, habitat, and macro-invertebrate sampling locations are shown in Figures 2.10-2.28.

2.3.1 pH Analysis

A spatial analysis of the various pH sample locations identified only a handful of sites in which the pH standard of 6 was violated. These sites are shown in Figure 2.29 and identified in Table 2.4. Somewhat surprising is the lack of abundant sites in Pike, Floyd, Letcher, Knott, Perrry, Harlan, and Clay counties which together contain over 1000 mines. However, according to the Report on Coal Mining and Ground-Water Resources in the United States (1981), most mining in these counties is conducted in the non-acid-bearing overburden as opposed to the more significant acid-producing lower

coal seams that occur along the transition between the Eastern Coal Field and the Eastern Pennyroyal area (see Figure 1.2). Thus, mining activities in these transition counties (i.e. McCreary, Whitley, and Pulaski) do tend to produce more observations of depressed pH values, presumably from acid mine drainage impacts. This observation is consistent with Figure 2.29 and the 1998 303(d) List of Impacted Waters for Kentucky.

2.3.2 Fecal Coliform Analysis

Unlike the pH readings, fecal coliform violations are much more spatially distributed across the region. In an attempt to provide a historical baseline of fecal contamination in the region, statistical analyses of the develop fecal coliform database were performed on both a county basis and a 8-digit HUC basis. Median, maximum, and minimum annual spatially averaged values for each county and 8-digit HUC are provided in Tables 2.5-2.10. Individual tables and associated plots for each county and 8-digit HUC are also provided in Tables 2.11-2.58 and Figures 2.30-2.77.

Using an acute standard of 400c/ml, nearly all counties with any historical data show some standard violations. A simultaneous examination of both median and maximum values reveals that several counties continue to have severe pathogen problems. These include Floyd County, Harlan County, Johnson County, Letcher County, and Perry County. Other counties that have had less severe although significant problems include Bell, Breathitt, Garrard, Jessamine, and Lawrence Counties. Several counties have no historical fecal data and indicate areas where additional sampling is needed. These include: Casey, Clinton, Knott, Martin, Metcalfe, and Taylor counties.

Because of the lack of and variability of the data, it is hard to draw any definitive conclusions with regard to general trends. However, it does appear that general fecal levels are beginning to decrease in Bell, Harlan, Letcher, and Perry counties.

An evaluation of the fecal data on an 8-digit watershed basis reveals similar impacts. As expected, the north Fork of the Kentucky River watershed and the Upper Cumberland watershed showed the most severe fecal impacts. These were followed in severity by the upper Licking River watershed and watershed 0570204 and 0570203 in the Big Sand river basin. Two watersheds have not had any fecal coliform sampling over the last ten years. These include watershed 05070201 in the Big Sandy River Basin and watershed 0511002 in the Upper Green River Basin.

Table 2.4 pH Monitoring Stations with Readings < 6

County	Stream
Bell	Little Clear Creek
Breathitt	Wolf Creek
Harlan	Martins Fork
Jackson	Horse Lick
Johnson	Paint Creek
Laurel	Wolf Creek

Lawrence	Blaine Creek
Letcher	Elkhorn
Magoffin	Licking River
McCreary	Bear Creek
McCreary	Copperas Fork
McCreary	Cane Branch
McCreary	Roaring Paunch Creek
McCreary	Rock Creek
McCreary	Ryans Creek
Pike	Grapevine Creek
Pike	Hurricane Creek
Pulaski	Wildcat Branch
Whitley	Bucks Branch

2.3.3 Habitat Analysis

In an attempt to provide a historical baseline of stream habitat in the region, a statistical analyses of the Kentucky ERDAS habitat database was performed on both a county basis and a 8-digit HUC basis. Median, maximum, and minimum annual average values for each county and 8-digit HUC are provided in Tables 2.59-2.64. Individual tables and associated plots for each county and 8-digit HUC are also provided in Tables 2.65-2.98 and Figures 2.78-2.111. As can be seen from both the figures and tables, habitat data were much more sparse than fecal data. Generally speaking, habitat scores above 165 are indicative of good environmental conditions while scores below 135 are indicative of stressed conditions. Using these criteria and the median scores for each county, it can be seen that most counties are in a fair to poor condition. General trends are difficult to determine given the sparsity of the data. However, where available, the data do tend to show a decrease in habitat scores over the last 10 years. Minimum habitat scores were obtained in Clay, Leslie, Magoffin, Menifee, Morgan, Perry, and Wolfe Counties. On a watershed basis, the most severely impacted habitats appear to be associated with the Kentucky River Basin and the Licking River Basin, however this observations may be biased on the basis of the increased biological sampling that has taken place in these two basins as part of the Kentucky Watershed Management Framework ininiative.

2.3.4 Macro-Invertebrate Analysis

In an attempt to provide a historical baseline of stream habitat in the region, a statistical analyses of the Kentucky ERDAS macro-invertebrate database was performed on both a county basis and a 8-digit HUC basis. Median, maximum, and minimum annual average values for each county and 8-digit HUC are provided in Tables 2.99-2.104. Individual tables and associated plots for each county and 8-digit HUC are also provided in Tables 2.105-2.151 and Figures 2.112-2.158. As can be seen from both the figures and tables, the macro-invertebrate data are much more comprehensive than the

habitat data. Generally speaking, macro-invertebrate scores below 4 are indicative of good environmental conditions while scores above 7 are indicative of stressed conditions. Using these criteria and the median scores for each county, it can be seen that most counties are in a fair condition. This is also true for most of the watersheds as well. General trends are difficult to determine given the scarcity and variability of the data. In general, no overall trends were observed across the region.

Figure 2.1. Map showing pH Sampling Locations

Figure 2.2. Map showing Habitat Assessment Locations

Figure 2.3. Map showing Macroinvertebrate Assessment Locations

Figure 2.4. Map of Fecal Coliform Sampling Locations

Figure 2.5. Map of PRIDE Watershed Watch Regions and Sampling Locations

Figure 2.6. Locations of DOW Water Quality Monitoring Stations

Figure 2.7. Locations of USGS Water Quality Monitoring Stations

Figure 2.8. North Fork Kentucky River TMDL Monitoring Stations (State Roads in Gray)

Figure 2.9. DOW Upper Cumberland River TMDL Monitoring Stations (State Roads in Gray)

Figure 2.10. Kentucky River Basin 05100201 HUC Watershed

Figure 2.11. Kentucky River Basin 05100202 HUC Watershed

Figure 2.12. Kentucky River Basin 05100203 HUC Watershed

Figure 2.13. Kentucky River Basin 05100204 HUC Watershed

Figure 2.14. Kentucky River Basin 05100205 HUC Watershed

Figure 2.15. Licking River Basin 05100101 HUC Watershed

Figure 2.16. Licking River Basin 05100103 HUC Watershed

Figure 2.17. Green River Basin 05110001 HUC Watershed

Figure 2.18. Green River Basin 05110002 HUC Watershed

Figure 2.19. Upper Cumberland River Basin 05130101 HUC Watershed

Figure 2.20. Upper Cumberland River Basin 05130102 HUC Watershed

Figure 2.21. Upper Cumberland River Basin 05130103 HUC Watershed

Figure 2.22. Upper Cumberland River Basin 05130104 HUC Watershed

Figure 2.23. Upper Cumberland River Basin 05130105 HUC Watershed

Figure 2.24. Little Sandy River Basin 05090104 HUC Watershed

Figure 2.25. Big Sandy River Basin 05070201 HUC Watershed

Figure 2.26. Big Sandy River Basin 05070202 HUC Watershed

Figure 2.27. Big Sandy River Basin 05070203 HUC Watershed

Figure 2.28. Big Sandy River Basin 05070204 HUC Watershed

Figure 2.29. Sampling Locations with pH Values < 6.0

Table 2.5. Median Fecal Coliform Values for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR									78	
BELL	360	370	100	130	260	560	500	260	200	95
BREATHITT	415	600	240	190	440	145	100	40	135	15
CASEY										
CLAY									140	80
CLINTON										
CUMBERLAND										10
ESTILL		50	85	10	37	20	90	40	105	10
FLOYD				26					250	6,000
GARRARD	440	125	115	65	10	150	215	1,200	185	20
GREEN									165	
HARLAN					1,200	1,200	2,000	760	755	605
JACKSON	20	45	55	100	25	40	40	25	90	10
JESSAMINE	235	55	35	20	40	30	25	25	390	325
JOHNSON	410	815		5						29,500
KNOTT										
KNOX										10
LAUREL										10
LAWRENCE	3,156	820	670	525	850	160				9,000
LEE	110	155	100	90	170	200	105	60	50	700
LESLIE									290	80
LETCHER	3,400	2,200	1,000	170	1,500	755	650	515	400	100
LINCOLN									38,000	90
MAGOFFIN	435								680	85
MARTIN										
MCCREARY	10	18	35	10	20	20	240	20	14	
MENIFEE									100	8
METCALFE										
MONROE	15	44	52	16	14	58	20	14	40	
MORGAN		365	285	380	435	480			400	280
OWSLEY	106	75	65	35	165	700	120	40	120	
PERRY	540	1,800	1,250	1,400	1,550	1,150	3,000	400	400	140
PIKE	230	600	400	60	900	255			300	
PULASKI	50								10	
ROCKCASTLE	25	80	30	15	20	24	239	28	42	10
RUSSELL										60,000
TAYLOR										
WAYNE										10
WHITLEY									80	10
WOLFE	109	335	90	485					180	10

Table 2.6. Maximum Fecal Coliform Values for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR									120	
BELL	720	1,800	520	340,000	59,000	6,800	74,000	10,800	4,400	1,400
BREATHITT	2,025	12,000	7,200	780	20,000	4,400	36,809	4,800	8,500	1,700
CASEY										
CLAY									1,400	150
CLINTON										
CUMBERLAND										10
ESTILL		330	2,000	2,300	1,600	440	2,000	600	8,000	10
FLOYD				600					11,000	20,000
GARRARD	2,000	240	6,400	4,000	2,500	18,300	16,000	6,800	60,000	1,100
GREEN									400	
HARLAN					480,000	84,000	230,000	150,000	137,000	60,000
JACKSON	220	200	400	440	270	1,750	197	80	1,600	30
JESSAMINE	2,200	410	8,000	3,600	1,900	800	3,200	1,800	2,700	2,000
JOHNSON	1,900	900		3,300						60,000
KNOTT										
KNOX										10
LAUREL										10
LAWRENCE	7,935	6,000	4,066	5,300	7,000	1,800				9,000
LEE	530	2,000	3,000	270	390	1,400	280	440	4,000	700
LESLIE									1,600	700
LETCHER	10,900	13,000	11,000	5,600	17,000	80,000	40,000	56,000	78,000	30,000
LINCOLN									38,000	90
MAGOFFIN	1,100								1,440	1,200
MARTIN										
MCCREARY	867	1,400	180	440	2,300	900	990	154	1,900	
MENIFEE									510	8
METCALFE										
MONROE	270	770	780	50	240	900	30	220	1,700	
MORGAN		1,400	1,800	2,400	2,100	1,400			9,600	960
OWSLEY	300	700	6,000	2,600	1,800	2,400	400	270	2,500	
PERRY	16,000	16,000	100,000	80,000	36,000	27,000	80,000	15,000	64,000	4,800
PIKE	710	6,000	3,800	60,000	6,000	2,400			24,000	
PULASKI	290								55	
ROCKCASTLE	890	840	2,300	150	950	750	3,200	350	450	10
RUSSELL										60,000
TAYLOR										
WAYNE										10
WHITLEY									110	10
WOLFE	3,400	2,600	4,000	820					270	10

Table 2.7. Average Fecal Coliform Values for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR									78	
BELL	385	548	136	33,261	2,214	1,382	5,323	1,050	667	212
BREATHITT	547	1,783	760	249	2,415	668	2,886	578	970	244
CASEY										
CLAY									328	83
CLINTON										
CUMBERLAND										10
ESTILL		106	258	257	311	133	425	164	688	10
FLOYD				89					1,624	8,203
GARRARD	587	120	693	527	131	2,199	2,824	2,819	5,149	238
GREEN									220	
HARLAN					1,958	2,895	6,338	1,497	2,199	2,446
JACKSON	54	57	93	160	77	277	84	32	240	14
JESSAMINE	424	119	788	342	364	163	778	325	766	680
JOHNSON	630	733		374						29,805
KNOTT										
KNOX										10
LAUREL										10
LAWRENCE	3,318	1,812	1,142	946	1,255	348				9,000
LEE	177	290	376	108	169	460	132	126	357	700
LESLIE									660	263
LETCHER	3,998	3,429	1,976	788	2,859	6,530	3,996	2,587	3,452	2,832
LINCOLN									38,000	90
MAGOFFIN	480								816	348
MARTIN										
MCCREARY	90	130	46	61	157	131	327	40	248	
MENIFEE									149	8
METCALFE										
MONROE	41	155	112	18	43	203	23	55	581	
MORGAN		512	408	629	704	522			2,280	440
OWSLEY	113	200	593	301	293	897	155	92	524	
PERRY	2,541	3,023	6,027	8,842	4,497	3,320	11,704	1,841	1,953	381
PIKE	272	1,541	805	1,521	1,433	781			3,353	
PULASKI	79								24	
ROCKCASTLE	107	133	239	46	166	199	1,147	103	138	10
RUSSELL										60,000
TAYLOR										
WAYNE										10
WHITLEY									75	10
WOLFE	394	489	902	485					183	10

Table 2.8. Median Fecal Coliform Values for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202				24						
05070203	345	600	405	60	900	215			260	6,000
05070204	3,156	2,213	2,245	5,300						9,000
05100101	435	365	285	380	435	480			552	110
05100201	610	1,400	425	300	1,400	530	630	340	370	125
05100202	105	155	100	90	170	200	105	60	50	80
05100203	106	75	65	35	165	700	120	40	133	80
05100204	130	100	90	40	37	20	90	40	95	10
05100205	330	88	50	45	10	75	100	70	205	80
05110001									155	
05110002										
05130101	220	185	65	130	555	650	850	450	450	170
05130102	23	55	40	31	20	32	119	28	52	10
05130103	34	44	52	16	14	58	20	14	25	
05130104	10	10	15	10	10	10	60	10	10	

Table 2.9. Maximum Fecal Coliform Values for HUCs

HUC8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202				60,000						
05070203	1,900	6,000	3,800	3,300	7,000	2,400			24,000	60,000
05070204	7,935	5,300	4,066	5,300						9,000
05100101	1,100	1,400	1,800	2,400	2,100	1,400			9,600	1,200
05100201	16,000	16,000	100,000	80,000	36,000	80,000	80,000	56,000	78,000	30,000
05100202	370	2,000	3,000	270	390	1,400	280	440	1,600	700
05100203	300	700	6,000	2,600	1,800	2,400	400	270	2,500	150
05100204	3,400	2,600	4,000	2,300	1,600	440	2,000	600	8,000	700
05100205	2,200	410	8,000	4,000	2,500	18,300	16,000	6,800	60,000	2,000
05110001									400	
05110002										
05130101	720	1,800	520	1,300,000	480,000	84,000	230,000	150,000	137,000	60,000
05130102	890	840	2,300	440	950	1,750	3,200	350	570	10
05130103	290	770	780	50	240	900	30	220	1,700	
05130104	867	900	180	440	530	530	420	75	80	

Table 2.10. Average Fecal Coliform Values for HUCs

HUC8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202				1,855						
05070203	451	1,326	735	350	1,344	564			2,530	14,375
05070204	3,318	2,494	2,574	5,300						9,000
05100101	480	512	408	629	704	522			1,485	340
05100201	2,174	2,653	2,934	3,410	3,405	4,067	6,709	1,942	2,226	992
05100202	152	290	376	108	169	460	132	126	241	263
05100203	113	200	593	301	293	897	155	92	411	83
05100204	298	297	447	289	311	133	425	164	460	89
05100205	505	119	740	434	183	1,181	1,801	1,668	4,509	400
05110001									173	
05110002										
05130101	250	373	103	64,149	6,864	3,743	7,275	4,429	3,449	2,863
05130102	80	95	166	100	122	238	616	66	147	10
05130103	59	155	112	18	43	203	23	55	303	
05130104	74	95	35	51	48	76	163	28	19	

Table 2.11. Fecal Coliform Statistics for Adair County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	2	35	120	78
1999				

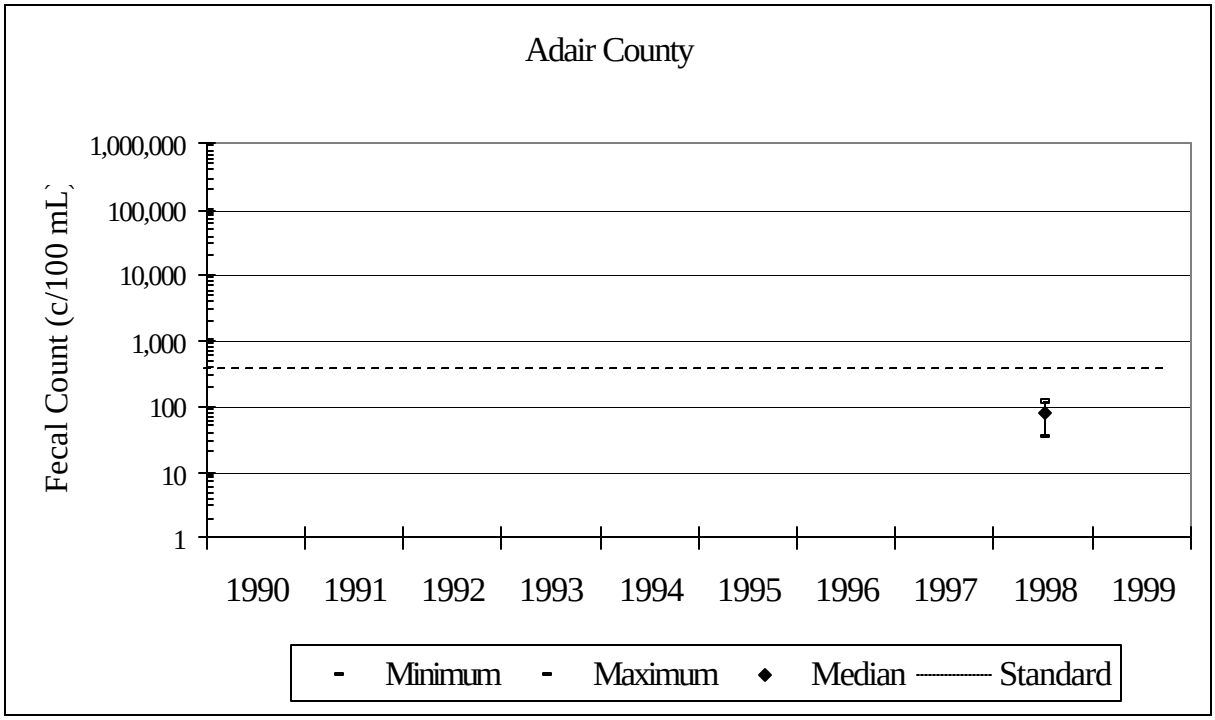

Figure 2.30. Fecal Coliform Results for Adair County

Table 2.12. Fecal Coliform Statistics for Bell County

Year	Samples	Minimum	Maximum	Median
1990	22	1	720	360
1991	24	10	1,800	370
1992	24	10	520	100
1993	32	20	340,000	130
1994	96	9	59,000	260
1995	70	10	6,800	560
1996	66	10	74,000	500
1997	78	10	10,800	260
1998	86	10	4,400	200
1999	60	10	1,400	95

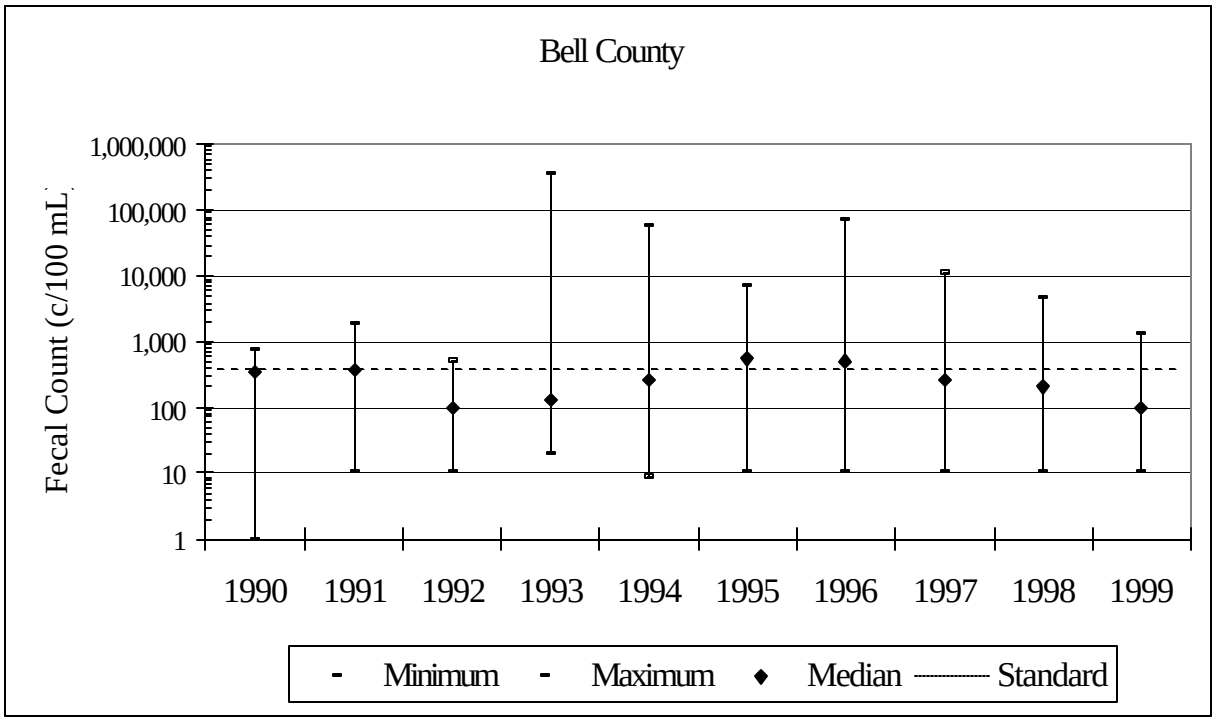

Figure 2.31. Fecal Coliform Results for Bell County

Table 2.13. Fecal Coliform Statistics for Breathitt County

Year	Samples	Minimum	Maximum	Median
1990	48	10	2,025	415
1991	52	1	12,000	600
1992	43	10	7,200	240
1993	32	10	780	190
1994	16	10	20,000	440
1995	14	10	4,400	145
1996	14	10	36,809	100
1997	12	10	4,800	40
1998	30	10	8,500	135
1999	10	10	1,700	15

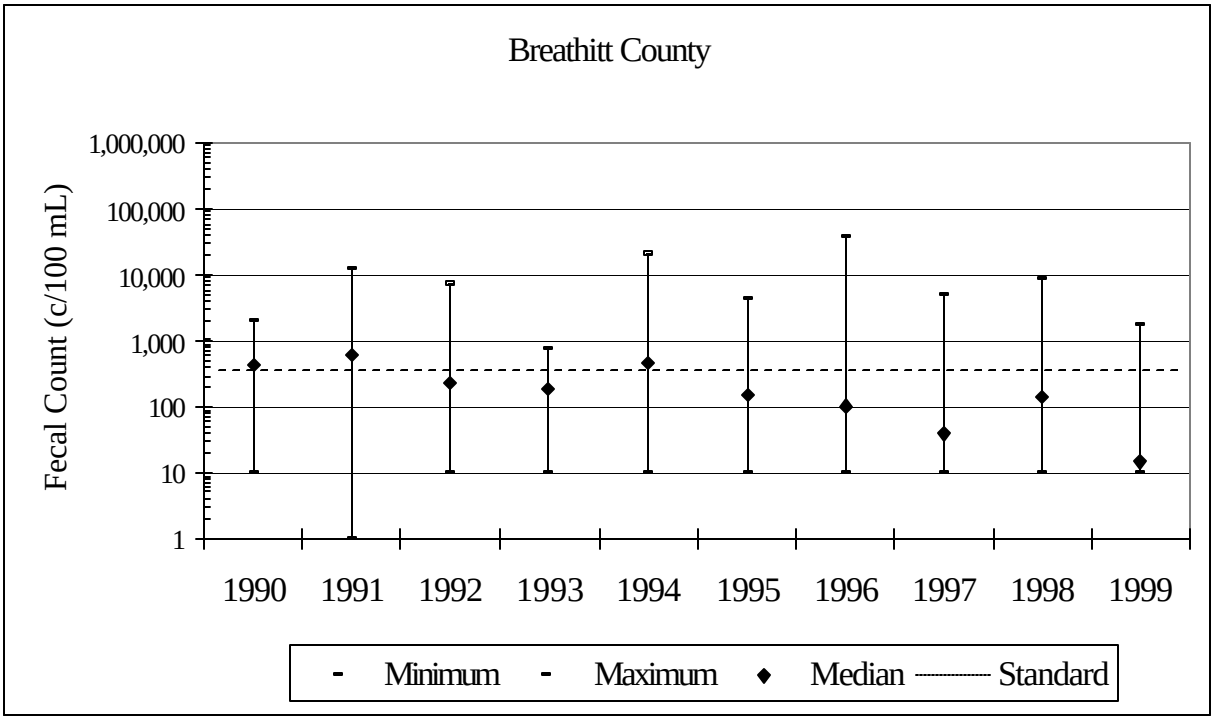

Figure 2.32. Fecal Coliform Results for Breathitt County

Table 2.14. Fecal Coliform Statistics for Clay County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	15	8	1,400	140
1999	4	20	150	80

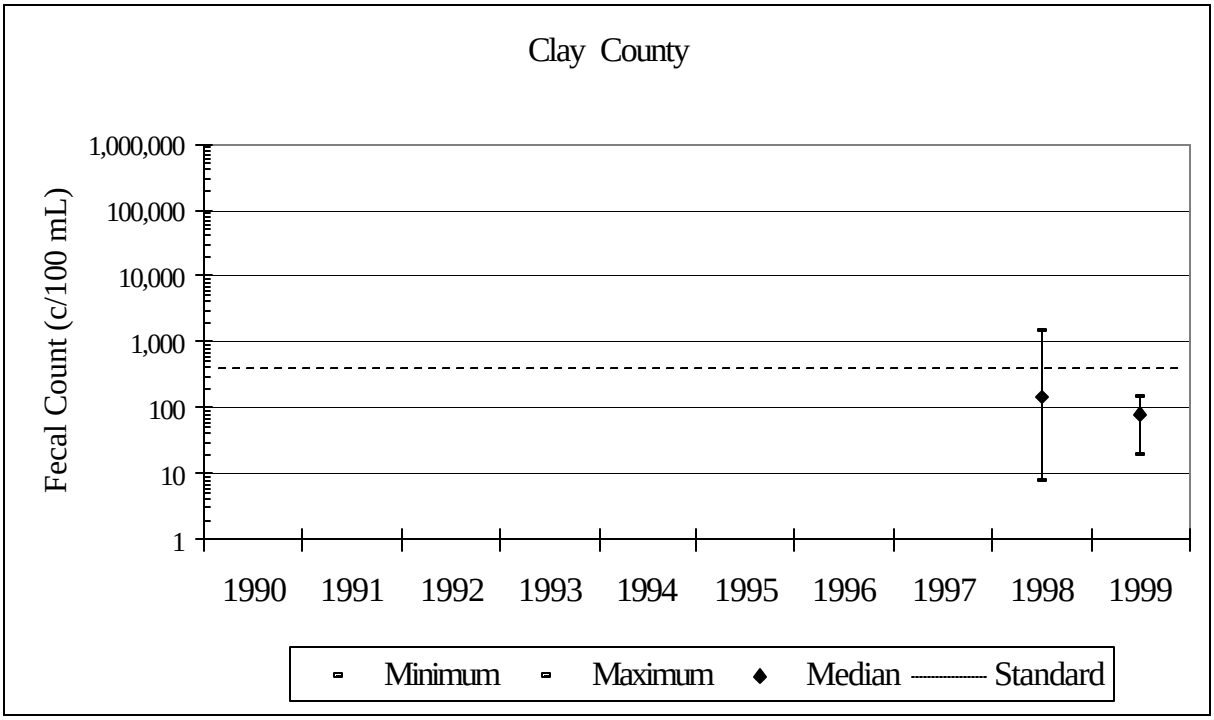

Figure 2.33. Fecal Coliform Results for Clay County

Table 2.15. Fecal Coliform Statistics for Cumberland County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	10	10	10

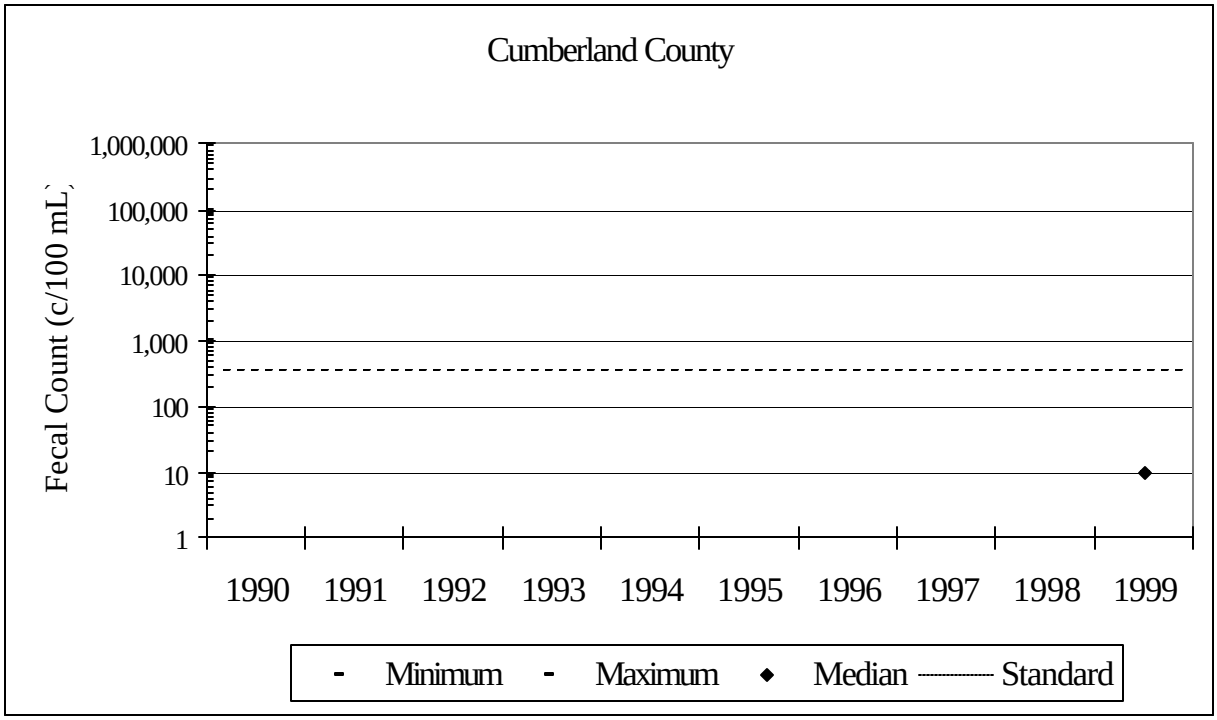

Figure 2.34. Fecal Coliform Results for Cumberland County

Table 2.16. Fecal Coliform Statistics for Estill County

Year	Samples	Minimum	Maximum	Median
1990				
1991	12	10	330	50
1992	12	10	2,000	85
1993	12	4	2,300	10
1994	12	10	1,600	37
1995	9	10	440	20
1996	6	10	2,000	90
1997	5	10	600	40
1998	14	10	8,000	105
1999	3	10	10	10

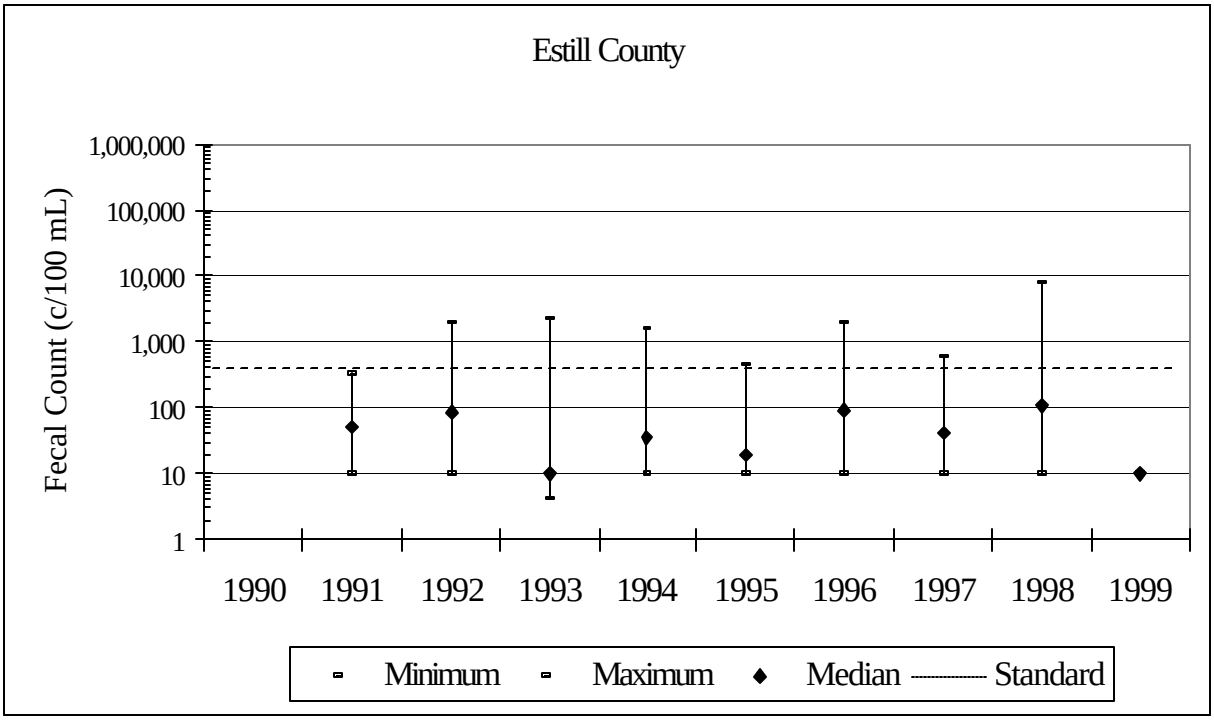

Figure 2.35. Fecal Coliform Results for Estill County

Table 2.17. Fecal Coliform Statistics for Floyd County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993	26	1	600	26
1994				
1995				
1996				
1997				
1998	10	30	11,000	250
1999	10	10	20,000	6,000

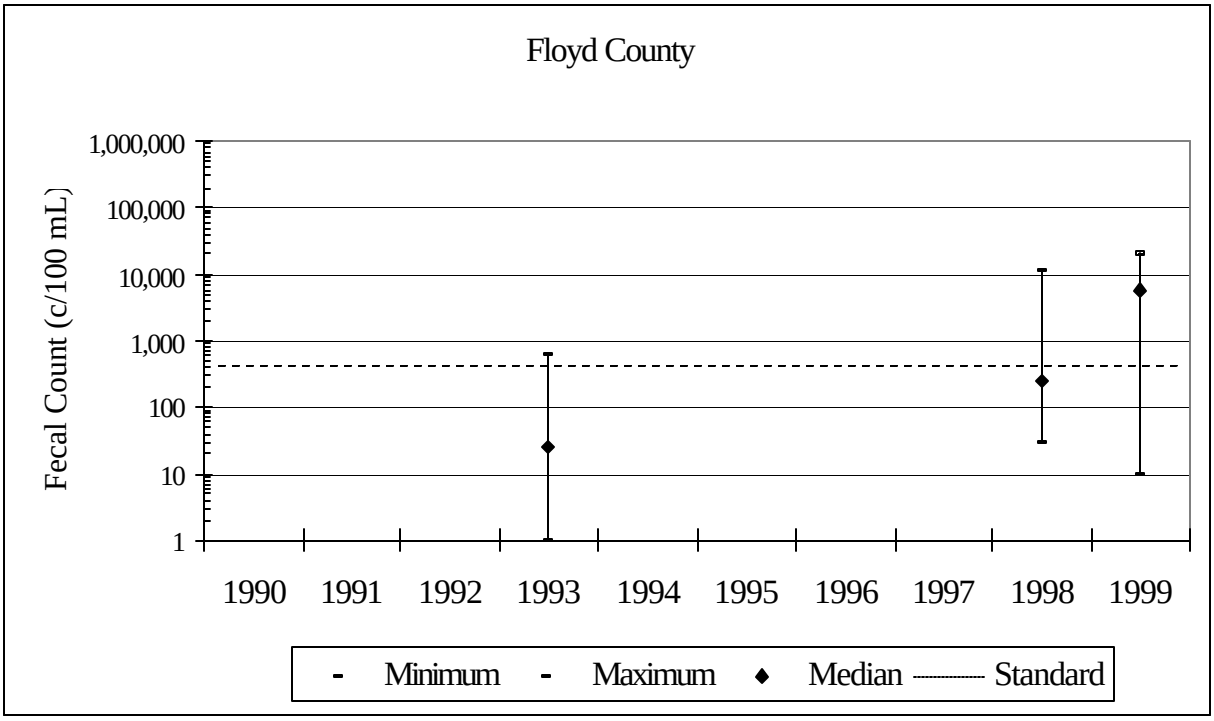

Figure 2.36. Fecal Coliform Results for Floyd County

Table 2.18. Fecal Coliform Statistics for Garrard County

Year	Samples	Minimum	Maximum	Median
1990	12	36	2,000	440
1991	12	20	240	125
1992	12	10	6,400	115
1993	12	10	4,000	65
1994	38	2	2,500	10
1995	9	10	18,300	150
1996	6	43	16,000	215
1997	7	30	6,800	1,200
1998	12	10	60,000	185
1999	5	10	1,100	20

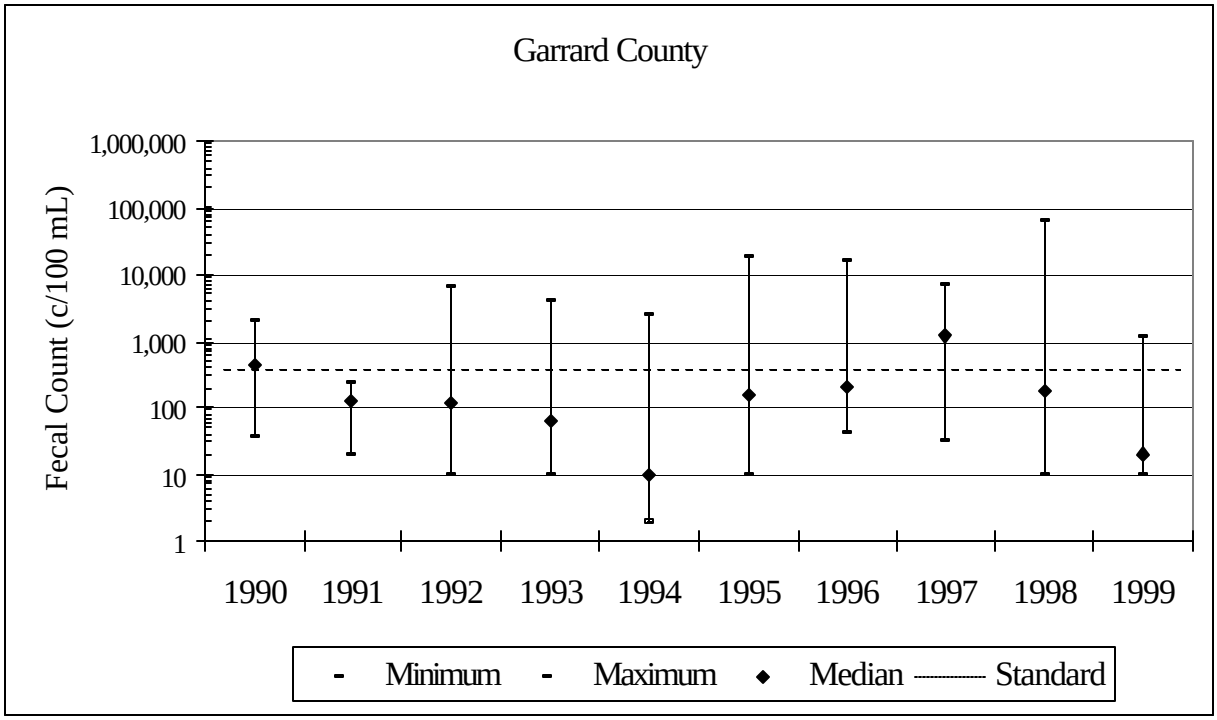

Figure 2.37. Fecal Coliform Results for Garrard County

Table 2.19. Fecal Coliform Statistics for Green County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	4	150	400	165
1999				

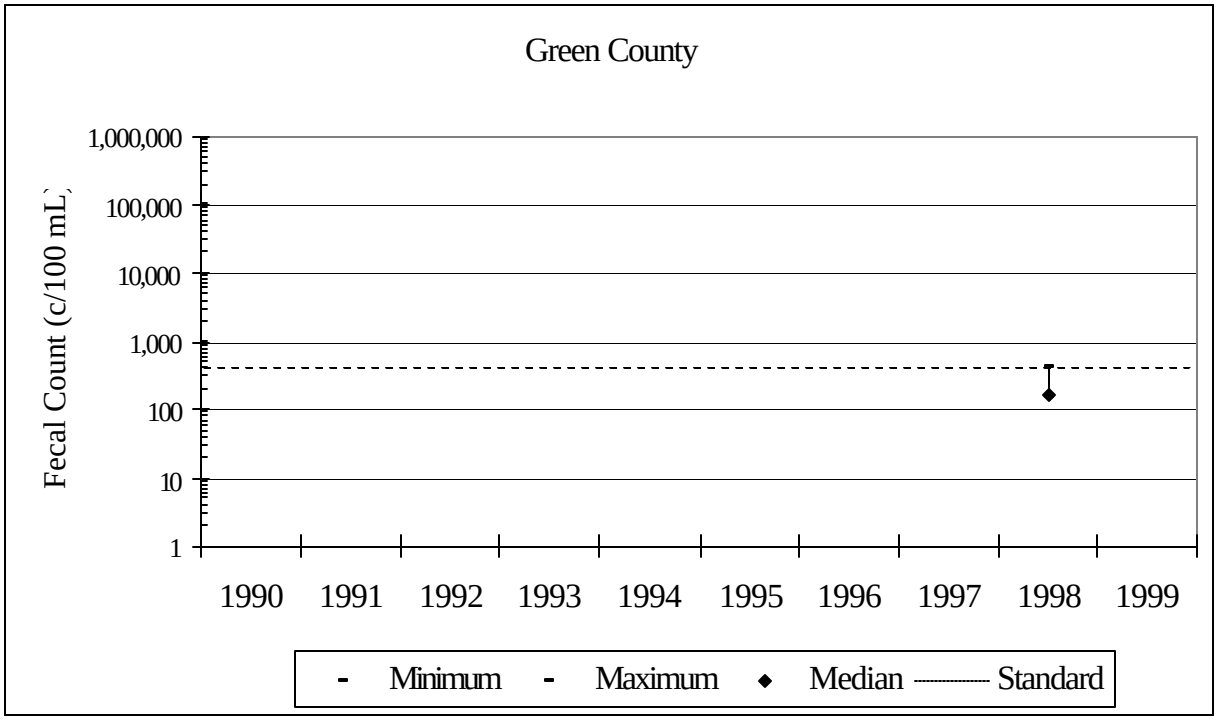

Figure 2.38. Fecal Coliform Results for Green County

Table 2.20. Fecal Coliform Statistics for Harlan County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994	104	10	480,000	1,200
1995	78	70	84,000	1,200
1996	89	80	230,000	2,000
1997	89	30	150,000	760
1998	104	15	137,000	755
1999	90	30	60,000	605

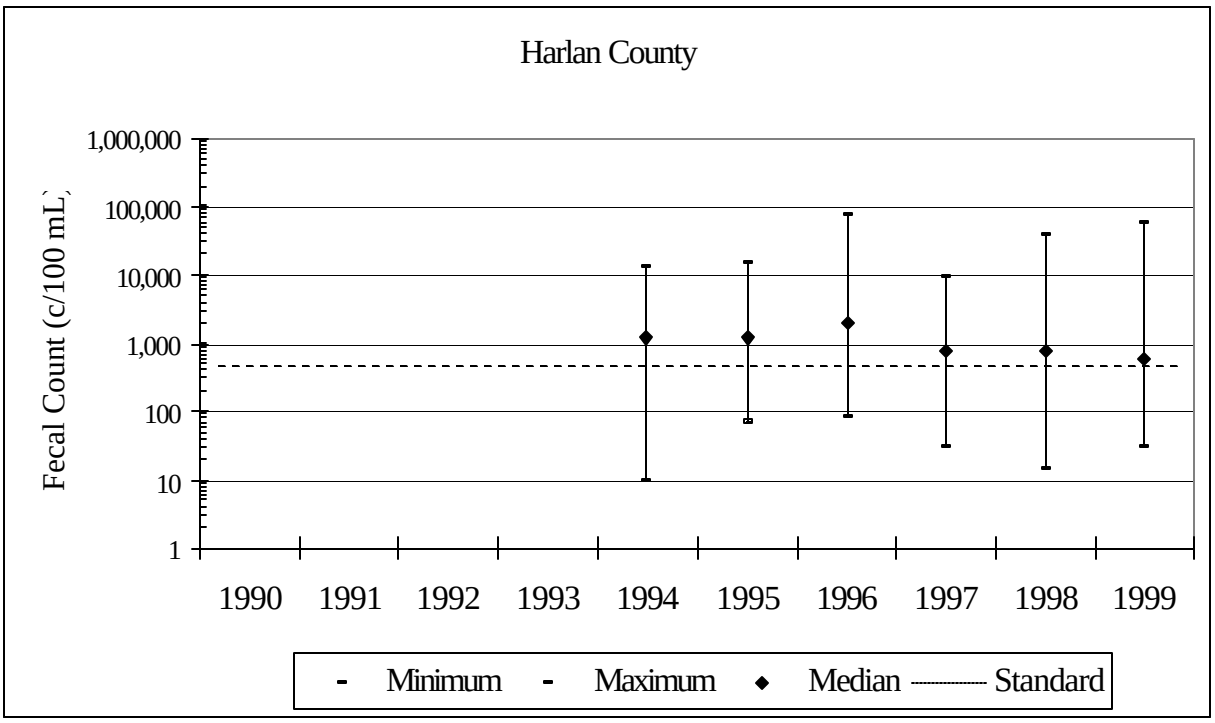

Figure 2.39. Fecal Coliform Results for Harlan County

Table 2.21. Fecal Coliform Statistics for Jackson County

Year	Samples	Minimum	Maximum	Median
1990	11	5	220	20
1991	12	10	200	45
1992	12	10	400	55
1993	11	10	440	100
1994	12	9	270	25
1995	9	4	1,750	40
1996	3	14	197	40
1997	10	7	80	25
1998	17	10	1,600	90
1999	5	10	30	10

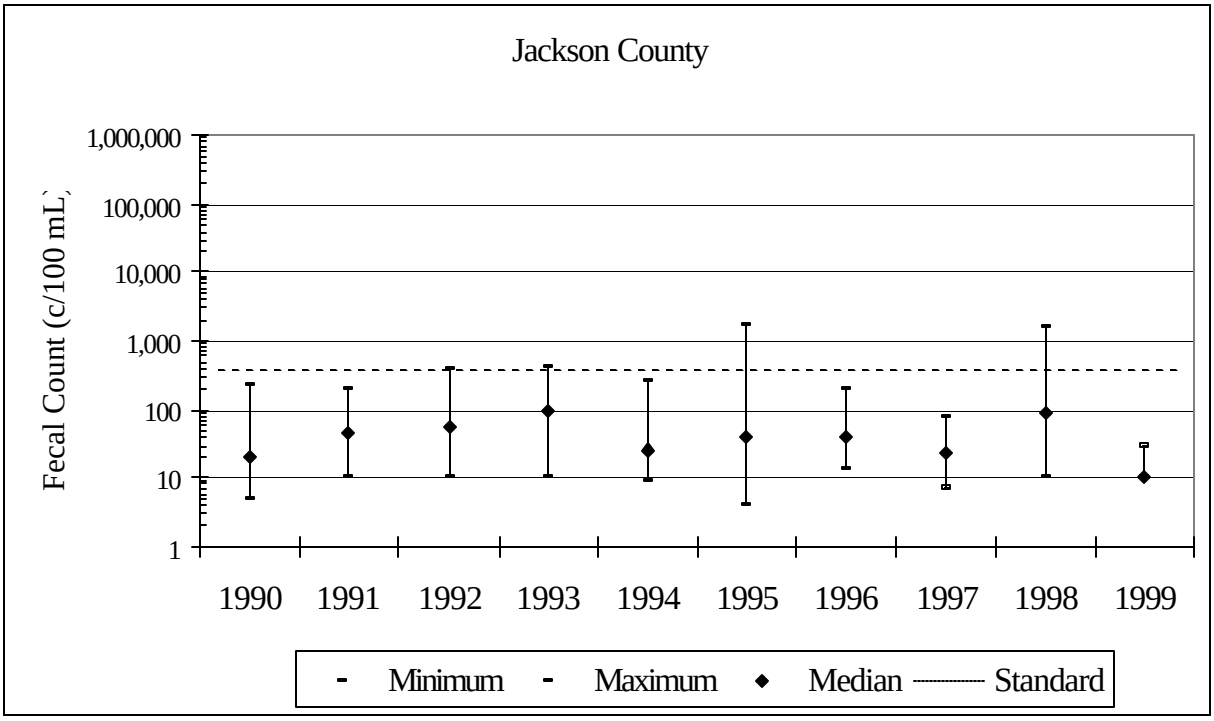

Figure 2.40. Fecal Coliform Results for Jackson County

Table 2.22. Fecal Coliform Statistics for Jessamine County

Year	Samples	Minimum	Maximum	Median
1990	12	4	2,200	235
1991	12	8	410	55
1992	12	10	8,000	35
1993	12	8	3,600	20
1994	11	10	1,900	40
1995	9	10	800	30
1996	6	10	3,200	25
1997	6	10	1,800	25
1998	11	10	2,700	390
1999	4	70	2,000	325

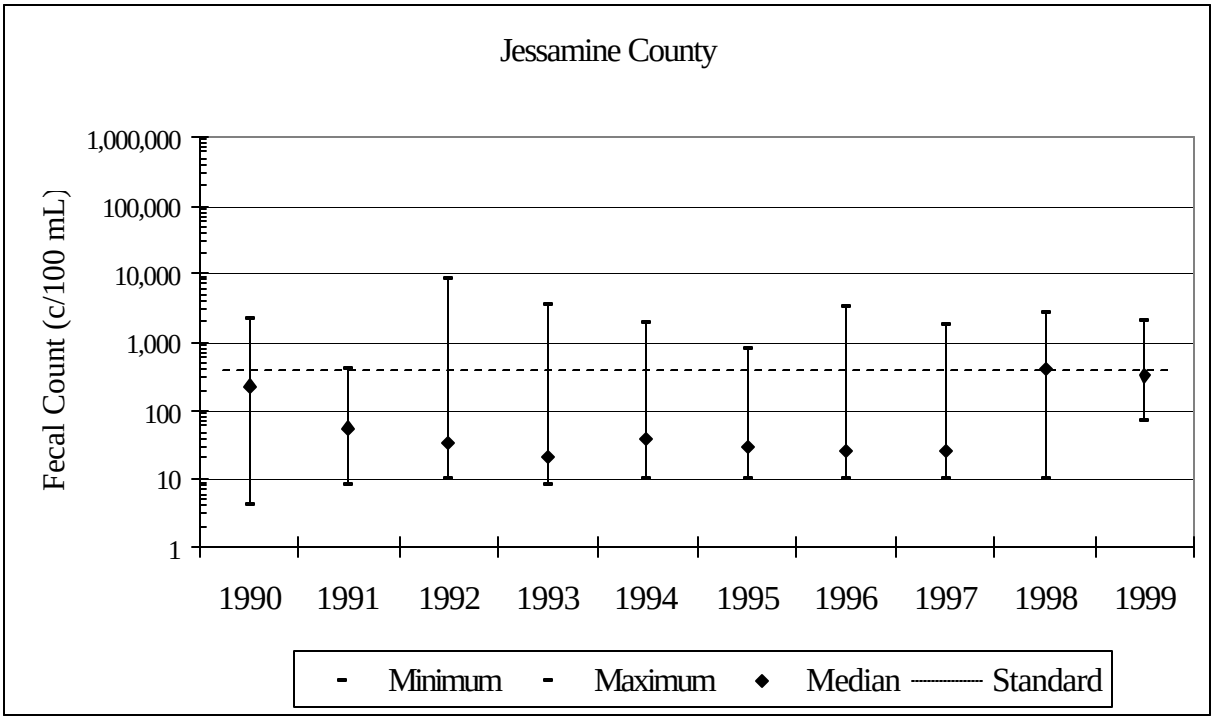

Figure 2.41. Fecal Coliform Results for Jessamine County

Table 2.23. Fecal Coliform Statistics for Johnson County

Year	Samples	Minimum	Maximum	Median
1990	12	230	1,900	410
1991	4	400	900	815
1992				
1993	17	1	3,300	5
1994				
1995				
1996				
1997				
1998				
1999	4	220	60,000	29,500

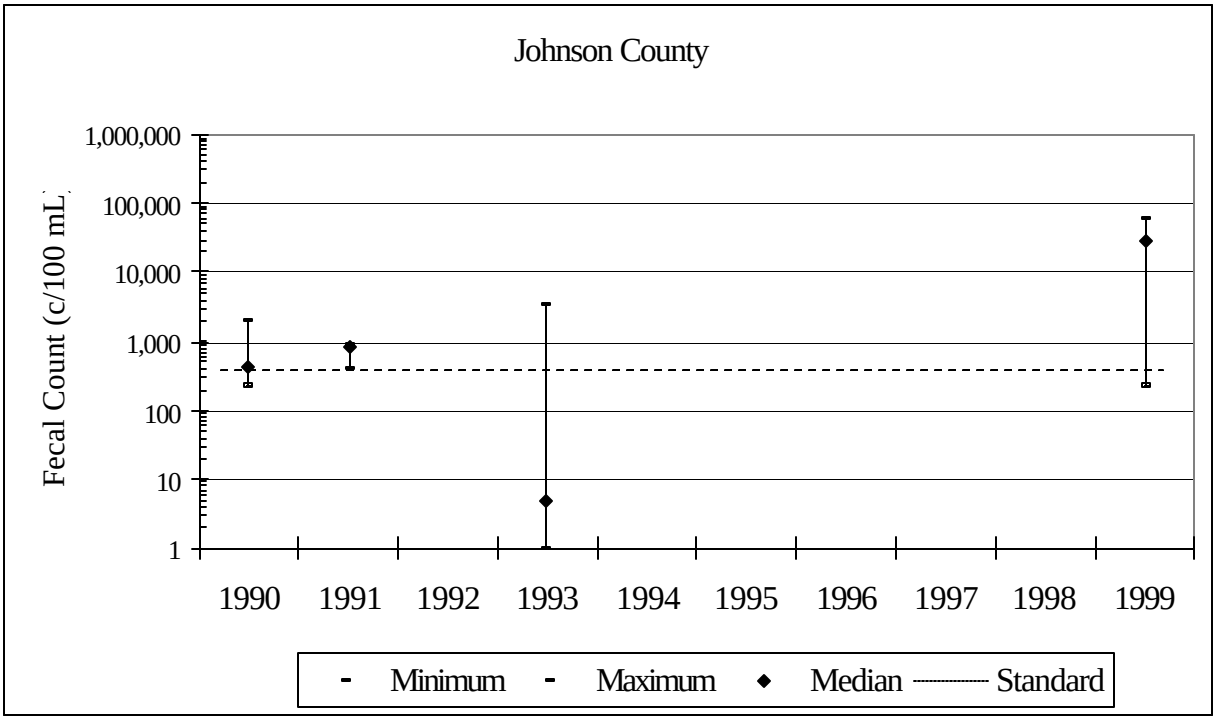

Figure 2.42. Fecal Coliform Results for Johnson County

Table 2.24. Fecal Coliform Statistics for Knox County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	10	10	10

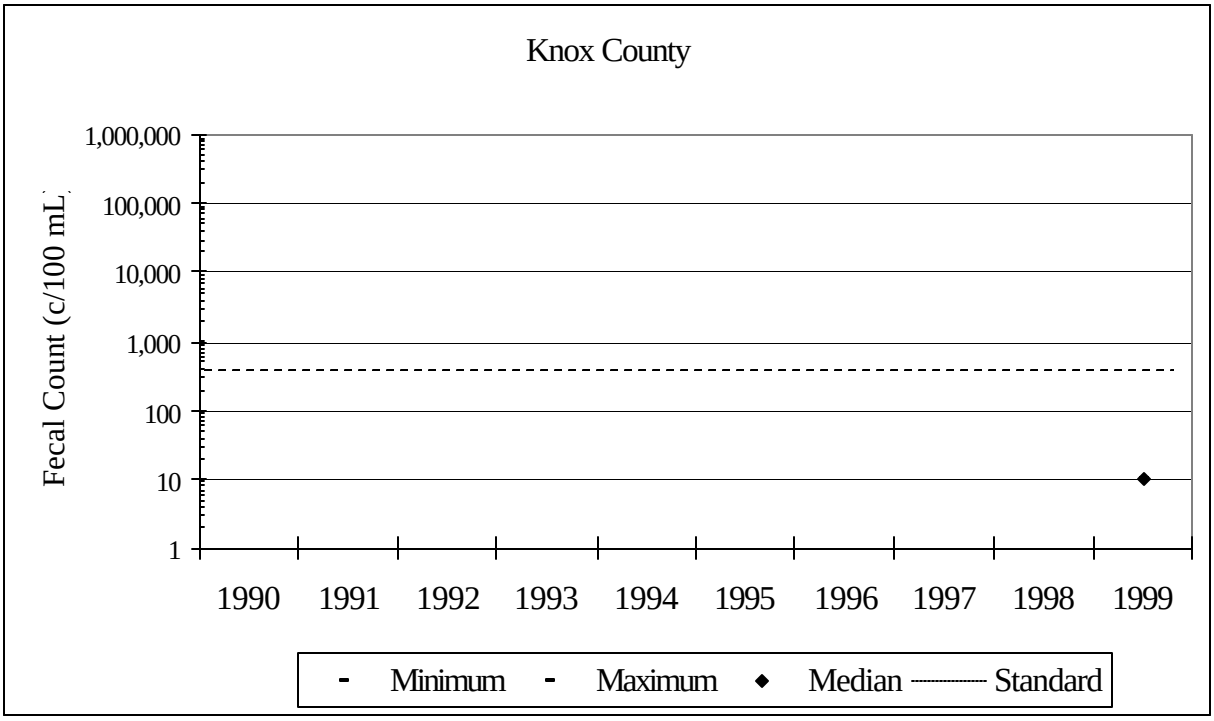

Figure 2.43. Fecal Coliform Results for Knox County

Table 2.25. Fecal Coliform Statistics for Laurel County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	10	10	10

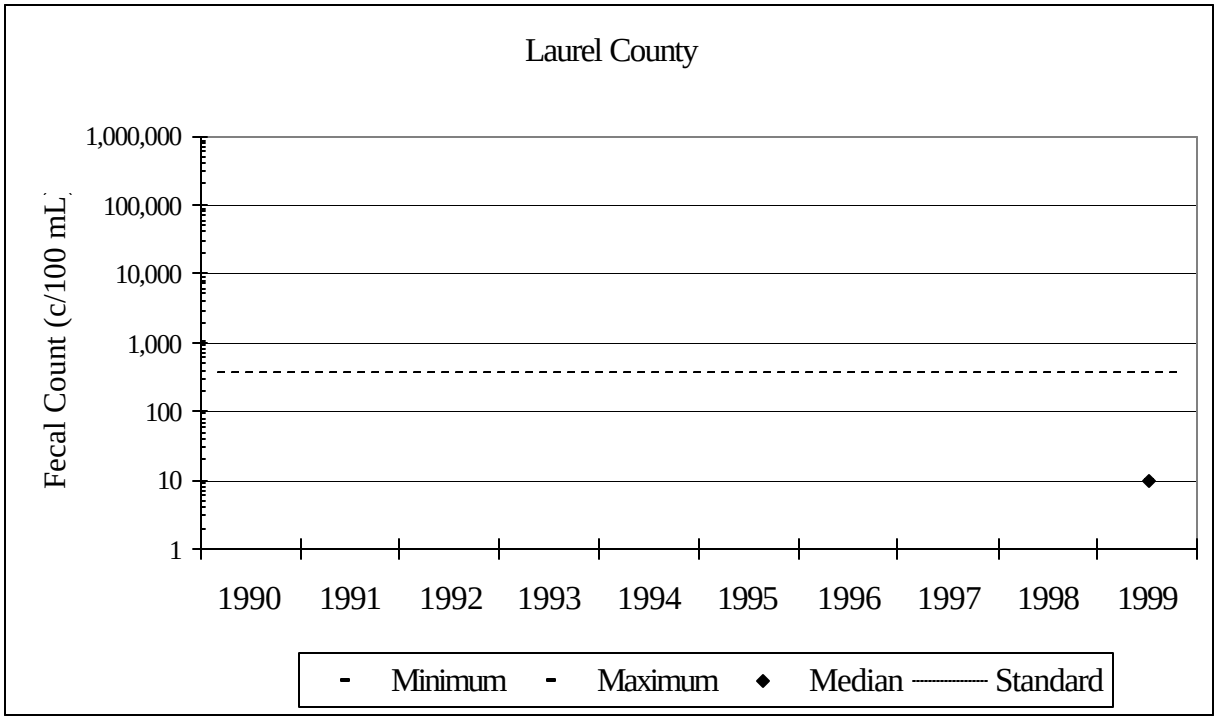

Figure 2.44. Fecal Coliform Results for Laurel County

Table 2.26. Fecal Coliform Statistics for Lawrence County

Year	Samples	Minimum	Maximum	Median
1990	6	260	7,935	3,156
1991	14	10	6,000	820
1992	16	60	4,066	670
1993	14	30	5,300	525
1994	12	20	7,000	850
1995	8	10	1,800	160
1996				
1997				
1998				
1999	1	9,000	9,000	9,000

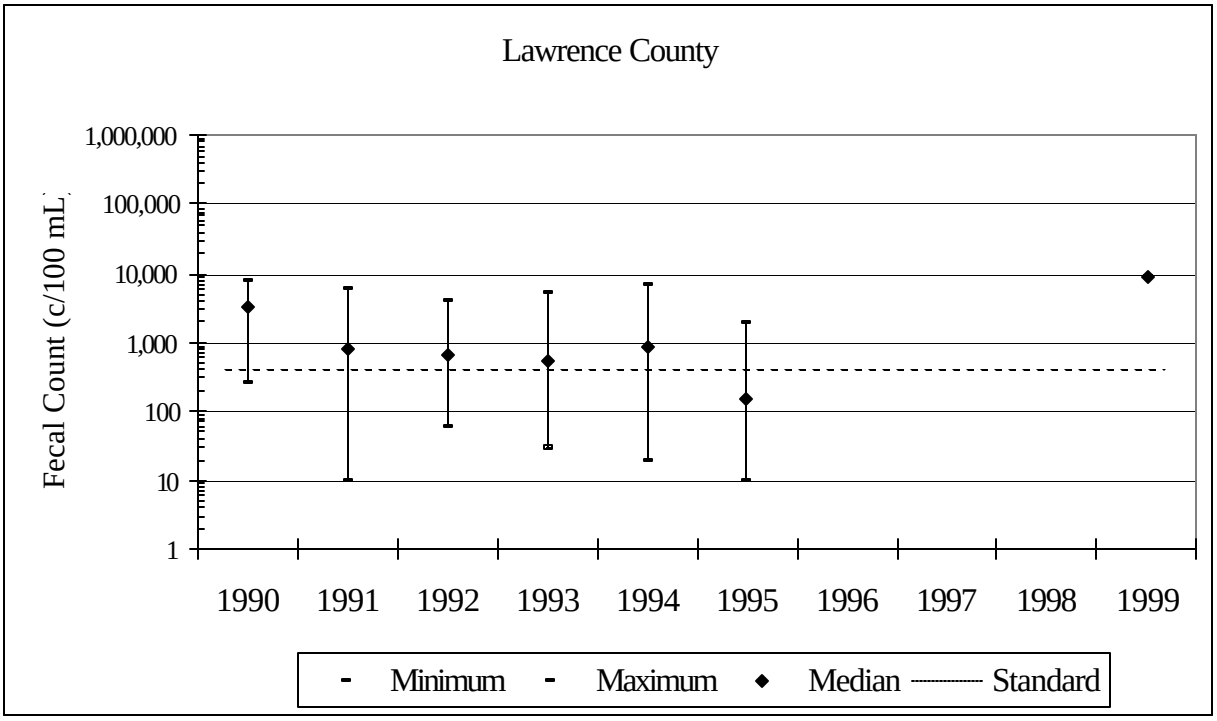

Figure 2.45. Fecal Coliform Results for Lawrence County

Table 2.27. Fecal Coliform Statistics for Lee County

Year	Samples	Minimum	Maximum	Median
1990	24	12	530	110
1991	12	20	2,000	155
1992	12	10	3,000	100
1993	12	10	270	90
1994	12	20	390	170
1995	9	20	1,400	200
1996	6	20	280	105
1997	5	10	440	60
1998	13	10	4,000	50
1999	1	700	700	700

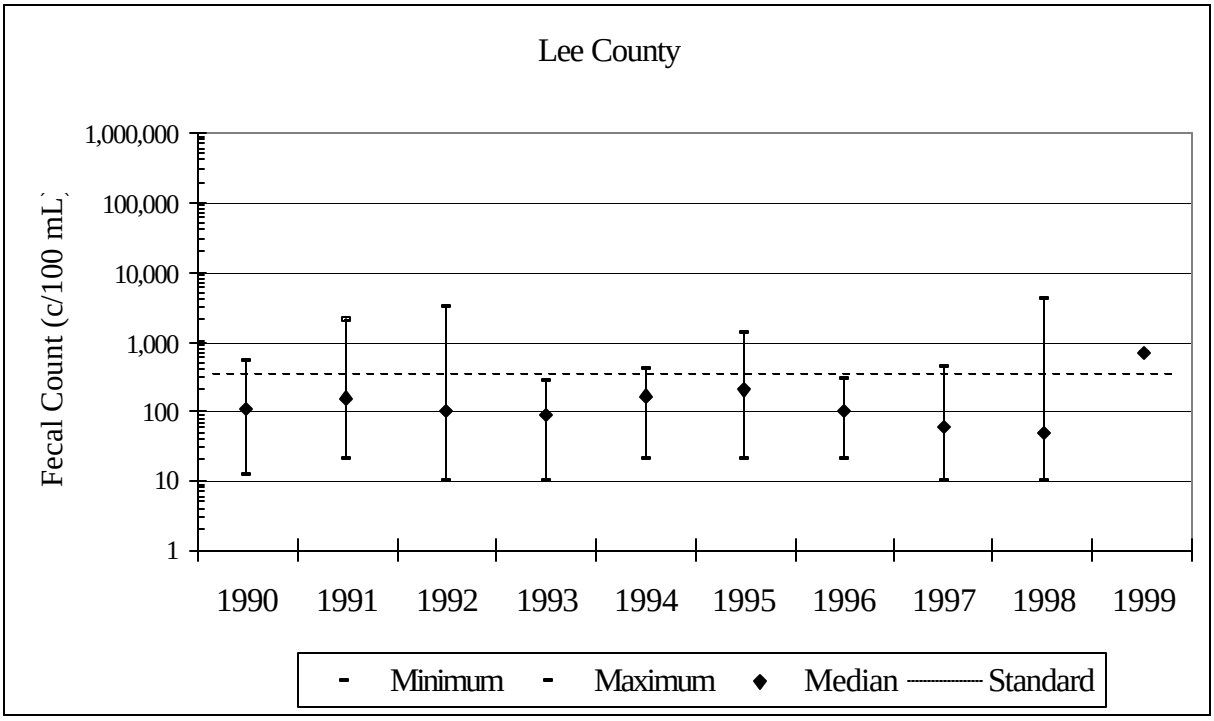

Figure 2.46. Fecal Coliform Results for Lee County

Table 2.28. Fecal Coliform Statistics for Leslie County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	3	90	1,600	290
1999	3	10	700	80

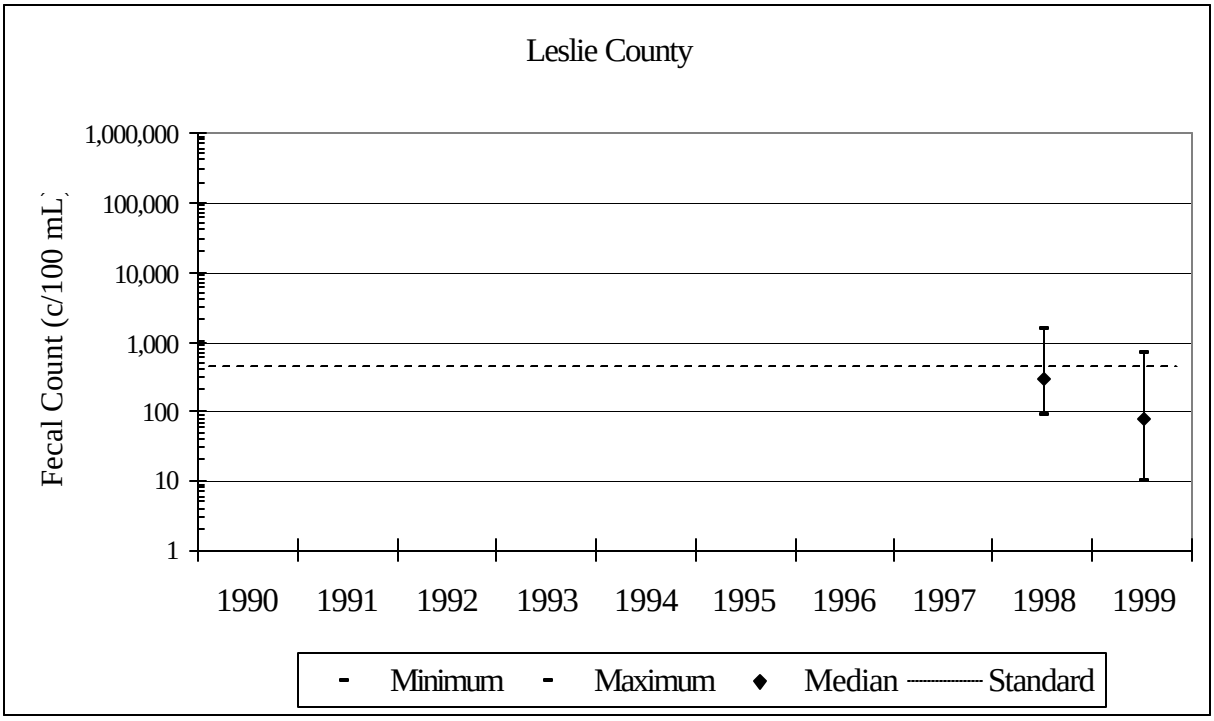

Figure 2.47. Fecal Coliform Results for Leslie County

Table 2.29. Fecal Coliform Statistics for Letcher County

Year	Samples	Minimum	Maximum	Median
1990	33	600	10,900	3,400
1991	35	10	13,000	2,200
1992	38	10	11,000	1,000
1993	36	10	5,600	170
1994	35	10	17,000	1,500
1995	26	10	80,000	755
1996	30	10	40,000	650
1997	30	10	56,000	515
1998	53	10	78,000	400
1999	33	10	30,000	100

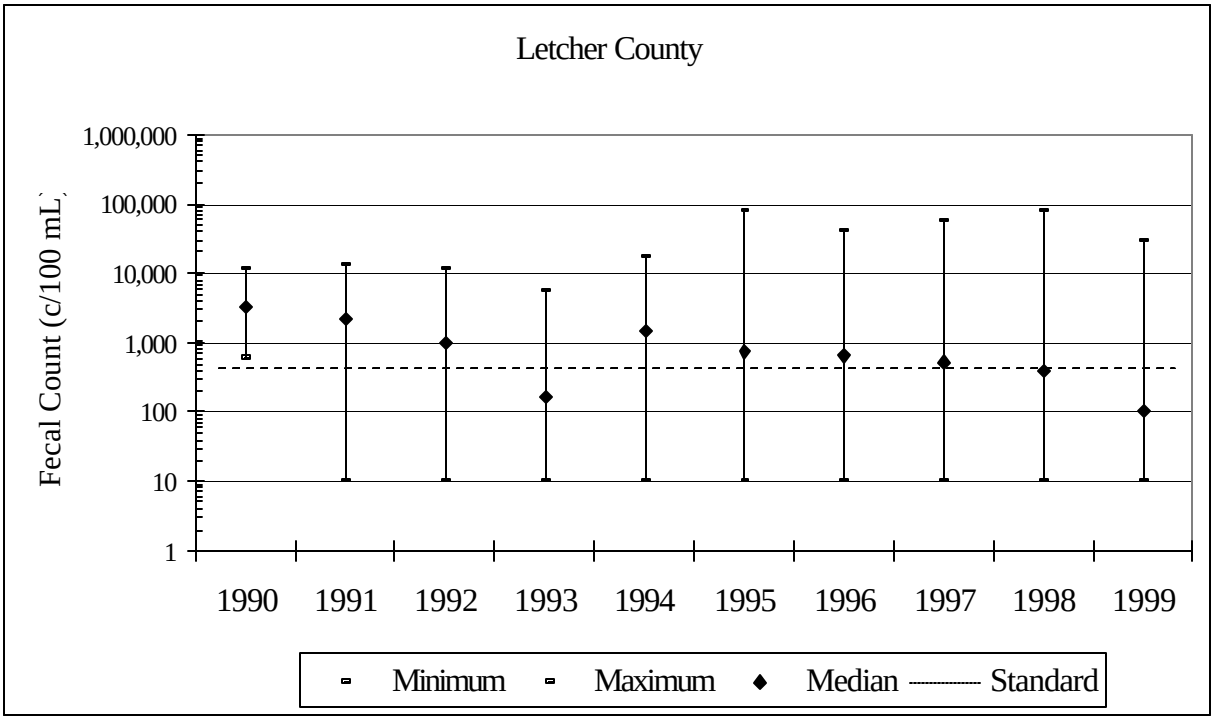

Figure 2.48. Fecal Coliform Results for Letcher County

Table 2.30. Fecal Coliform Statistics for Lincoln County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	1	38,000	38,000	38,000
1999	1	90	90	90

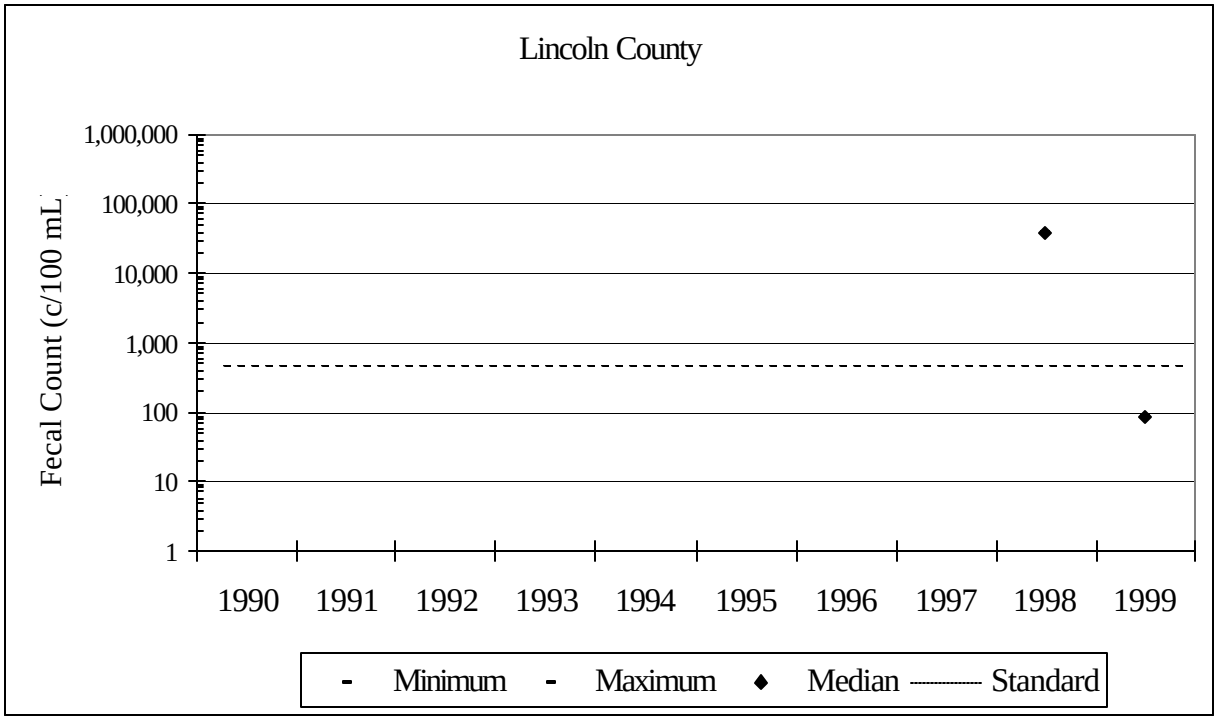

Figure 2.49. Fecal Coliform Results for Lincoln County

Table 2.31. Fecal Coliform Statistics for Magoffin County

Year	Samples	Minimum	Maximum	Median
1990	12	80	1,100	435
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	4	464	1,440	680
1999	4	20	1,200	85

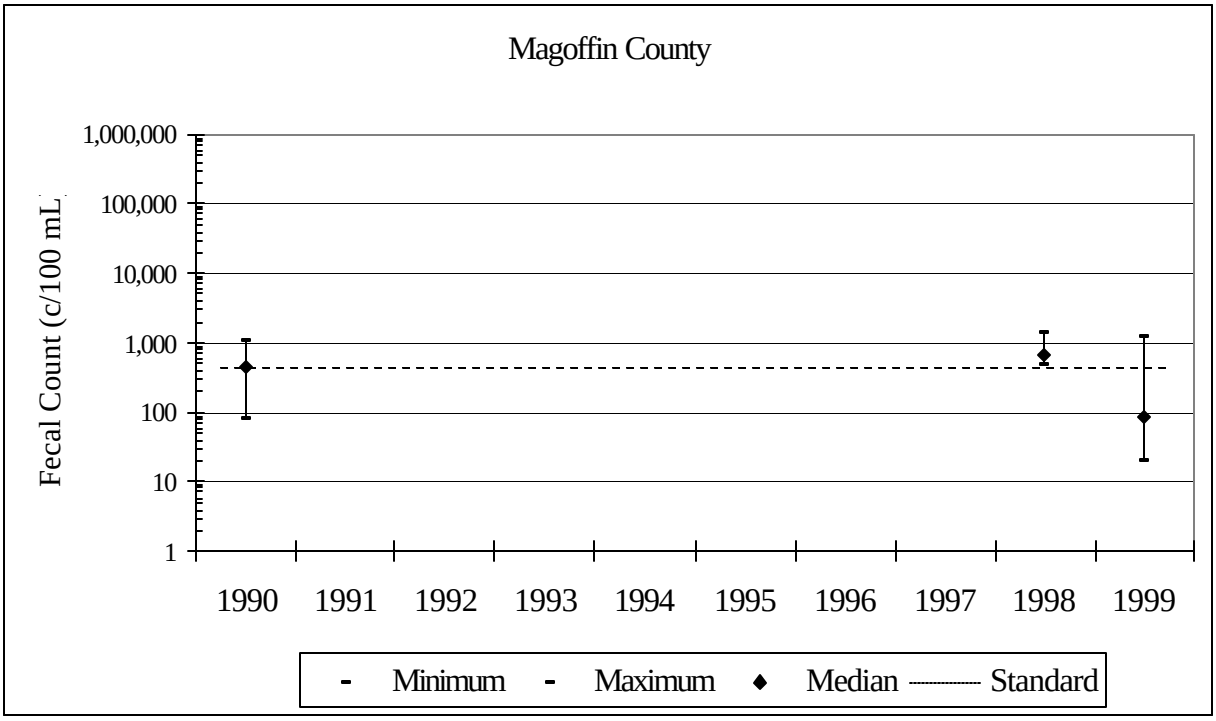

Figure 2.50. Fecal Coliform Results for Magoffin County

Table 2.32. Fecal Coliform Statistics for McCreary County

Year	Samples	Minimum	Maximum	Median
1990	28	2	867	10
1991	36	1	1,400	18
1992	38	1	180	35
1993	35	1	440	10
1994	31	2	2,300	20
1995	21	1	900	20
1996	6	10	990	240
1997	17	7	154	20
1998	16	5	1,900	14
1999				

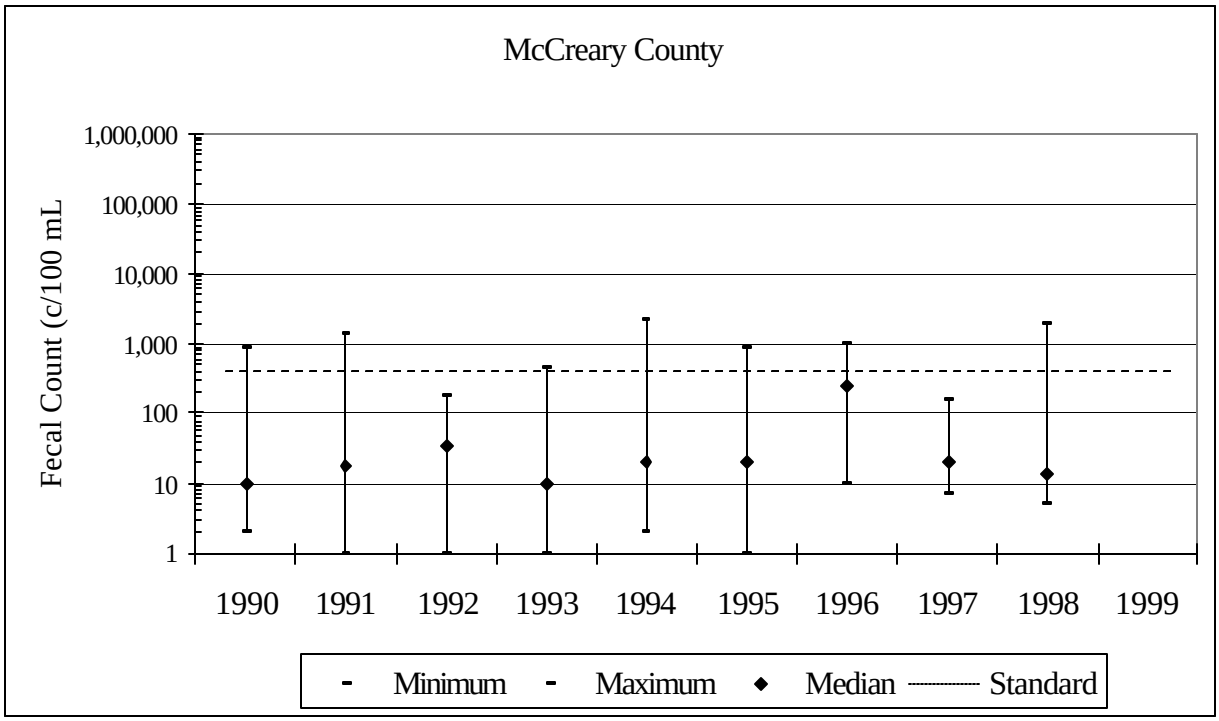

Figure 2.51. Fecal Coliform Results for McCreary County

Table 2.33. Fecal Coliform Statistics for Menifee County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	7	10	510	100
1999	1	8	8	8

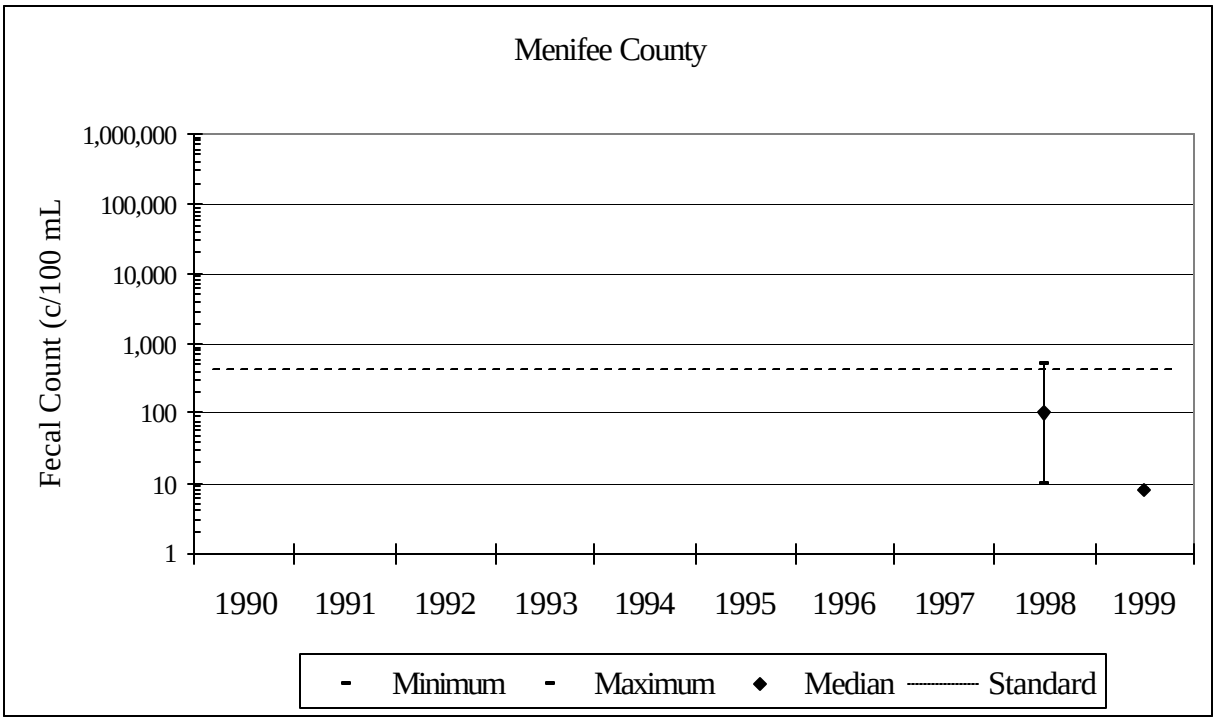

Figure 2.52. Fecal Coliform Results for Menifee County

Table 2.34. Fecal Coliform Statistics for Monroe County

Year	Samples	Minimum	Maximum	Median
1990	12	7	270	15
1991	9	8	770	44
1992	11	1	780	52
1993	12	1	50	16
1994	10	1	240	14
1995	9	9	900	58
1996	3	20	30	20
1997	5	10	220	14
1998	3	4	1,700	40
1999				

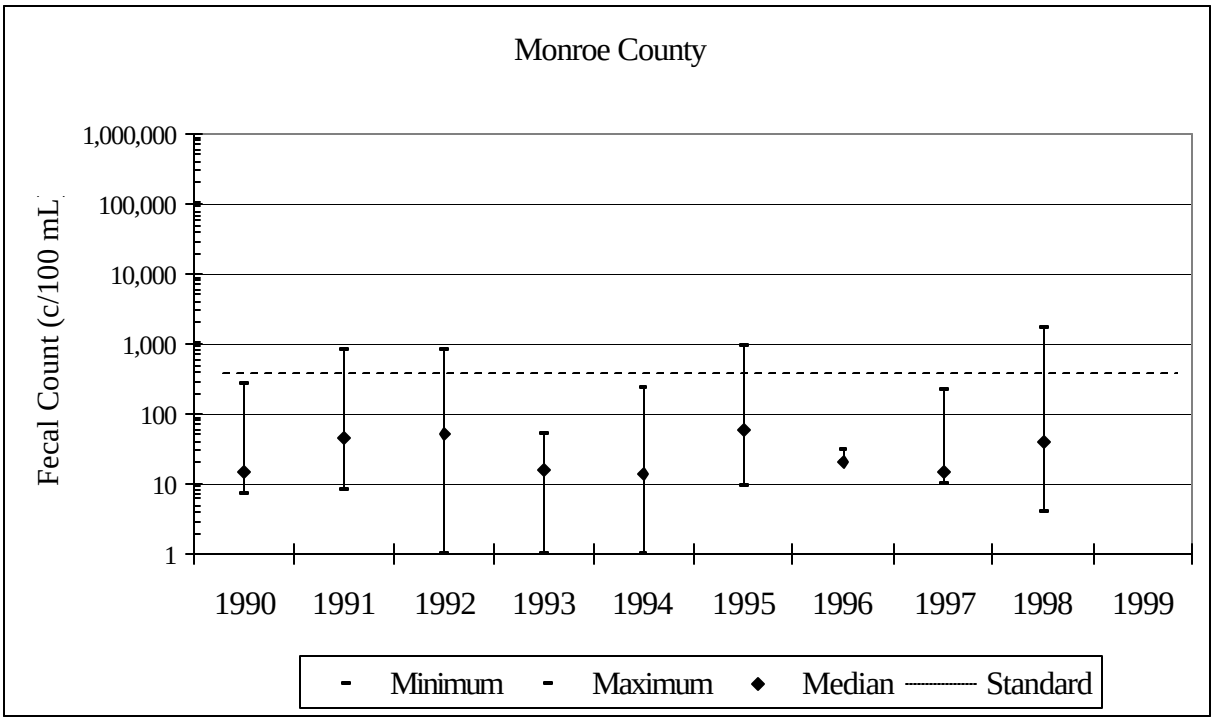

Figure 2.53. Fecal Coliform Results for Monroe County

Table 2.35. Fecal Coliform Statistics for Morgan County

Year	Samples	Minimum	Maximum	Median
1990				
1991	12	25	1,400	365
1992	12	12	1,800	285
1993	11	12	2,400	380
1994	12	57	2,100	435
1995	9	80	1,400	480
1996				
1997				
1998	5	300	9,600	400
1999	3	80	960	280

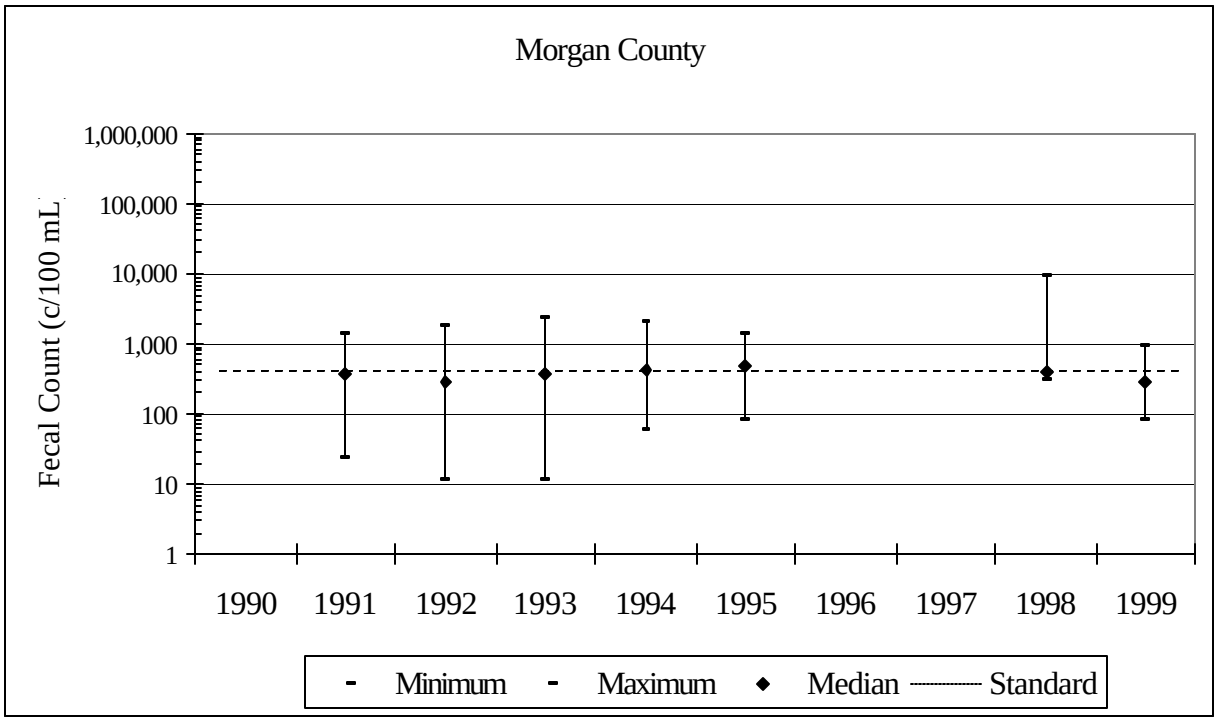

Figure 2.54. Fecal Coliform Results for Morgan County

Table 2.36. Fecal Coliform Statistics for Owsley County

Year	Samples	Minimum	Maximum	Median
1990	12	30	300	106
1991	12	10	700	75
1992	12	10	6,000	65
1993	12	10	2,600	35
1994	12	10	1,800	165
1995	9	50	2,400	700
1996	6	40	400	120
1997	5	10	270	40
1998	11	10	2,500	120
1999				

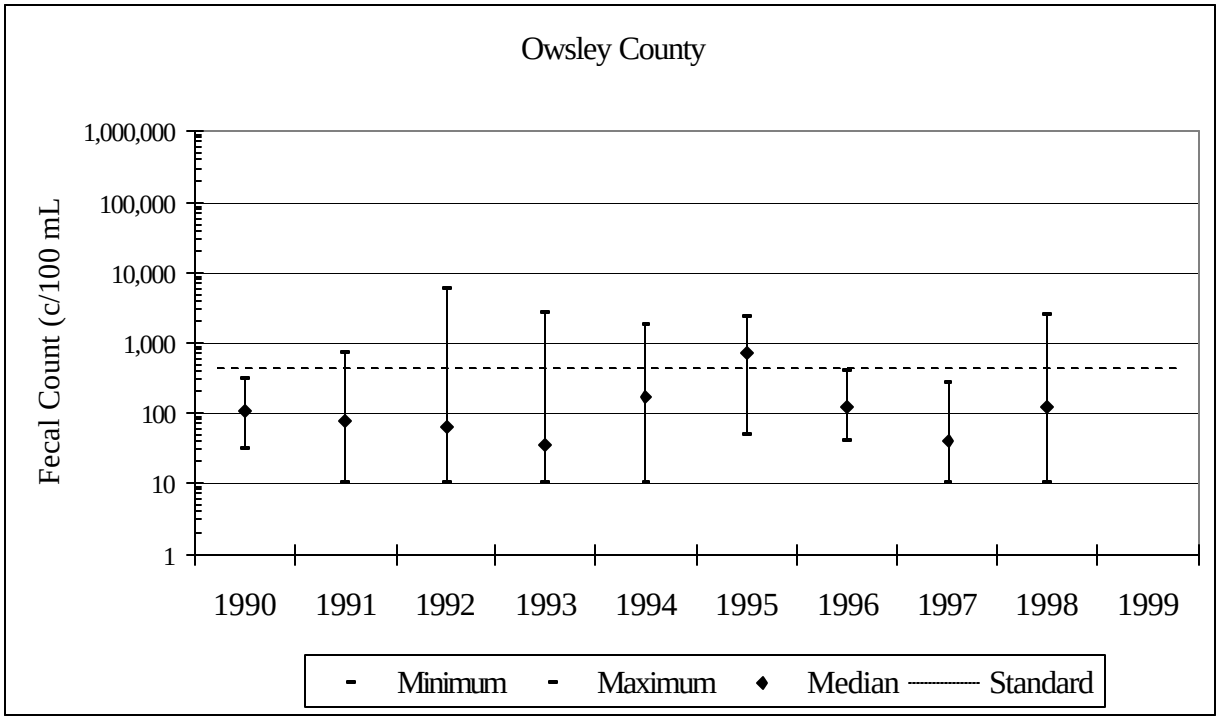

Figure 2.55. Fecal Coliform Results for Owsley County

Table 2.37. Fecal Coliform Statistics for Perry County

Year	Samples	Minimum	Maximum	Median
1990	49	60	16,000	540
1991	49	10	16,000	1,800
1992	42	10	100,000	1,250
1993	36	10	80,000	1,400
1994	32	10	36,000	1,550
1995	22	10	27,000	1,150
1996	27	10	80,000	3,000
1997	30	10	15,000	400
1998	108	10	64,000	400
1999	87	10	4,800	140

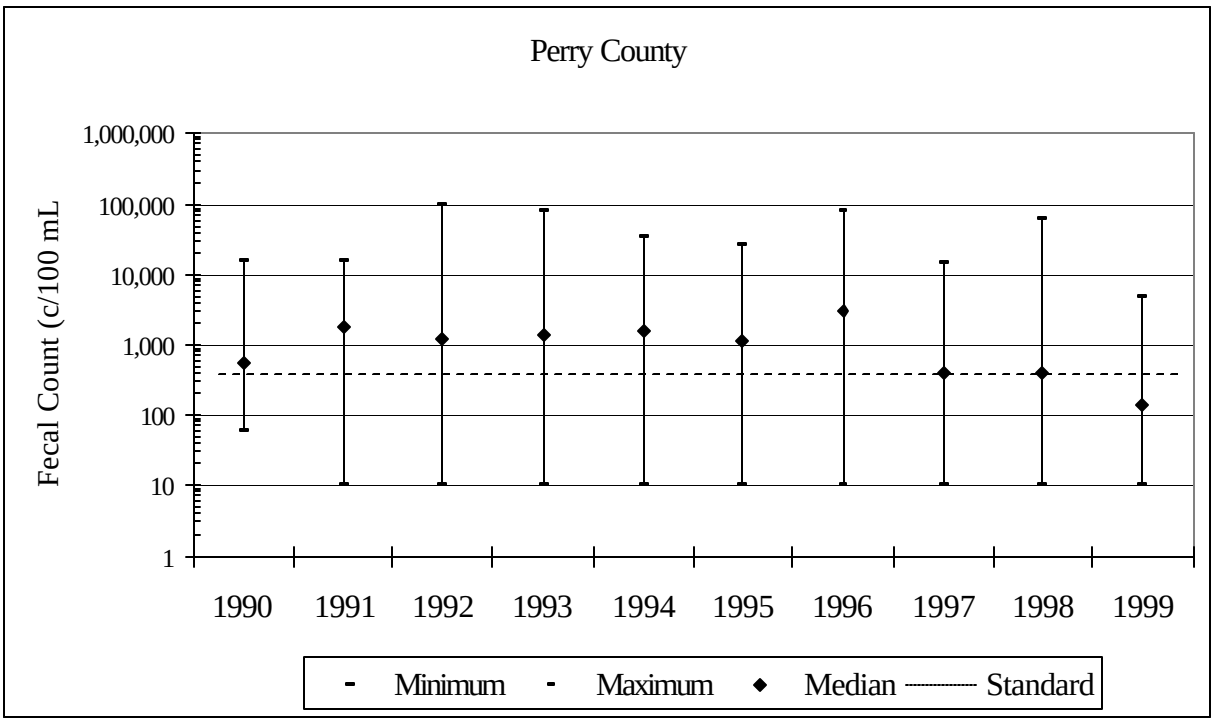

Figure 2.56. Fecal Coliform Results for Perry County

Table 2.38. Fecal Coliform Statistics for Pike County

Year	Samples	Minimum	Maximum	Median
1990	12	30	710	230
1991	12	150	6,000	600
1992	12	90	3,800	400
1993	45	1	60,000	60
1994	12	60	6,000	900
1995	8	40	2,400	255
1996				
1997				
1998	11	70	24,000	300
1999				

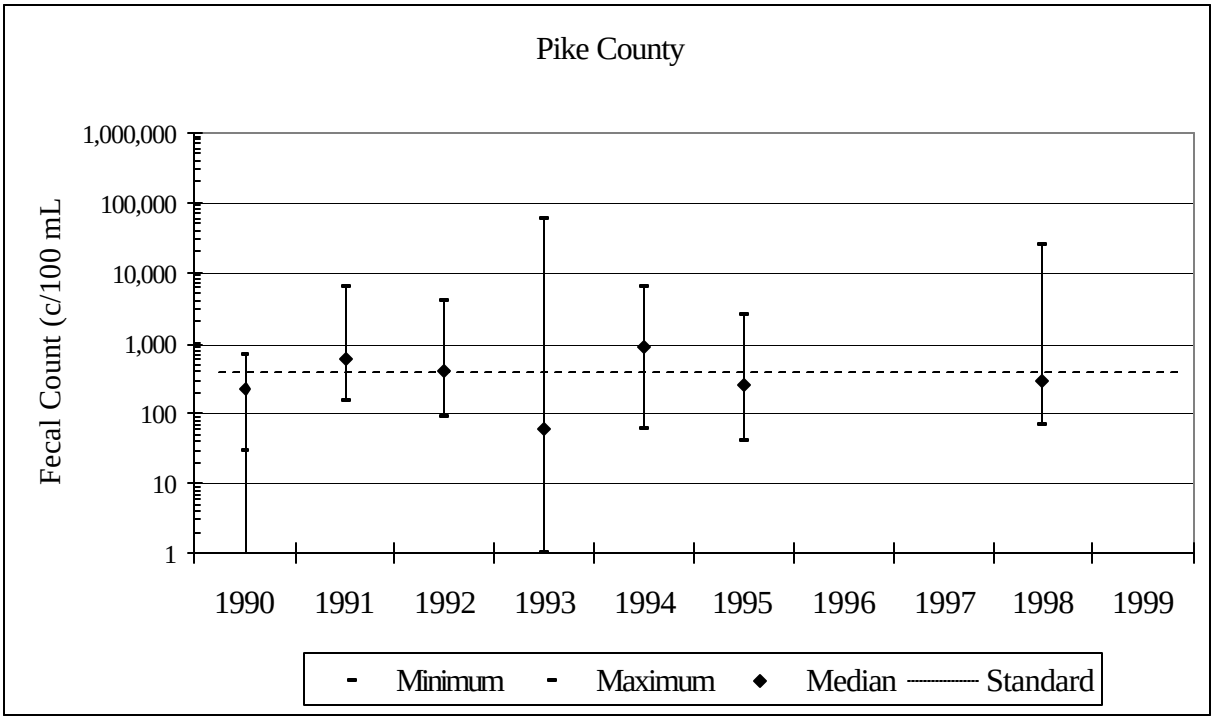

Figure 2.57. Fecal Coliform Results for Pike County

Table 2.39. Fecal Coliform Statistics for Pulaski County

Year	Samples	Minimum	Maximum	Median
1990	11	5	290	50
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	3	8	55	10
1999				

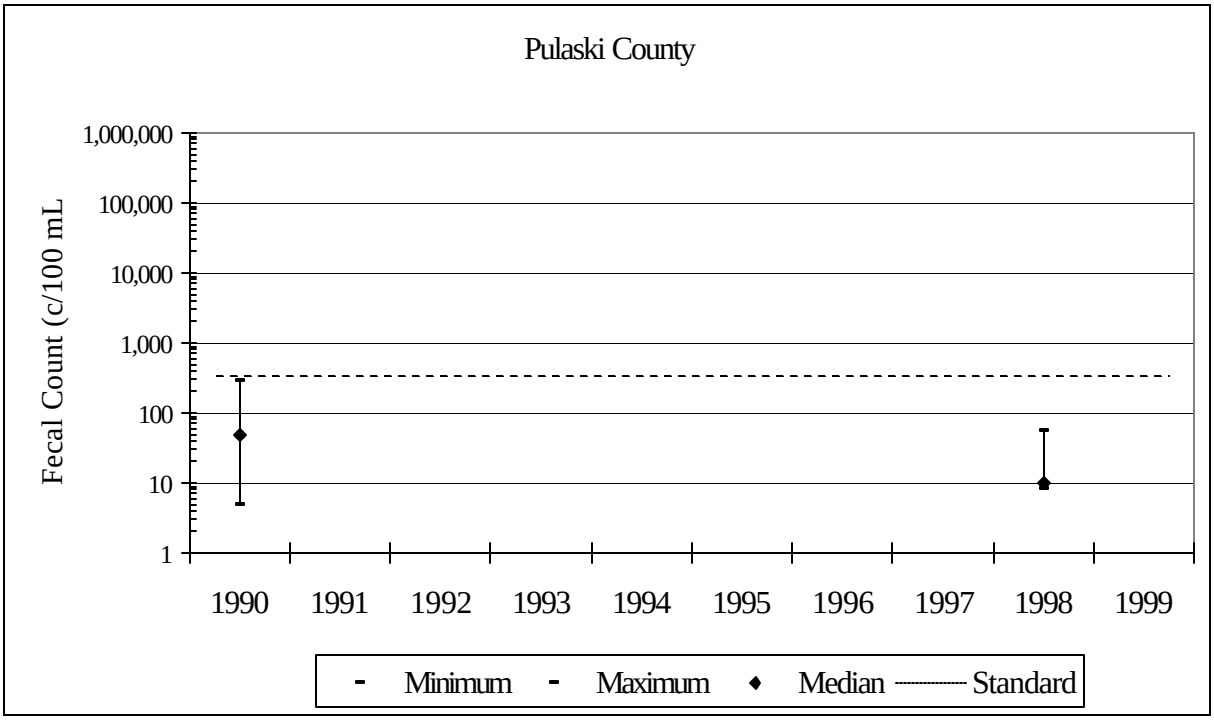

Figure 2.58. Fecal Coliform Results for Pulaski County

Table 2.40. Fecal Coliform Statistics for Rockcastle County

Year	Samples	Minimum	Maximum	Median
1990	11	5	890	25
1991	12	10	840	80
1992	12	10	2,300	30
1993	12	10	150	15
1994	12	6	950	20
1995	9	10	750	24
1996	3	3	3,200	239
1997	9	5	350	28
1998	8	10	450	42
1999	2	10	10	10

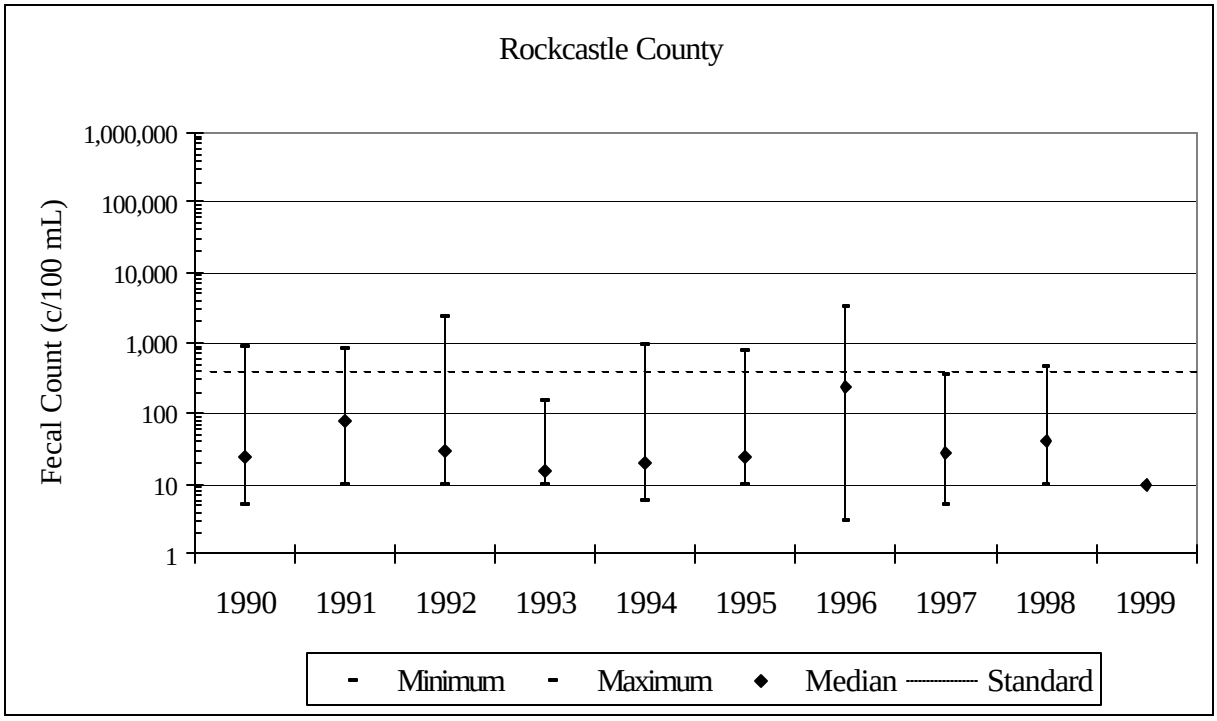

Figure 2.59. Fecal Coliform Results for Rockcastle County

Table 2.41. Fecal Coliform Statistics for Russell County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	60,000	60,000	60,000

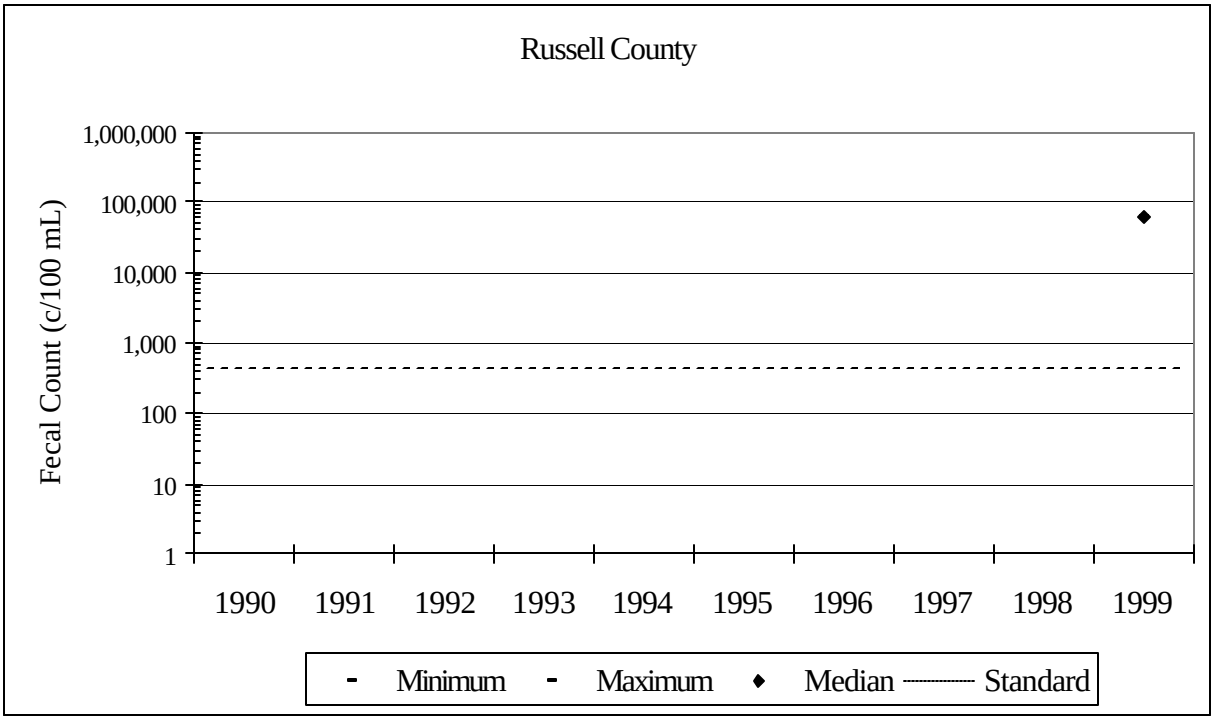

Figure 2.60. Fecal Coliform Results for Russell County

Table 2.42. Fecal Coliform Statistics for Wayne County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	10	10	10

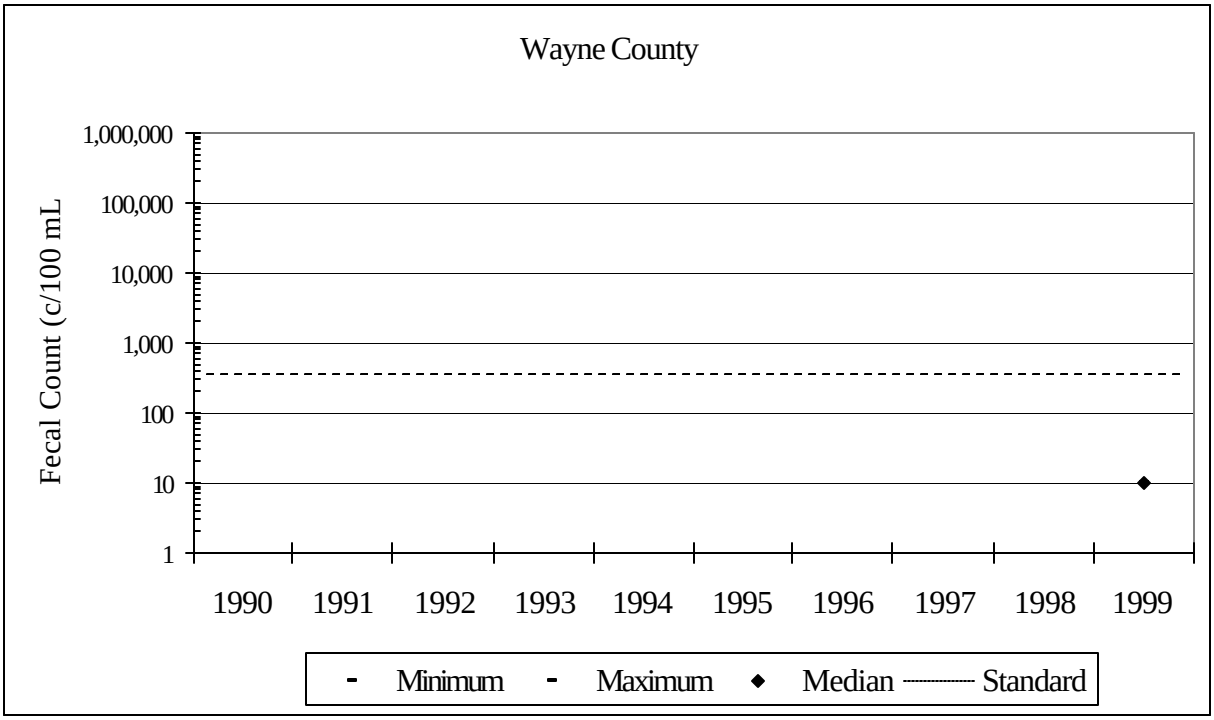

Figure 2.61. Fecal Coliform Results for Wayne County

Table 2.43. Fecal Coliform Statistics for Whitley County

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	3	35	110	80
1999	2	10	10	10

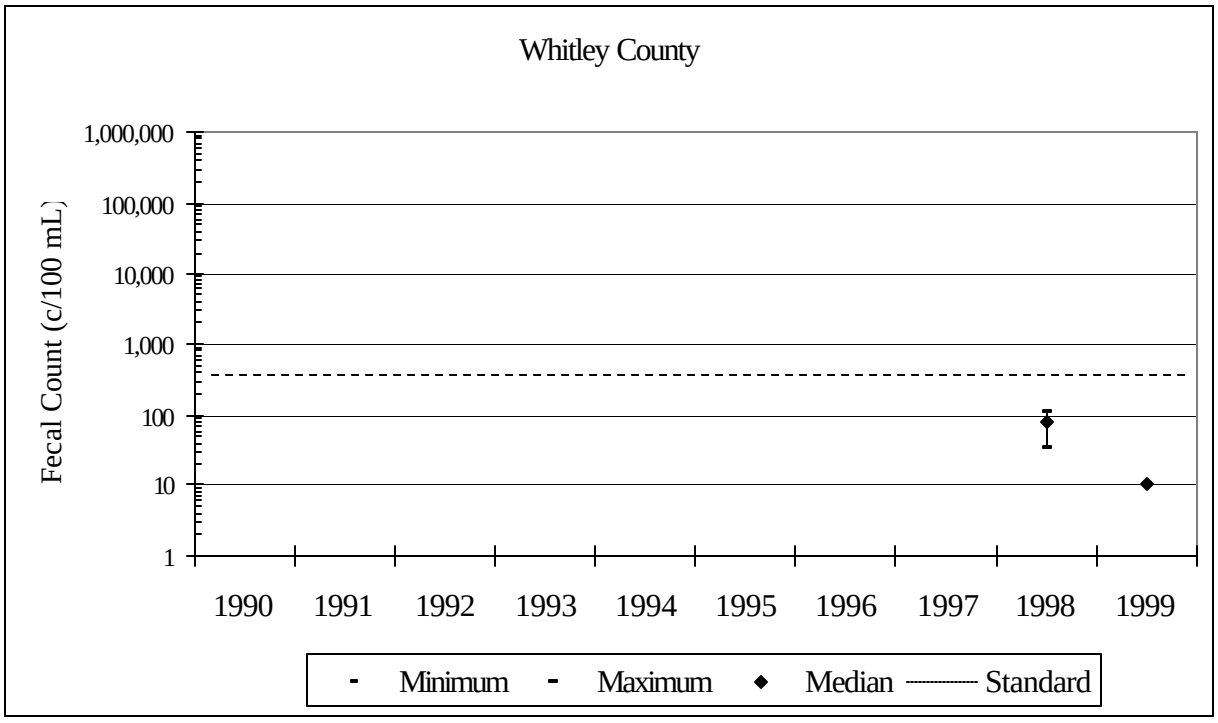

Figure 2.62 Fecal Coliform Results for Whitley County

Table 2.44. Fecal Coliform Statistics for Wolfe County

Year	Samples	Minimum	Maximum	Median
1990	12	30	3,400	109
1991	12	10	2,600	335
1992	5	10	4,000	90
1993	2	150	820	485
1994				
1995				
1996				
1997				
1998	3	100	270	180
1999	3	10	10	10

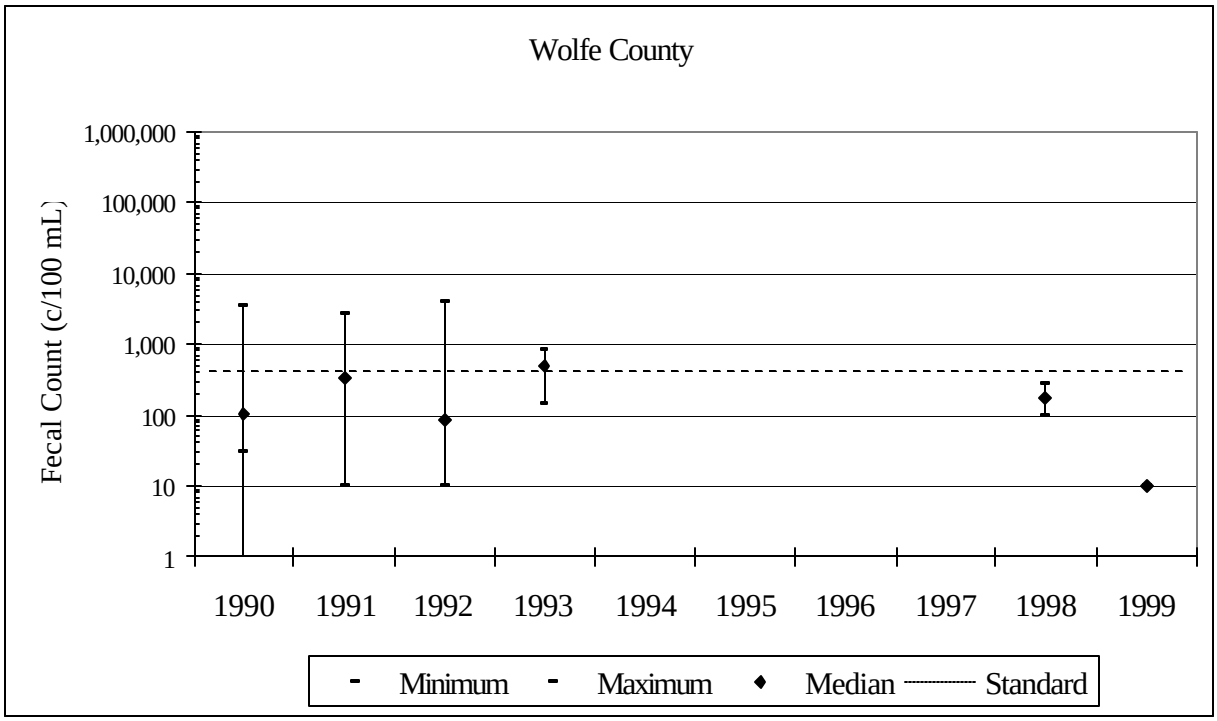

Figure 2.63. Fecal Coliform Results for Wolfe County

Table 2.45. Fecal Coliform Statistics for Big Sandy River Basin 05070202 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993	33	1	60,000	24
1994				
1995				
1996				
1997				
1998				
1999				

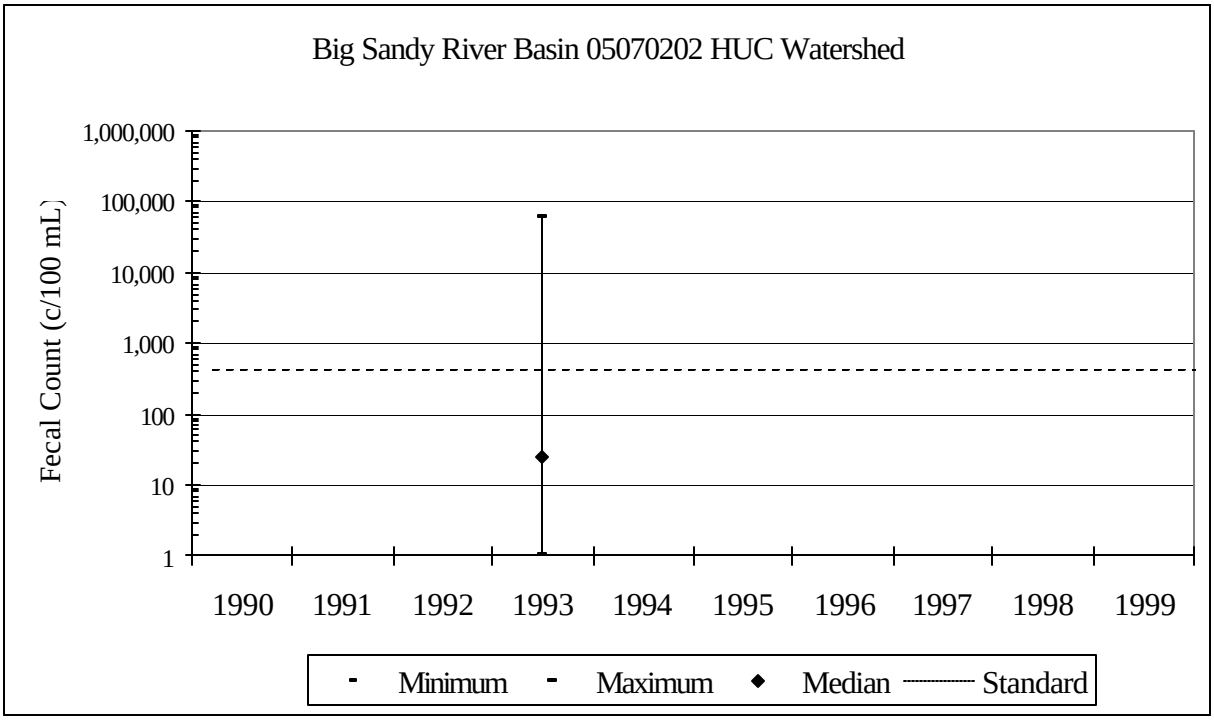

Figure 2.64. Fecal Coliform Results for Big Sandy River Basin 05070202 HUC Watershed

Table 2.46. Fecal Coliform Statistics for Big Sandy River Basin 05070203 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	24	30	1,900	345
1991	24	10	6,000	600
1992	24	60	3,800	405
1993	68	1	3,300	60
1994	24	20	7,000	900
1995	16	10	2,400	215
1996				
1997				
1998	21	30	24,000	260
1999	14	10	60,000	6,000

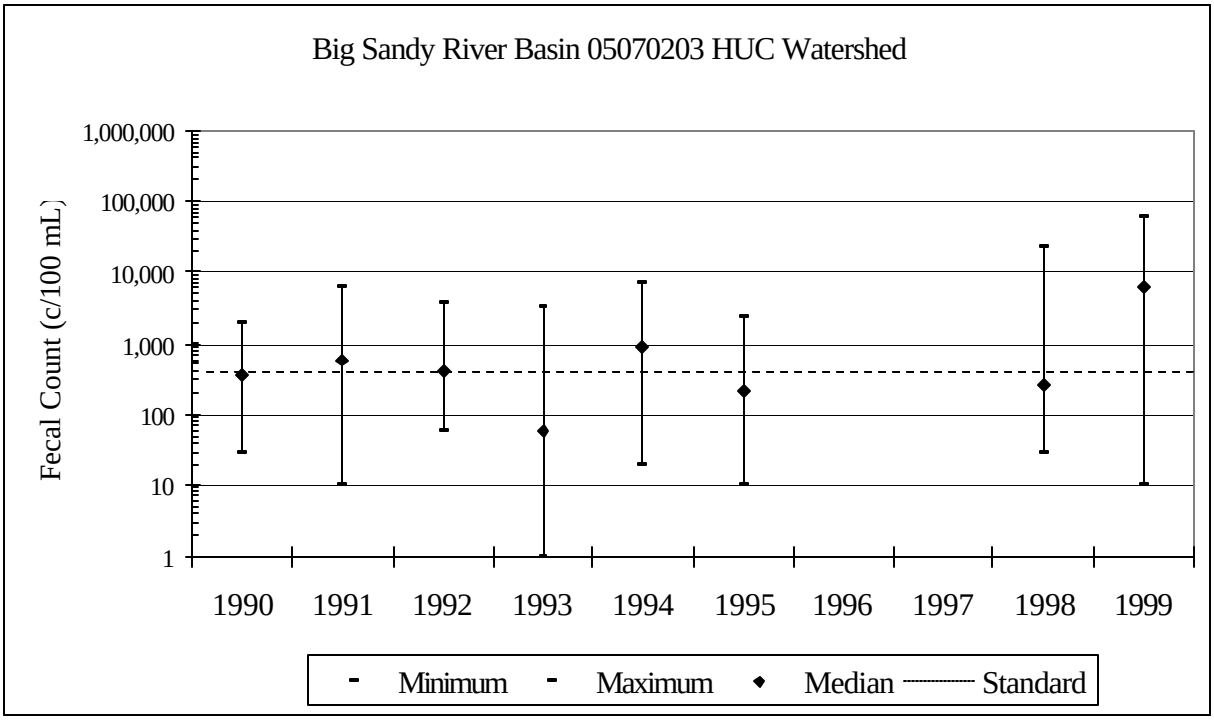

Figure 2.65. Fecal Coliform Results for Big Sandy River Basin 05070203 HUC Watershed

Table 2.47. Fecal Coliform Statistics for Big Sandy River Basin 05070204 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	6	260	7,935	3,156
1991	6	680	5,300	2,213
1992	4	1,739	4,066	2,245
1993	1	5,300	5,300	5,300
1994				
1995				
1996				
1997				
1998				
1999	1	9,000	9,000	9,000

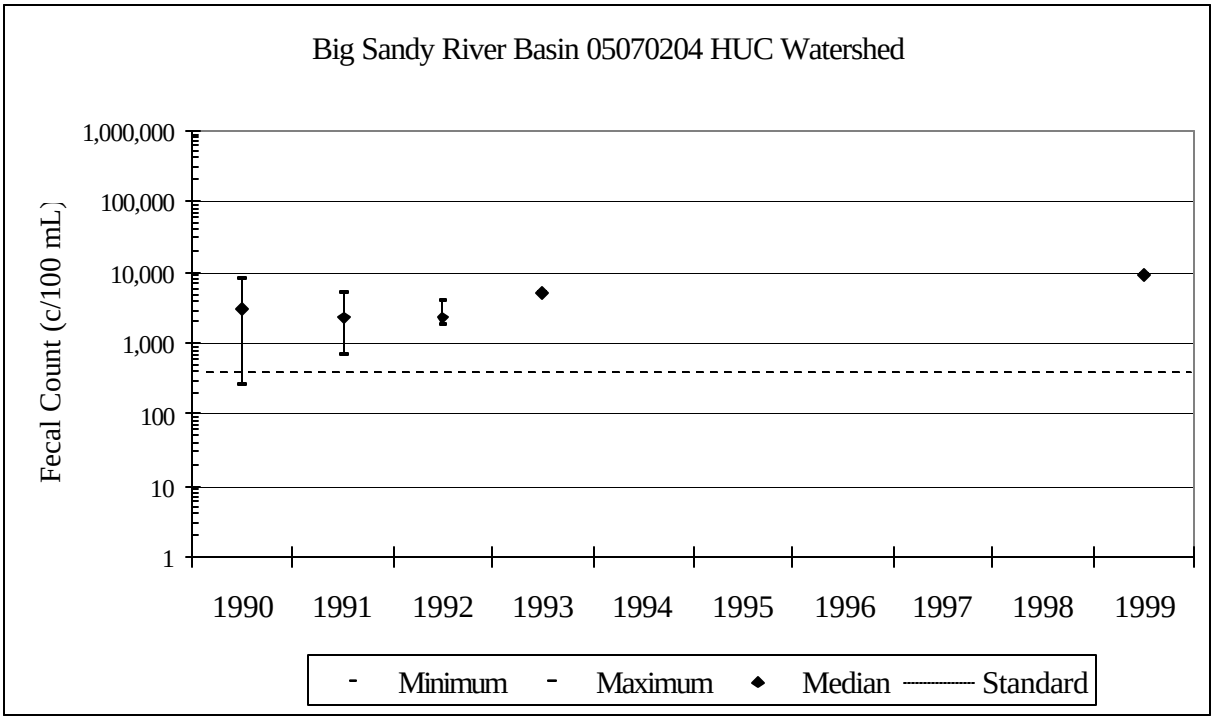

Figure 2.66. Fecal Coliform Results for Big Sandy River Basin 05070204 HUC Watershed

Table 2.48. Fecal Coliform Statistics for Licking River Basin 05100101 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	12	80	1,100	435
1991	12	25	1,400	365
1992	12	12	1,800	285
1993	11	12	2,400	380
1994	12	57	2,100	435
1995	9	80	1,400	480
1996				
1997				
1998	10	184	9,600	552
1999	8	8	1,200	110

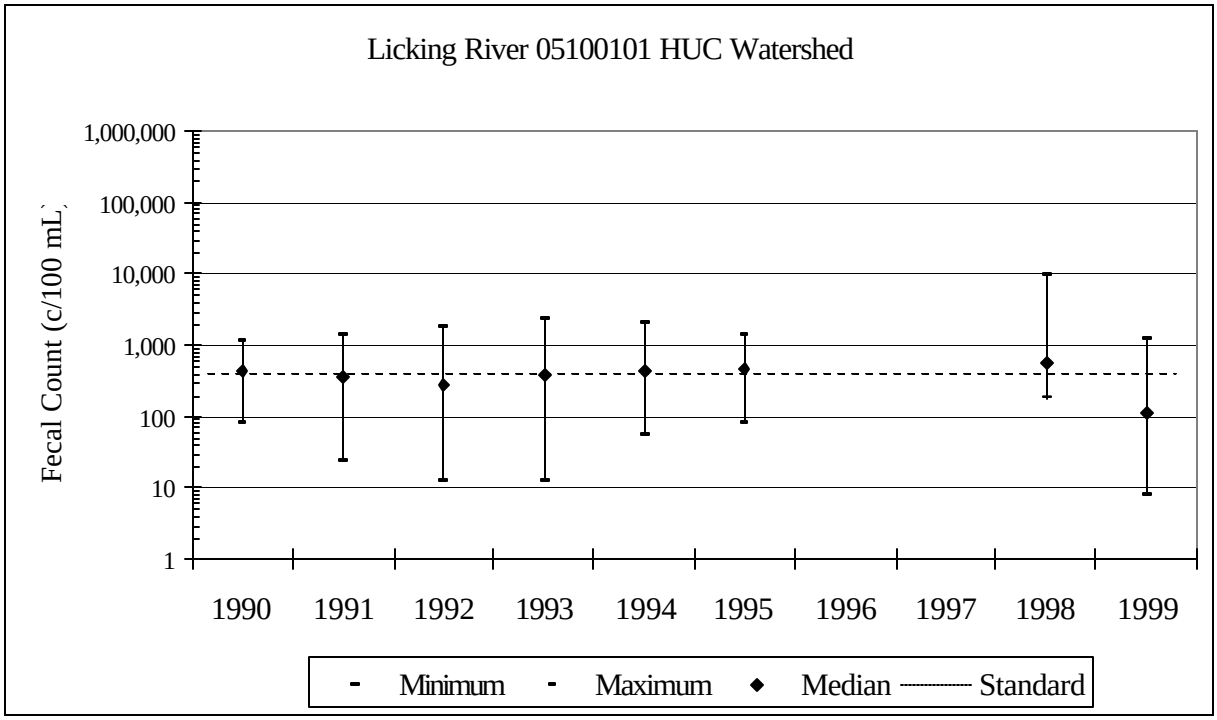

Figure 2.67. Fecal Coliform Results for Licking River 05100101 HUC Watershed

Table 2.49. Fecal Coliform Statistics for Kentucky River Basin 05100201 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	130	10	16,000	610
1991	136	1	16,000	1,400
1992	123	10	100,000	425
1993	104	10	80,000	300
1994	83	10	36,000	1,400
1995	62	10	80,000	530
1996	71	10	80,000	630
1997	72	10	56,000	340
1998	190	10	78,000	370
1999	130	10	30,000	125

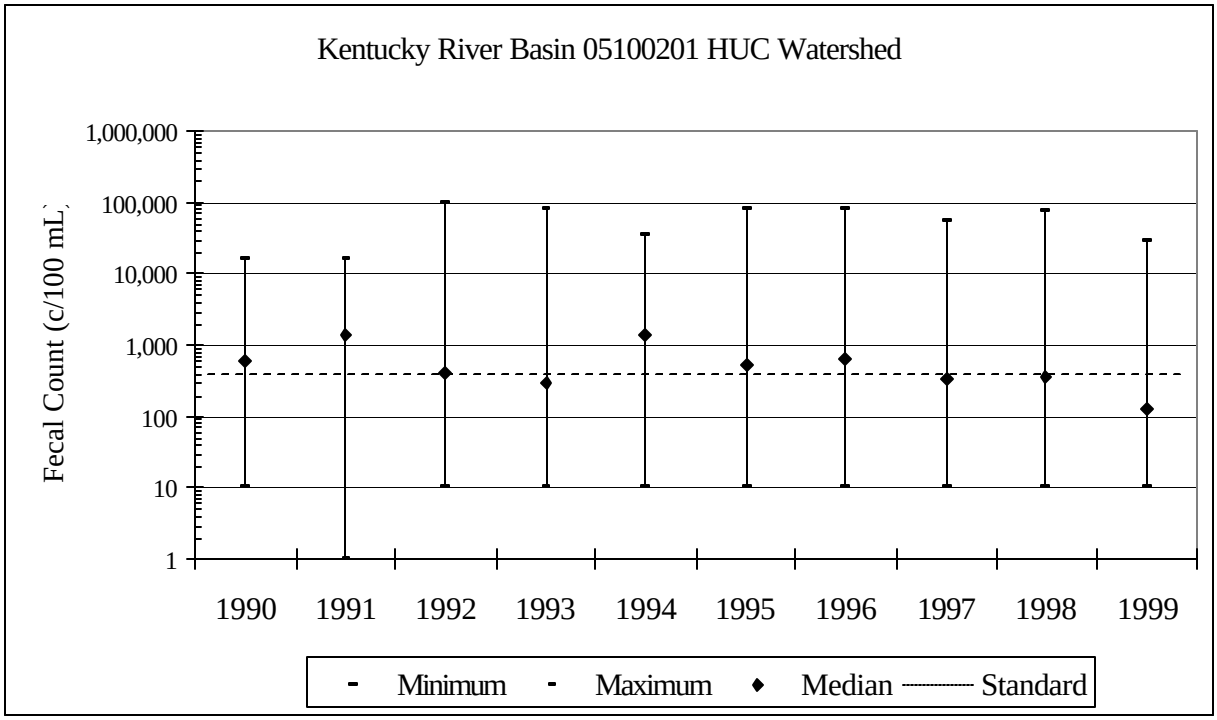

Figure 2.68. Fecal Coliform Results for Kentucky River Basin 05100201 HUC Watershed

Table 2.50. Fecal Coliform Statistics for Kentucky River Basin 05100202 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	12	30	370	105
1991	12	20	2,000	155
1992	12	10	3,000	100
1993	12	10	270	90
1994	12	20	390	170
1995	9	20	1,400	200
1996	6	20	280	105
1997	5	10	440	60
1998	9	10	1,600	50
1999	3	10	700	80

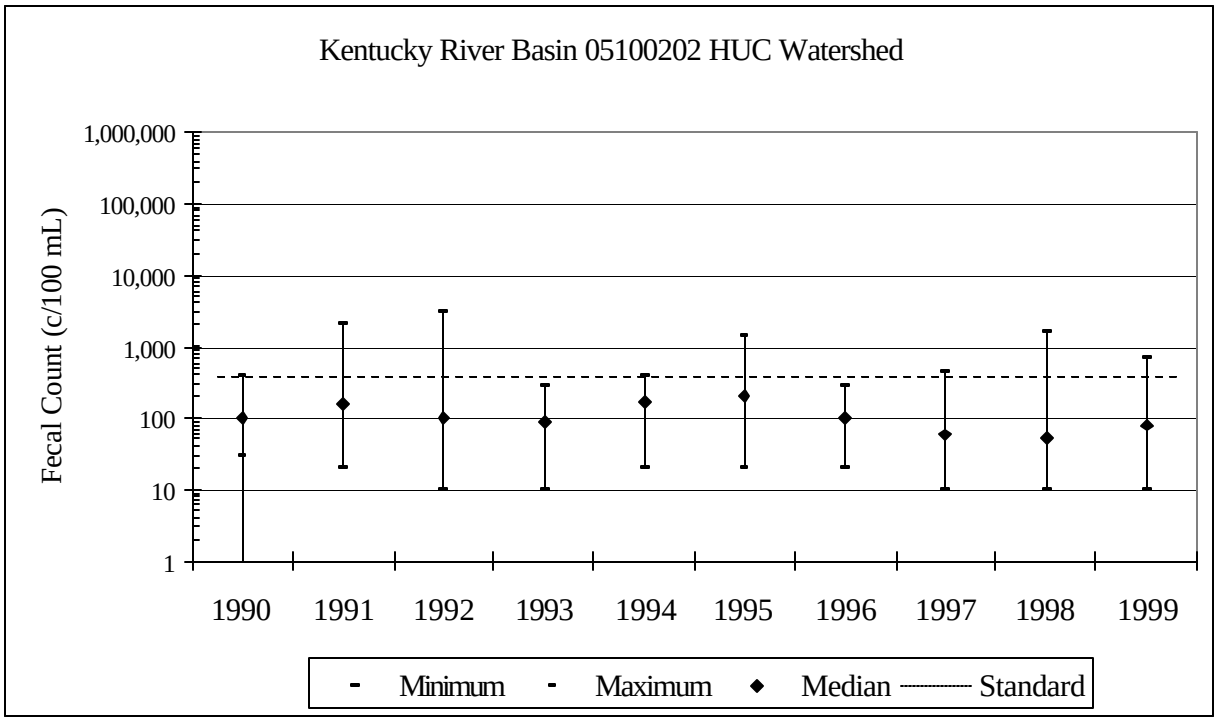

Figure 2.69. Fecal Coliform Results for Kentucky River Basin 05100202 HUC Watershed

Table 2.51. Fecal Coliform Statistics for Kentucky River Basin 05100203 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	12	30	300	106
1991	12	10	700	75
1992	12	10	6,000	65
1993	12	10	2,600	35
1994	12	10	1,800	165
1995	9	50	2,400	700
1996	6	40	400	120
1997	5	10	270	40
1998	26	8	2,500	133
1999	4	20	150	80

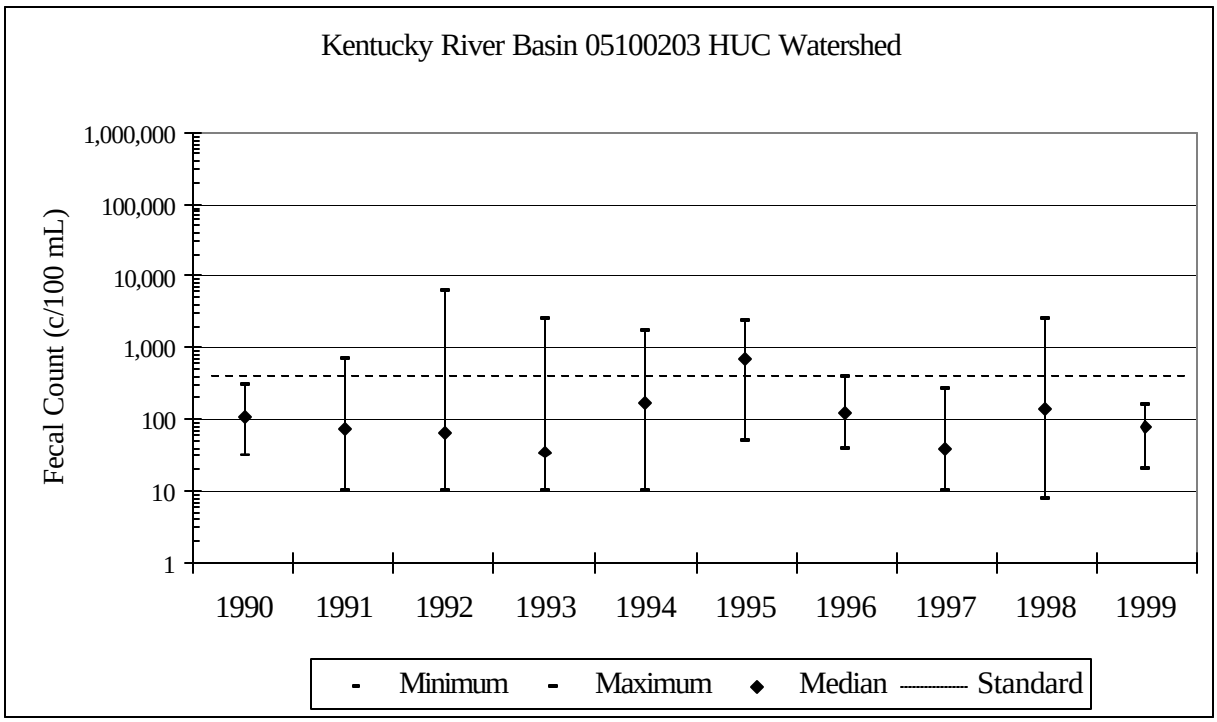

Figure 2.70. Fecal Coliform Results for Kentucky River Basin 05100203 HUC Watershed

Table 2.52. Fecal Coliform Statistics for Kentucky River Basin 05100204 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	24	12	3,400	130
1991	24	10	2,600	100
1992	17	10	4,000	90
1993	14	4	2,300	40
1994	12	10	1,600	36.5
1995	9	10	440	20
1996	6	10	2,000	90
1997	5	10	600	40
1998	40	10	8,000	95
1999	9	10	700	10

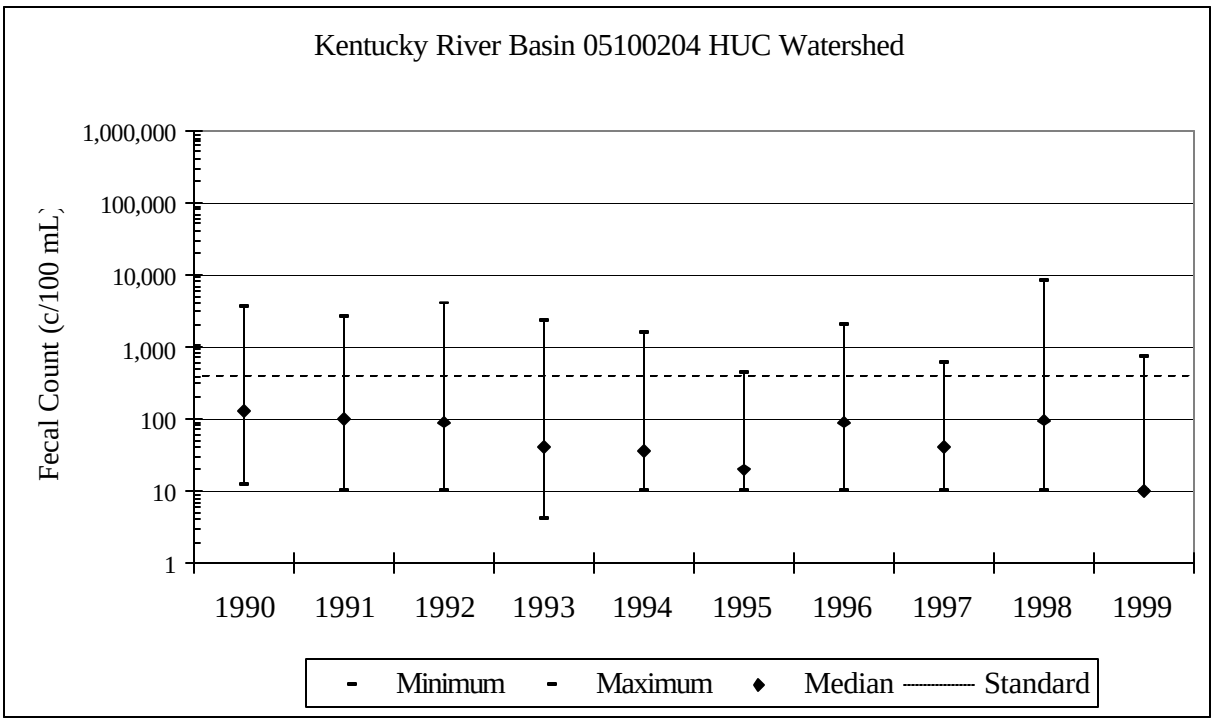

Figure 2.71. Fecal Coliform Results for Kentucky River Basin 05100204 HUC Watershed

Table 2.53. Fecal Coliform Statistics for Kentucky River Basin 05100205 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	24	4	2,200	330
1991	24	8	410	88
1992	24	10	8,000	50
1993	24	8	4,000	44.5
1994	49	2	2,500	10
1995	18	10	18,300	75
1996	12	10	16,000	100
1997	13	10	6,800	70
1998	24	10	60,000	205
1999	10	10	2,000	80

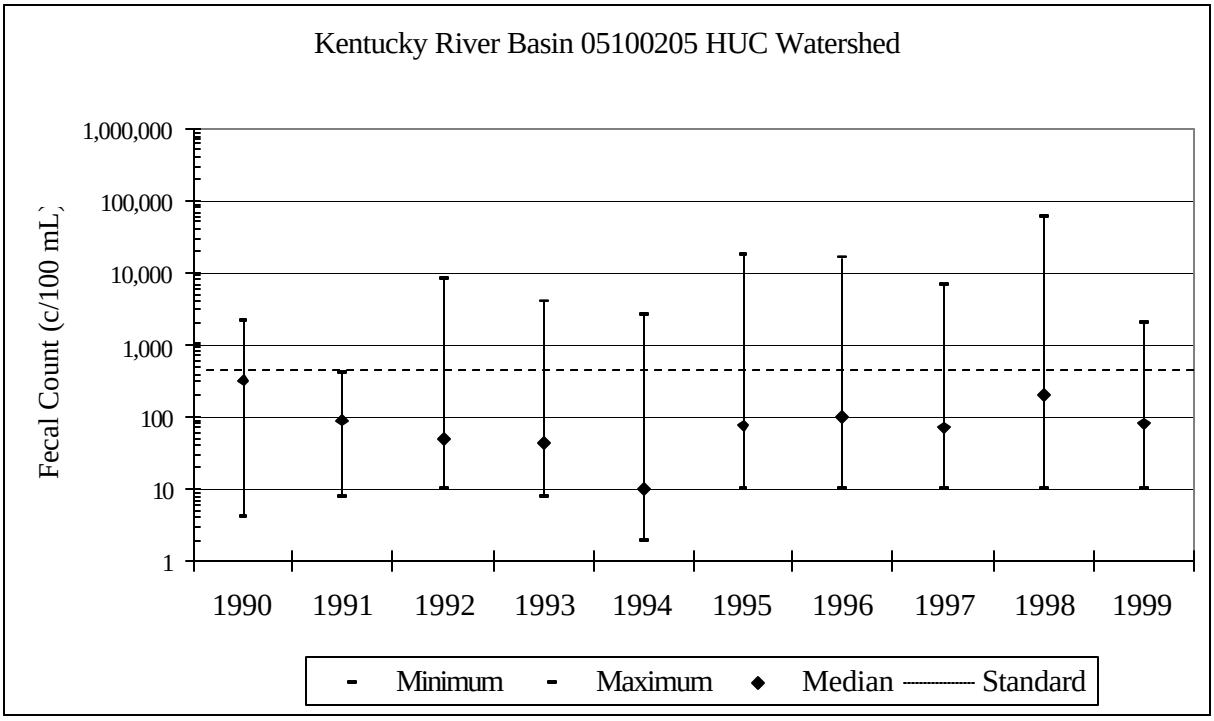

Figure 2.72. Fecal Coliform Results for Kentucky River Basin 05100205 HUC Watershed

Table 2.54. Fecal Coliform Statistics for Green River Basin 05110001 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	6	35	400	155
1999				

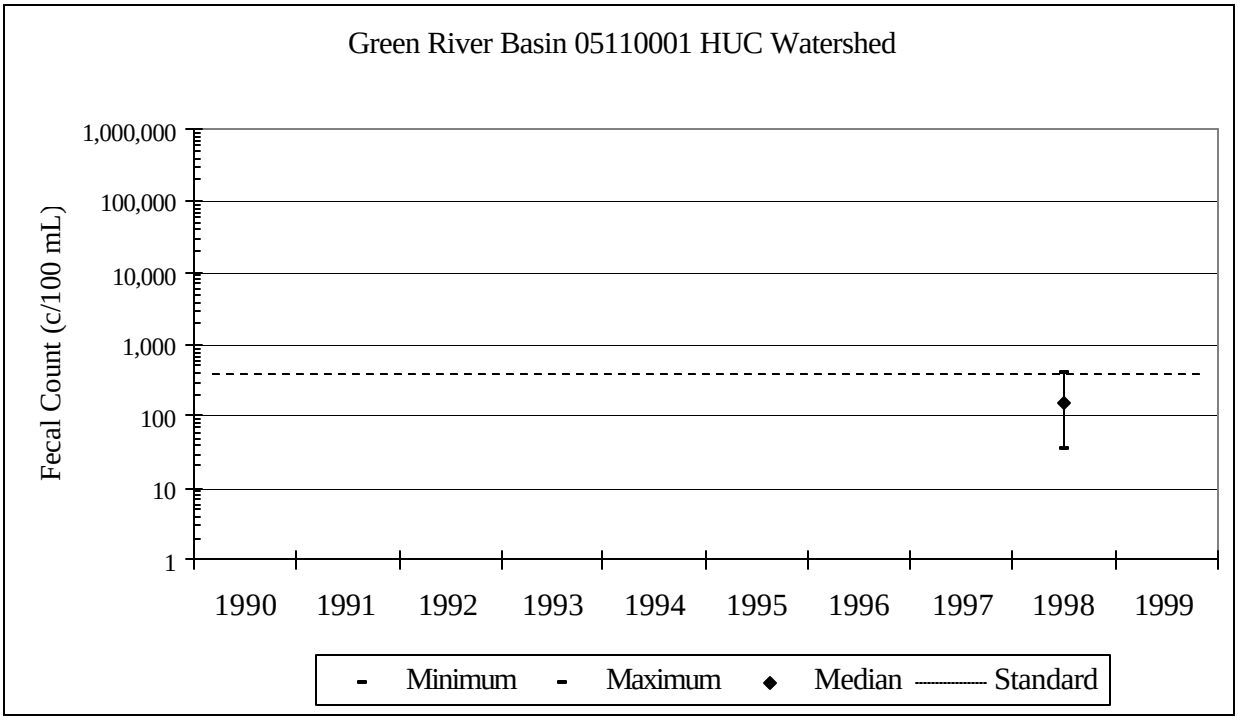

Figure 2.73. Fecal Coliform Results for Green River Basin 05110001 HUC Watershed

Table 2.55. Fecal Coliform Statistics for Upper Cumberland River Basin 05130101 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	22	1	720	220
1991	24	10	1,800	185
1992	24	10	520	65
1993	40	9	1,300,000	130
1994	218	4	480,000	555
1995	145	4	84,000	650
1996	161	10	230,000	850
1997	173	10	150,000	450
1998	199	5	137,000	450
1999	159	10	60,000	170

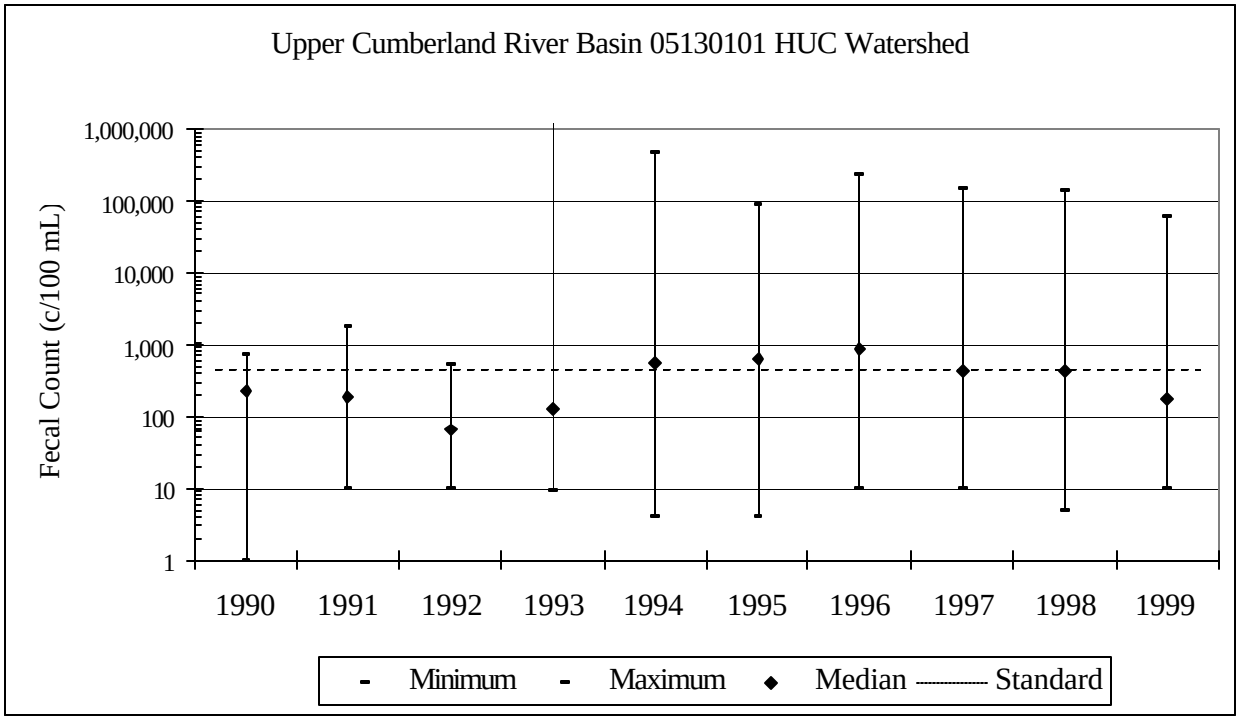

Figure 2.74. Fecal Coliform Results for Upper Cumberland River Basin 05130101 HUC Watershed

Table 2.56. Fecal Coliform Statistics for Upper Cumberland River Basin 05130102 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	22	5	890	22.5
1991	24	10	840	55
1992	24	10	2,300	40
1993	23	10	440	31
1994	24	6	950	20
1995	18	4	1,750	32
1996	6	3	3,200	118.5
1997	19	5	350	28
1998	16	10	570	52
1999	5	10	10	10

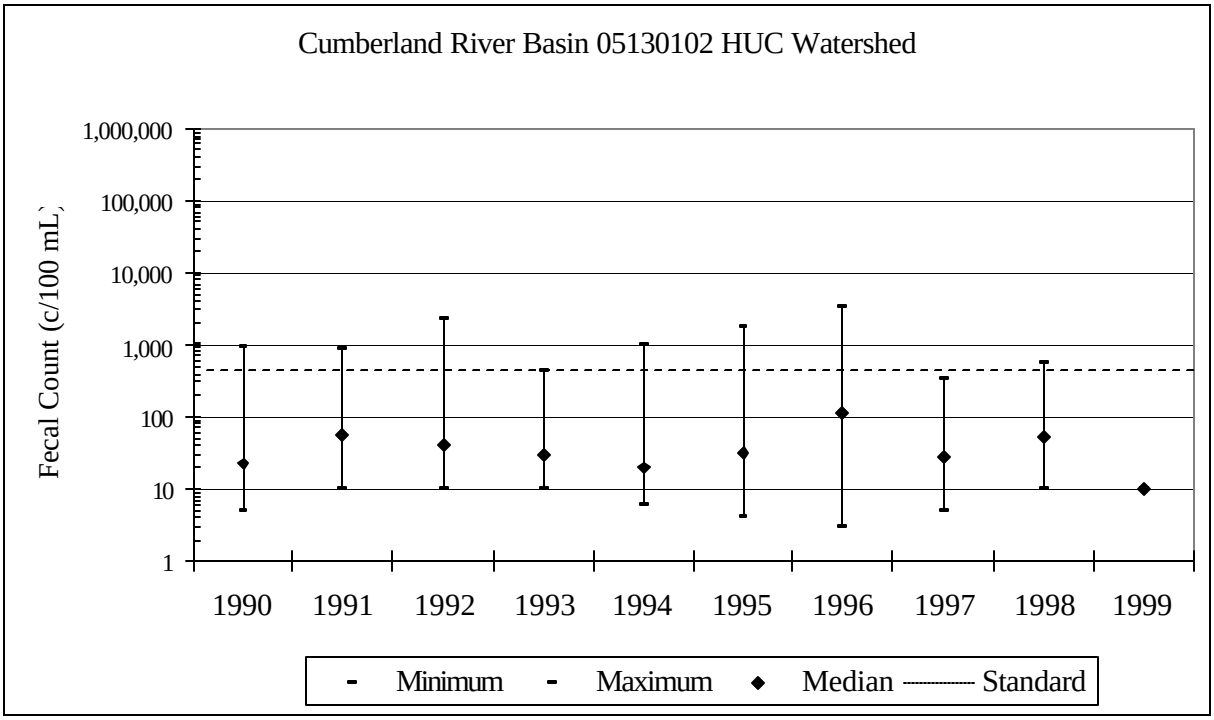

Figure 2.75. Fecal Coliform Results for Upper Cumberland River Basin 05130102 HUC Watershed

Table 2.57. Fecal Coliform Statistics for Upper Cumberland River Basin 05130103 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	23	5	290	34
1991	9	8	770	44
1992	11	1	780	52
1993	12	1	50	15.5
1994	10	1	240	13.5
1995	9	9	900	58
1996	3	20	30	20
1997	5	10	220	14
1998	6	4	1,700	25
1999				

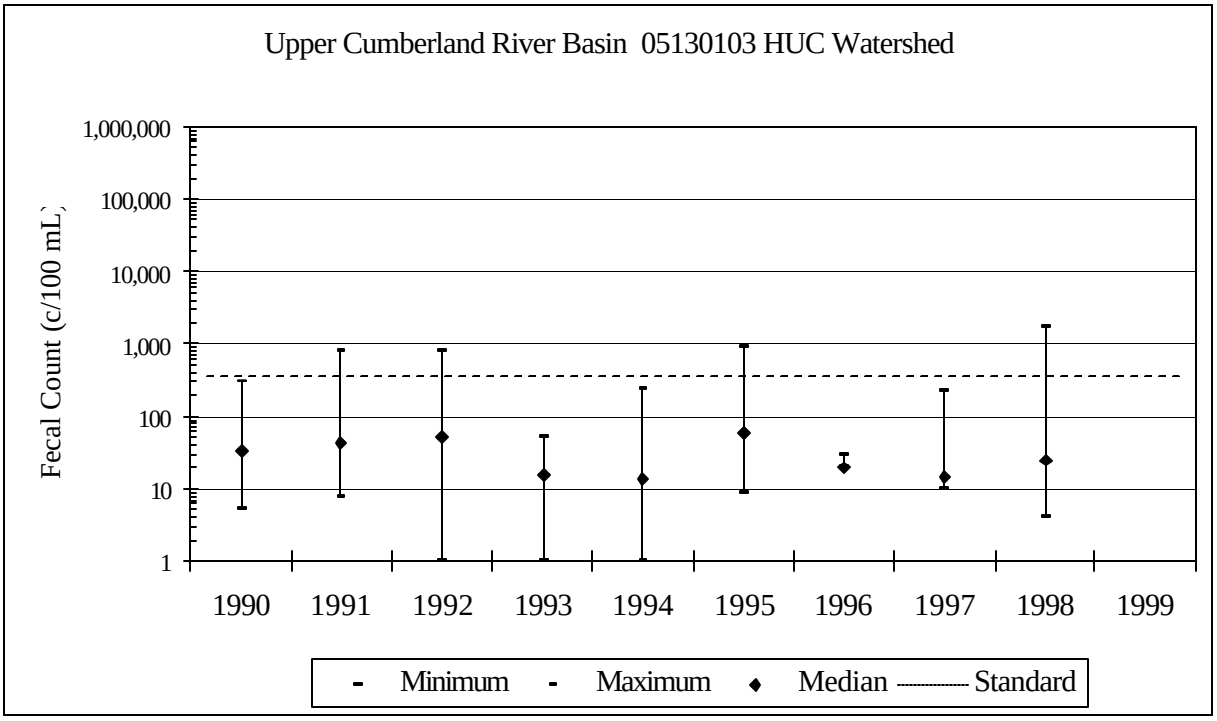

Figure 2.76. Fecal Coliform Results for Upper Cumberland River Basin 05130103 HUC Watershed

Table 2.58. Fecal Coliform Statistics for Upper Cumberland River Basin 05130104 HUC Watershed

Year	Samples	Minimum	Maximum	Median
1990	17	2	867	10
1991	24	1	900	10
1992	26	1	180	15
1993	23	1	440	10
1994	19	2	530	10
1995	12	1	530	10
1996	3	10	420	60
1997	8	7	75	10
1998	8	5	80	10
1999				

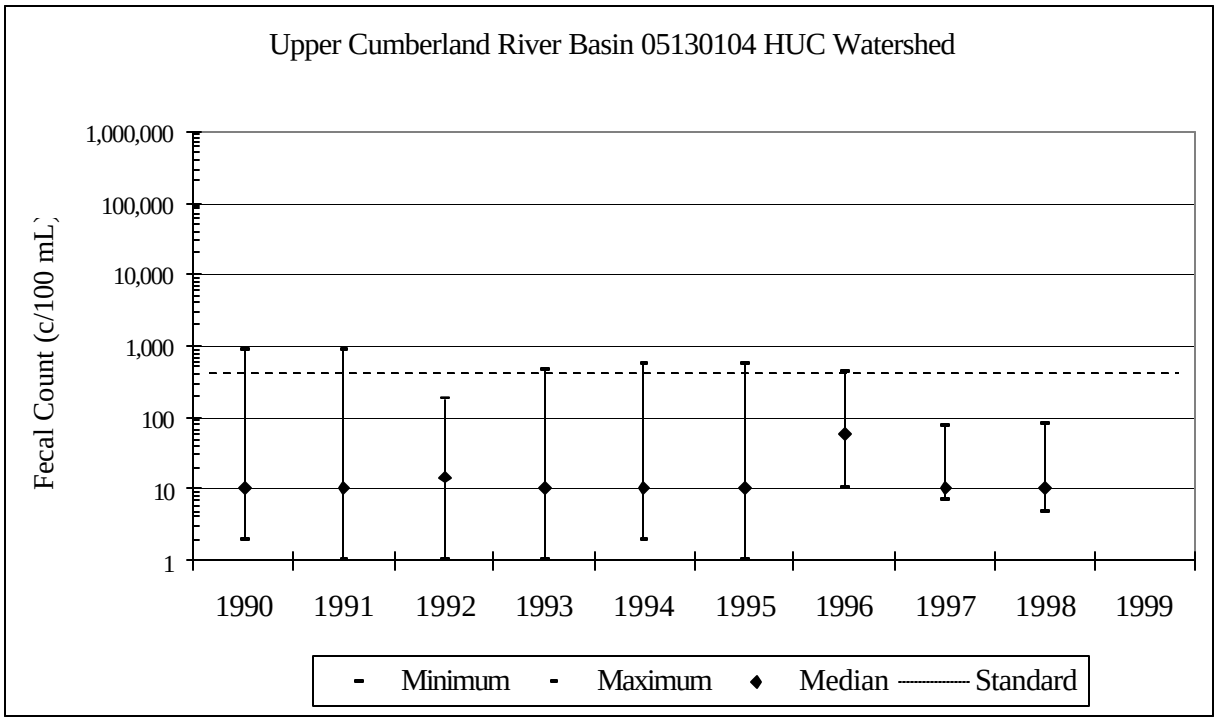

Figure 2.77. Fecal Coliform Results for Upper Cumberland River Basin 05130104 HUC Watershed

Table 2.59. Mean Habitat Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			162.50							
BELL										
BREATHITT		183.00							139.07	153.00
CASEY									166.00	
CLAY									124.00	
CLINTON										
CUMBERLAND										
ESTILL			184.00						145.00	
FLOYD										
GARRARD									137.25	
GREEN										
HARLAN										
JACKSON			167.00						131.67	
JESSAMINE										
JOHNSON										
KNOTT		173.00							157.00	
KNOX										
LAUREL			182.00							
LAWRENCE										
LEE			165.00						155.25	
LESLIE									139.15	
LETCHER			186.00						149.00	
LINCOLN										
MAGOFFIN										124.22
MARTIN										
MCCREARY		172.00	160.00							
MENIFEE									142.80	79.00
METCALFE						152.00				
MONROE										
MORGAN			173.67							130.69
OWSLEY			175.00						153.75	
PERRY									139.22	
PIKE										
PULASKI			162.00							
ROCKCASTLE			183.00						123.00	
RUSSELLL										
TAYLOR										
WAYNE										
WHITLEY		183.00								
WOLFE									128.67	

Table 2.60. Maximum Habitat Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			163.00							
BELL										
BREATHITT		183.00							176.00	167.00
CASEY									166.00	
CLAY									153.00	
CLINTON										
CUMBERLAND										
ESTILL			184.00						172.00	
FLOYD										
GARRARD									153.00	
GREEN										
HARLAN										
JACKSON			167.00						165.00	
JESSAMINE										
JOHNSON										
KNOTT		173.00							178.00	
KNOX										
LAUREL			182.00							
LAWRENCE										
LEE			165.00						166.00	
LESLIE									174.00	
LETCHER			186.00						165.00	
LINCOLN										
MAGOFFIN										146.00
MARTIN										
MCCREARY		172.00	160.00							
MENIFEE									174.00	79.00
METCALFE						152.00				
MONROE										
MORGAN			178.00							175.00
OWSLEY			175.00						174.00	
PERRY									165.00	
PIKE										
PULASKI			162.00							
ROCKCASTLE			183.00						123.00	
RUSSELLL										
TAYLOR										
WAYNE										
WHITLEY		188.00								
WOLFE									160.00	

Table 2.61. Minimum Habitat Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			162.00							
BELL										
BREATHITT		183.00							109.00	139.00
CASEY									166.00	
CLAY									153.00	
CLINTON										
CUMBERLAND										
ESTILL			184.00						117.00	
FLOYD										
GARRARD									127.00	
GREEN										
HARLAN										
JACKSON			167.00						113.00	
JESSAMINE										
JOHNSON										
KNOTT		173.00							136.00	
KNOX										
LAUREL			182.00							
LAWRENCE										
LEE			165.00						140.00	
LESLIE									90.00	
LETCHER			186.00						132.00	
LINCOLN										
MAGOFFIN										84.00
MARTIN										
MCCREARY		172.00	160.00							
MENIFEE									101.00	79.00
METCALFE						152.00				
MONROE										
MORGAN			168.00							97.00
OWSLEY			175.00						118.00	
PERRY									96.00	
PIKE										
PULASKI			162.00							
ROCKCASTLE			183.00						123.00	
RUSSELLL										
TAYLOR										
WAYNE										
WHITLEY		178.00								
WOLFE									97.00	

Table 2.62. Mean Habitat Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202										
05070203										
05070204										
05100101			173.67							125.91
05100201		178.00							140.22	153.00
05100202									137.75	
05100203			175.00						142.73	
05100204			172.00						140.71	
05100205									134.40	
05110001			162.50						166.00	
05110002						152.00				
05130101		179.33	173.00							
05130102			182.50							
05130103			162.00							
05130104										

Table 2.63. Maximum Habitat Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202										
05070203										
05070204										
05100101			178.00							175.00
05100201		183.00							178.00	167.00
05100202									174.00	
05100203			175.00						174.00	
05100204			184.00						174.00	
05100205									153.00	
05110001			163.00						166.00	
05110002						152.00				
05130101		188.00	186.00							
05130102			183.00							
05130103			162.00							
05130104										

Table 2.64. Minimum Habitat Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201										
05070202										
05070203										
05070204										
05100101			168.00							79.00
05100201		173.00							96.00	139.00
05100202									90.00	
05100203			175.00						84.00	
05100204			165.00						101.00	
05100205									123.00	
05110001			162.00						166.00	
05110002						152.00				
05130101		172.00	160.00							
05130102			182.00							
05130103			162.00							
05130104										

Table 2.65. Habitat Index Scores for Adair County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	162.00	163.00	162.50
1993				
1994				
1995				
1996				
1997				
1998				
1999				

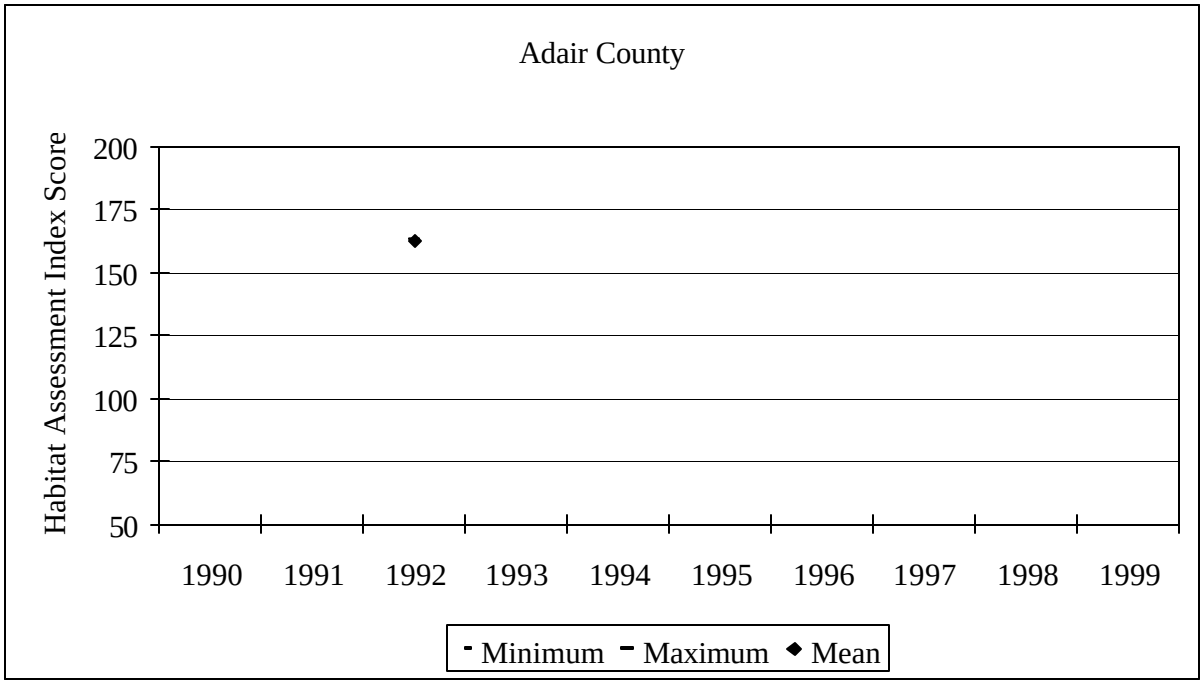

Figure 2.78. Habitat Index Scores for Adair County

Table 2.66. Habitat Index Scores for Breathitt County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	1	183.00	183.00	183.00
1992				
1993				
1994				
1995				
1996				
1997				
1998	15	109.00	176.00	139.07
1999	2	139.00	167.00	153.00

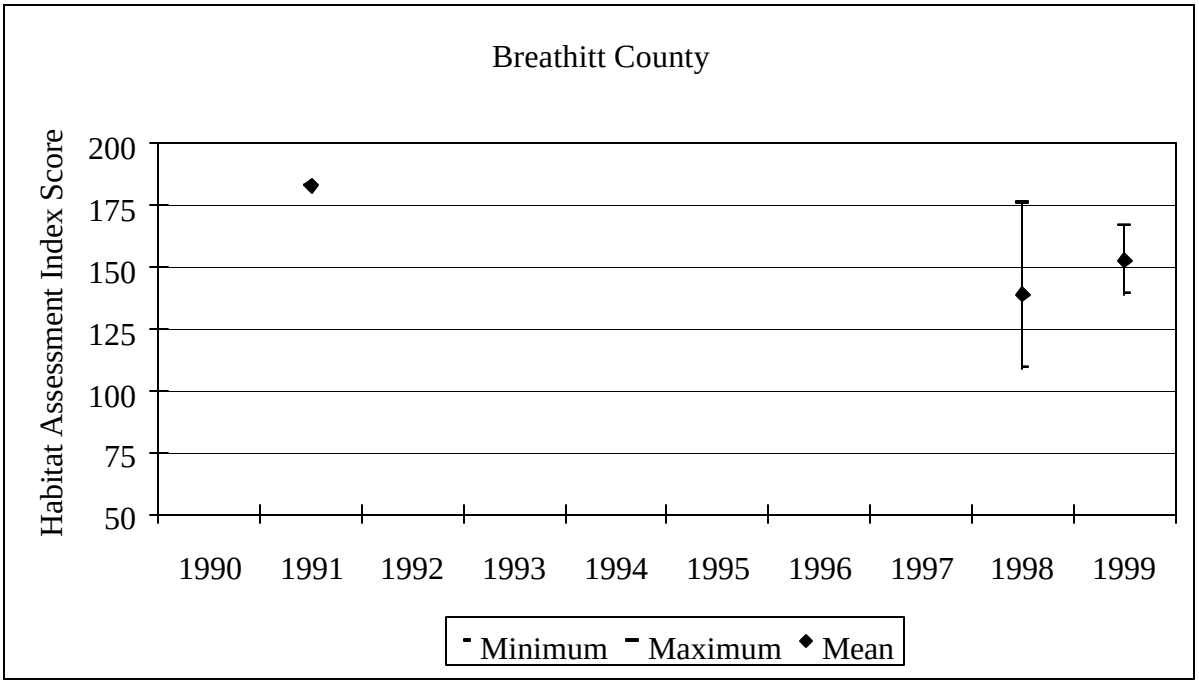

Figure 2.79. Habitat Index Scores for Breathitt County

Table 2.67. Habitat Index Scores for Casey County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	1	166.00	166.00	166.00
1999				

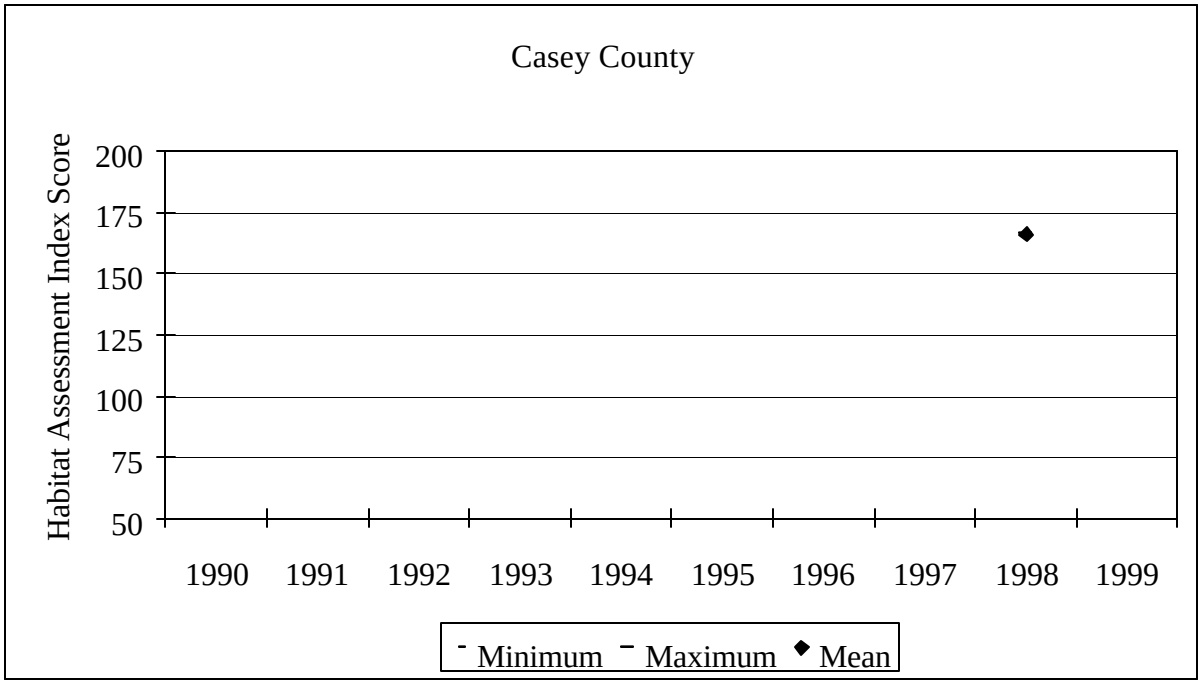

Figure 2.80. Habitat Index Scores for Casey County

Table 2.68. Habitat Index Scores for Clay County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	4	84.00	153.00	124.00
1999				

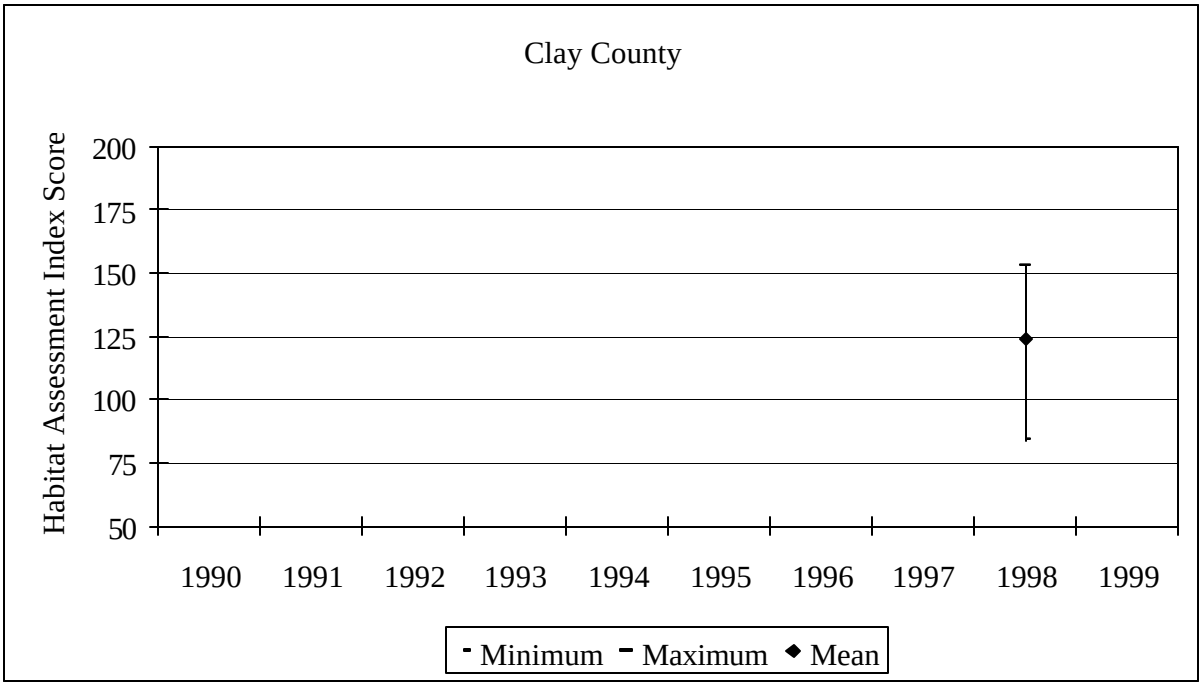

Figure 2.81. Habitat Index Scores for Clay County

Table 2.69. Habitat Index Scores for Estill County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	184.00	184.00	184.00
1993				
1994				
1995				
1996				
1997				
1998	4	117.00	172.00	145.00
1999				

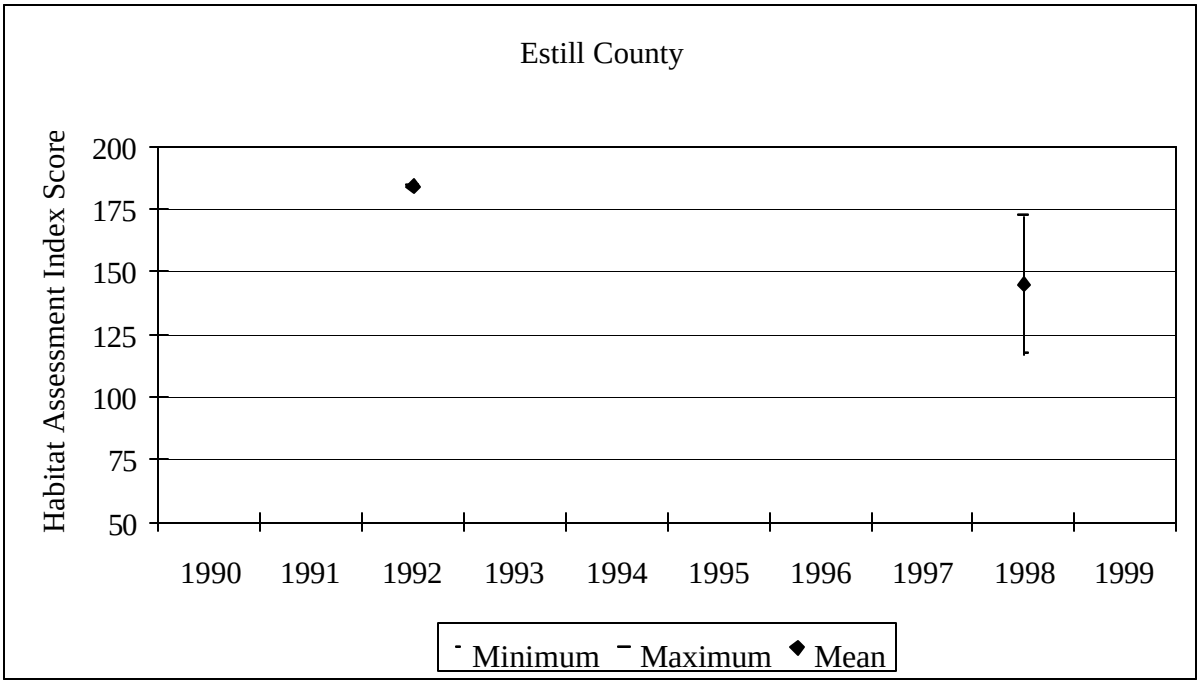

Figure 2.82. Habitat Index Scores for Estill County

Table 2.70. Habitat Index Scores for Garrard County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	4	127.00	153.00	137.25
1999				

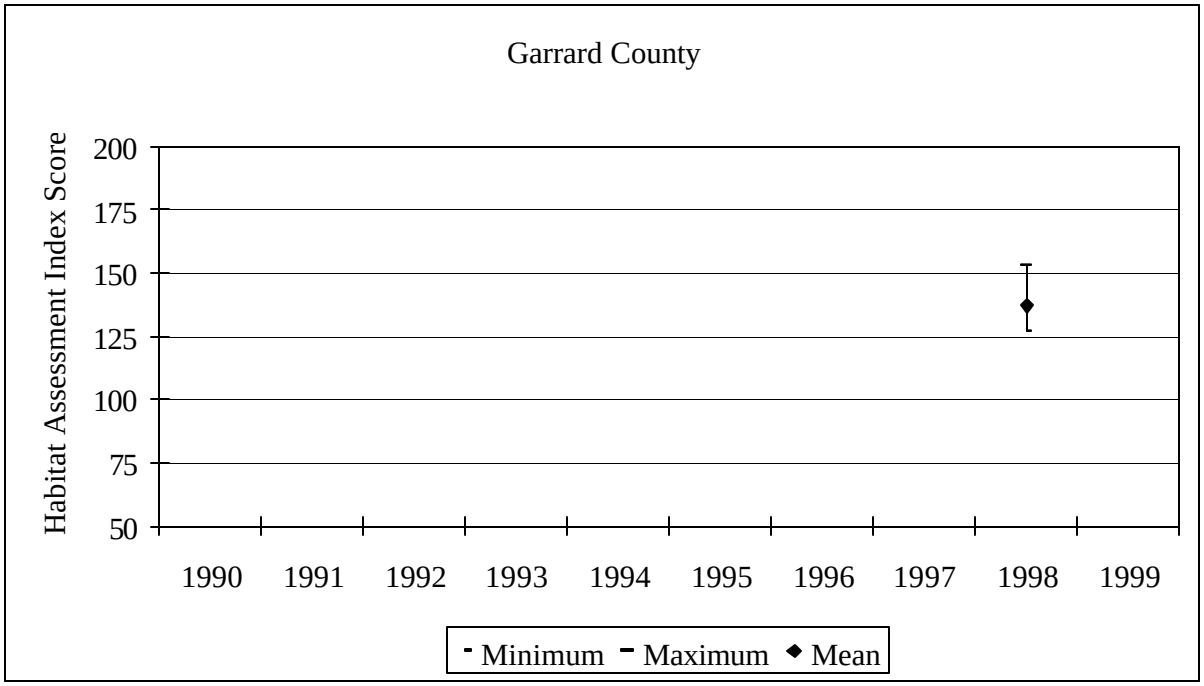

Figure 2.83. Habitat Index Scores for Garrard County

Table 2.71. Habitat Index Scores for Jackson County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	167.00	167.00	167.00
1993				
1994				
1995				
1996				
1997				
1998	3	113.00	165.00	131.67
1999				

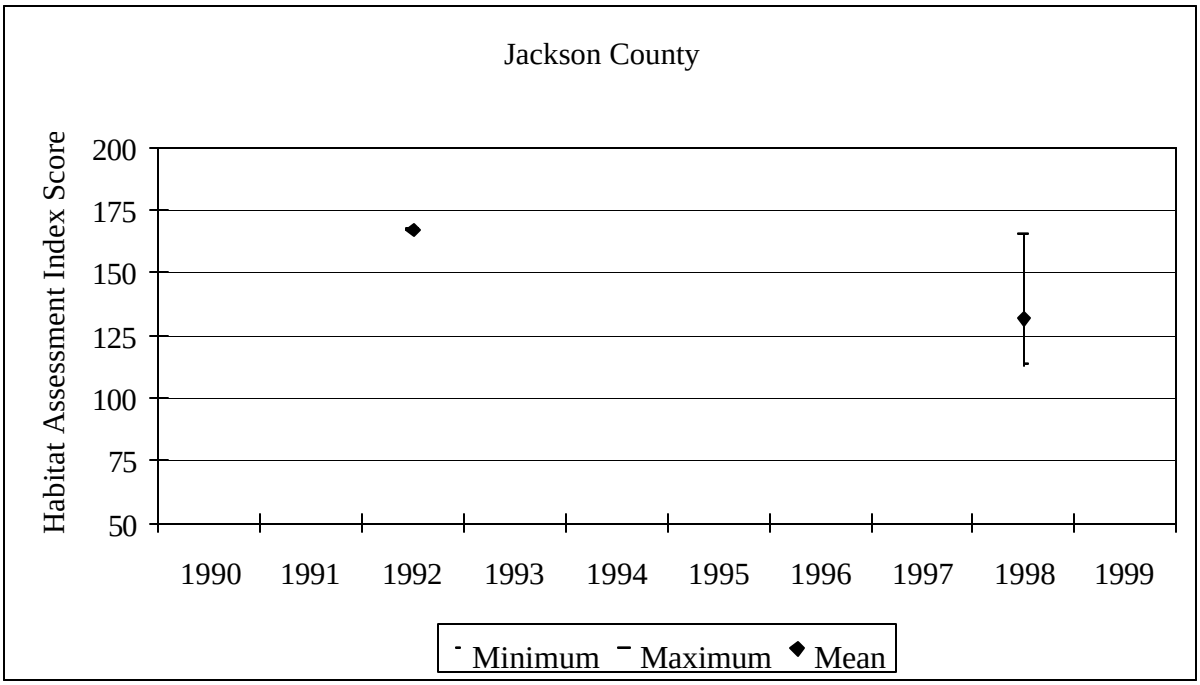

Figure 2.84. Habitat Index Scores for Jackson County

Table 2.72. Habitat Index Scores for Knott County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	1	173.00	173.00	173.00
1992				
1993				
1994				
1995				
1996				
1997				
1998	2	136.00	178.00	157.00
1999				

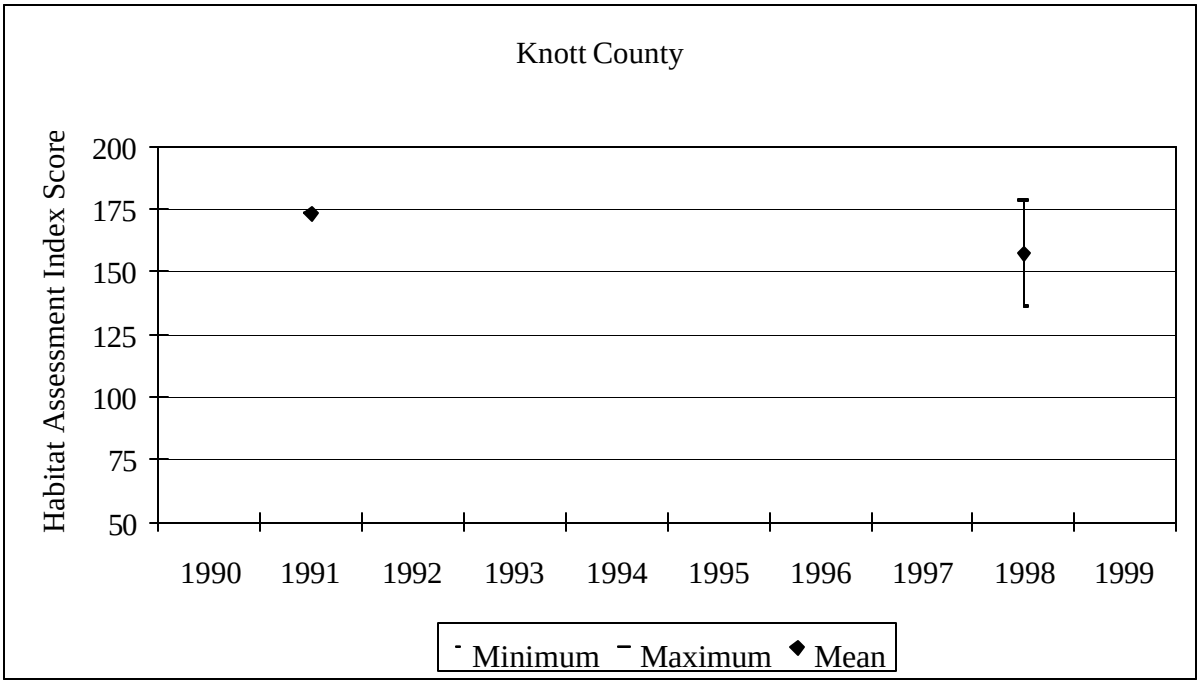

Figure 2.85. Habitat Index Scores for Knott County

Table 2.73. Habitat Index Scores for Laurel County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	182.00	182.00	182.00
1993				
1994				
1995				
1996				
1997				
1998				
1999				

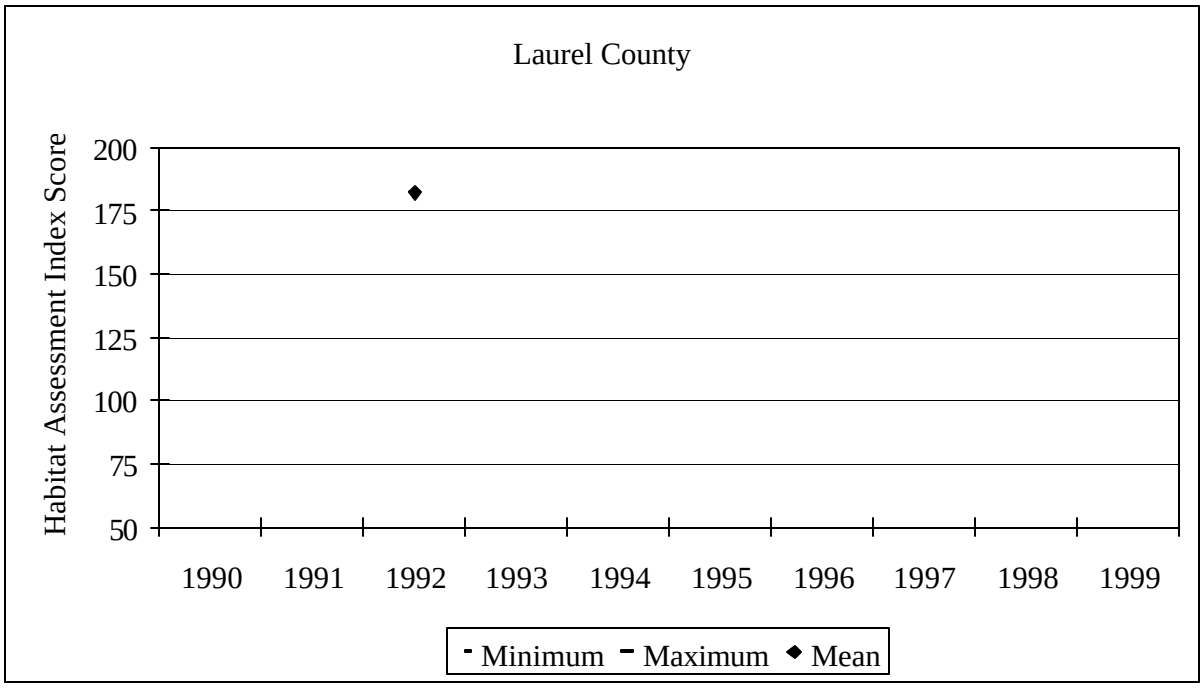

Figure 2.86. Habitat Index Scores for Laurel County

Table 2.74. Habitat Index Scores for Lee County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	165.00	165.00	165.00
1993				
1994				
1995				
1996				
1997				
1998	4	140.00	166.00	155.25
1999				

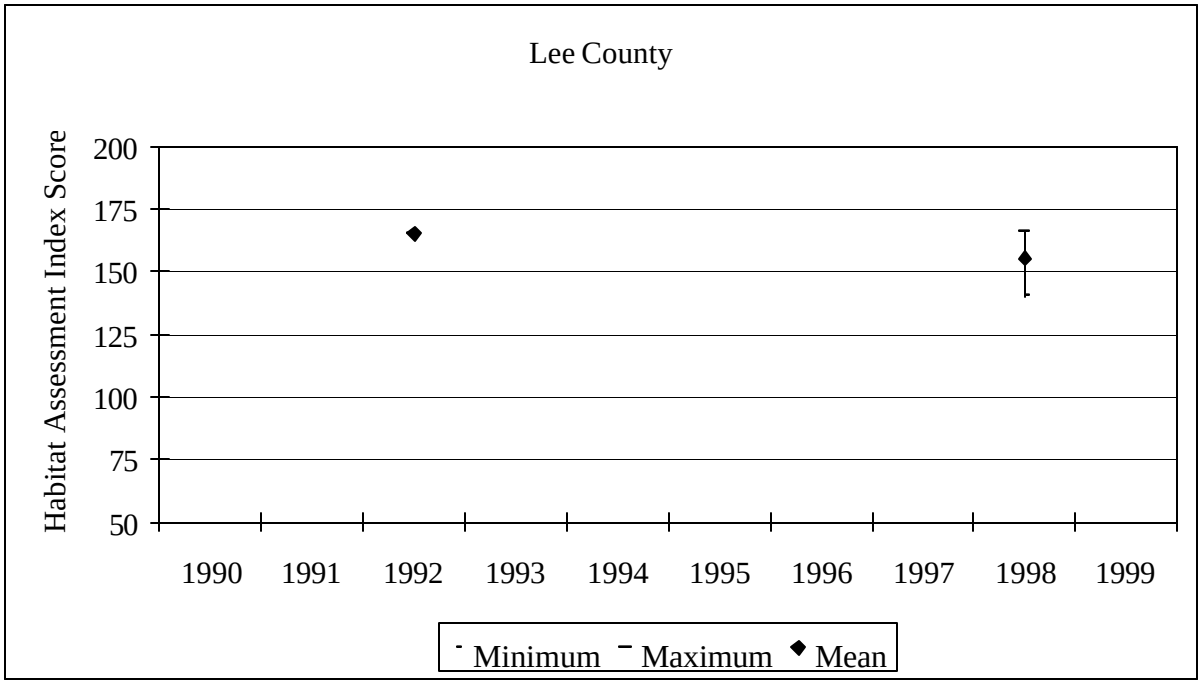

Figure 2.87. Habitat Index Scores for Lee County

Table 2.75. Habitat Index Scores for Leslie County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	13	90.00	174.00	139.15
1999				

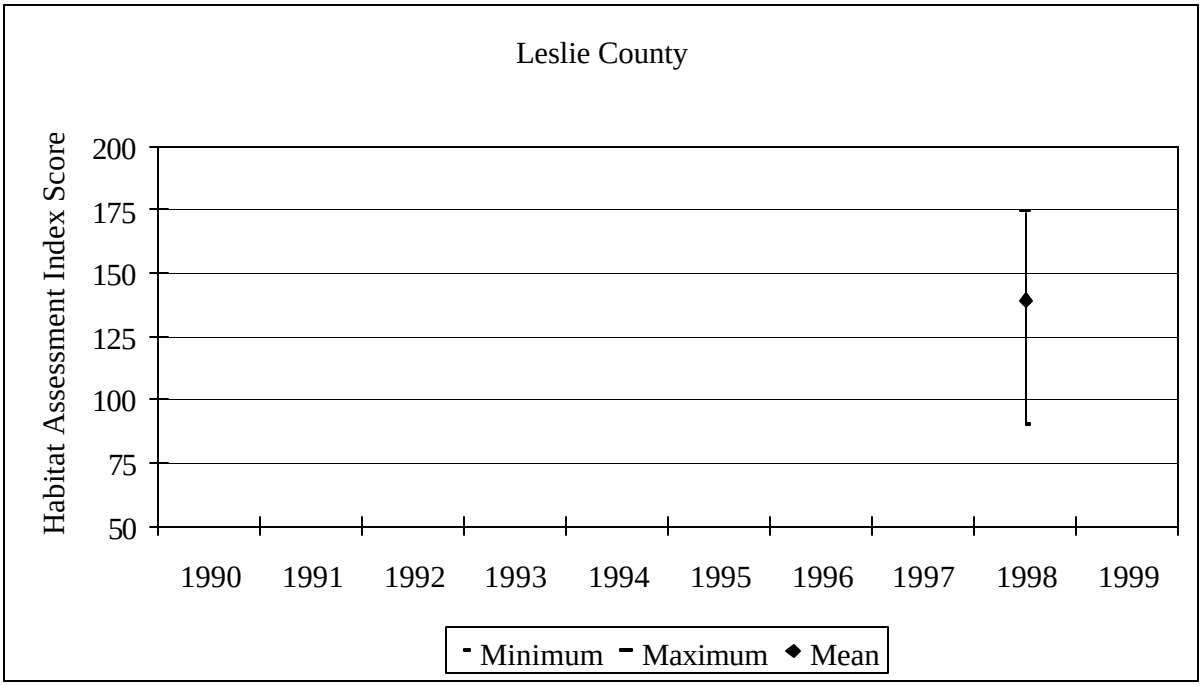

Figure 2.88. Habitat Index Scores for Leslie County

Table 2.76. Habitat Index Scores for Letcher County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	186.00	186.00	186.00
1993				
1994				
1995				
1996				
1997				
1998	3	132.00	165.00	149.00
1999				

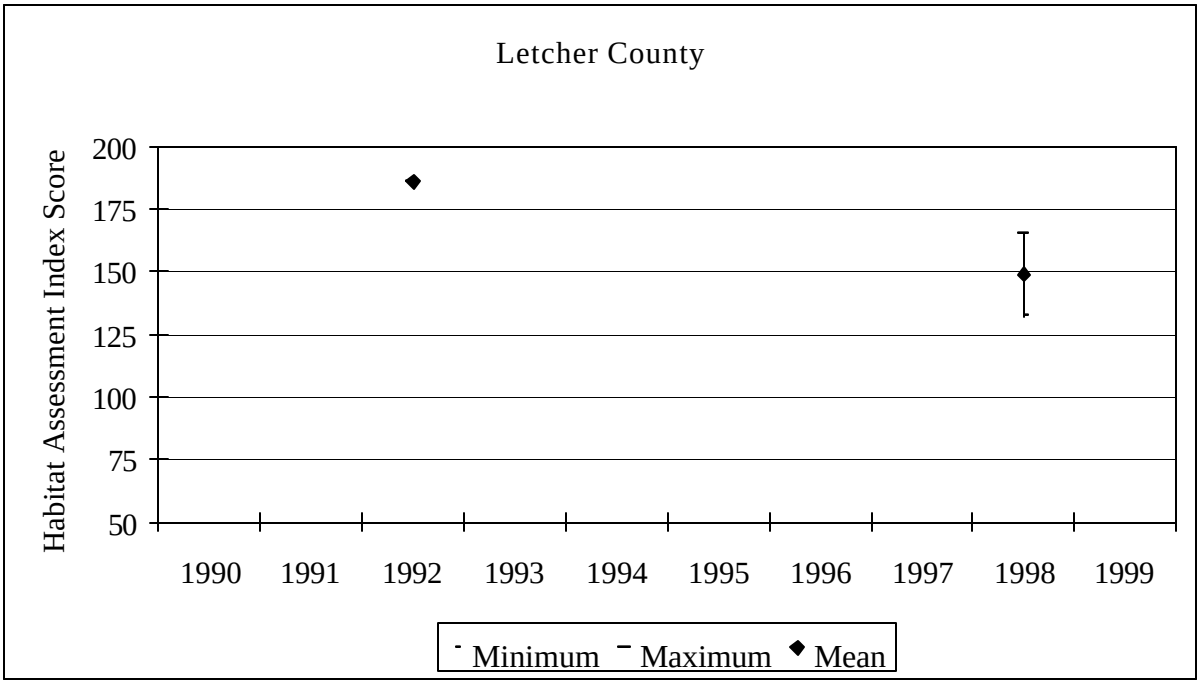

Figure 2.89. Habitat Index Scores for Letcher County

Table 2.77. Habitat Index Scores for Magoffin County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	9	84.00	146.00	124.22

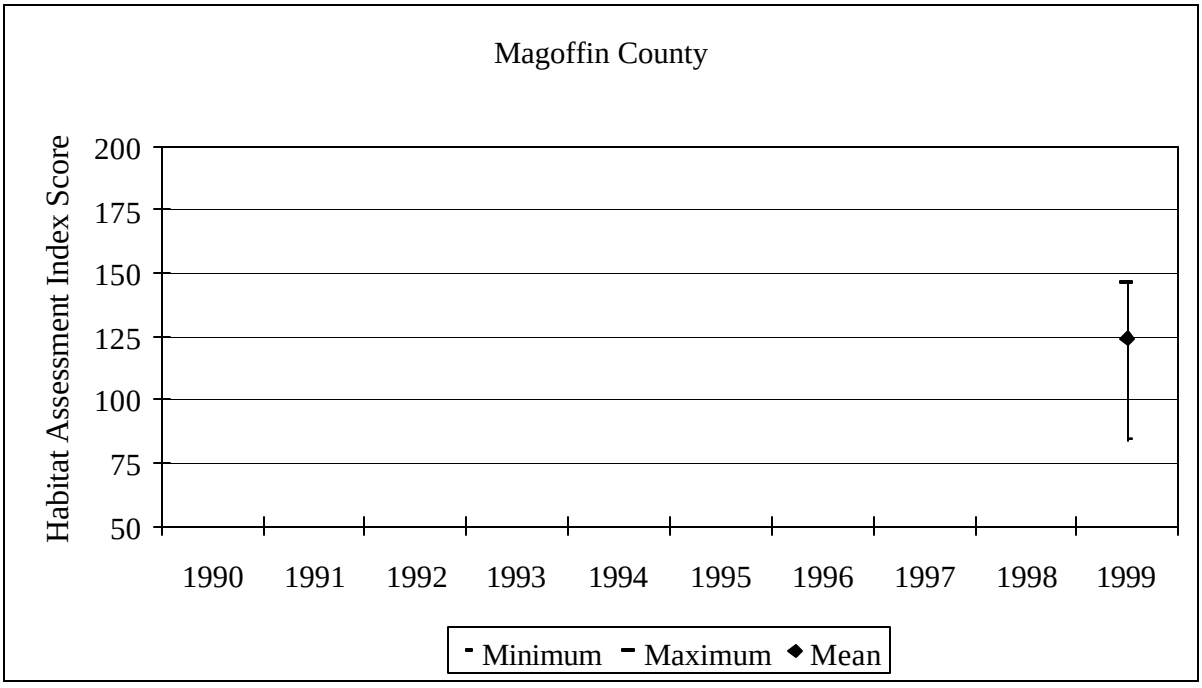

Figure 2.90. Habitat Index Scores for Magoffin County

Table 2.78. Habitat Index Scores for McCreary County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	1	172.00	172.00	172.00
1992	1	160.00	160.00	160.00
1993				
1994				
1995				
1996				
1997				
1998				
1999				

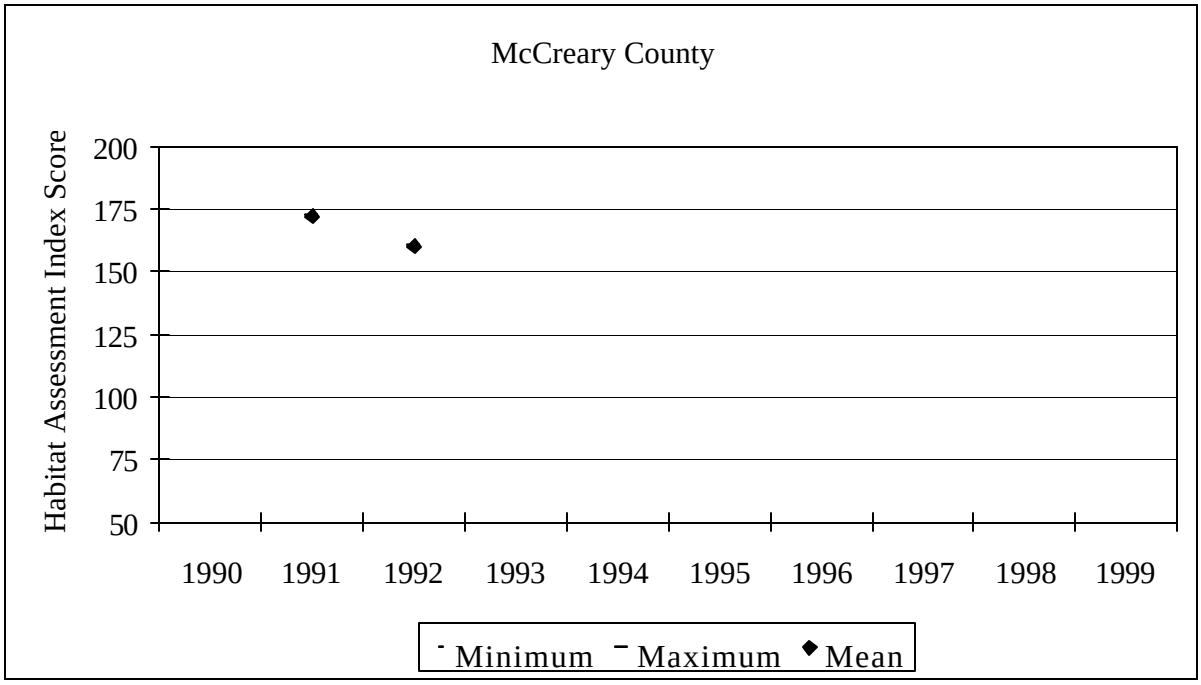

Figure 2.91. Habitat Index Scores for McCreary County

Table 2.79. Habitat Index Scores for Menifee County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	5	101.00	174.00	142.80
1999	1	79.00	79.00	79.00

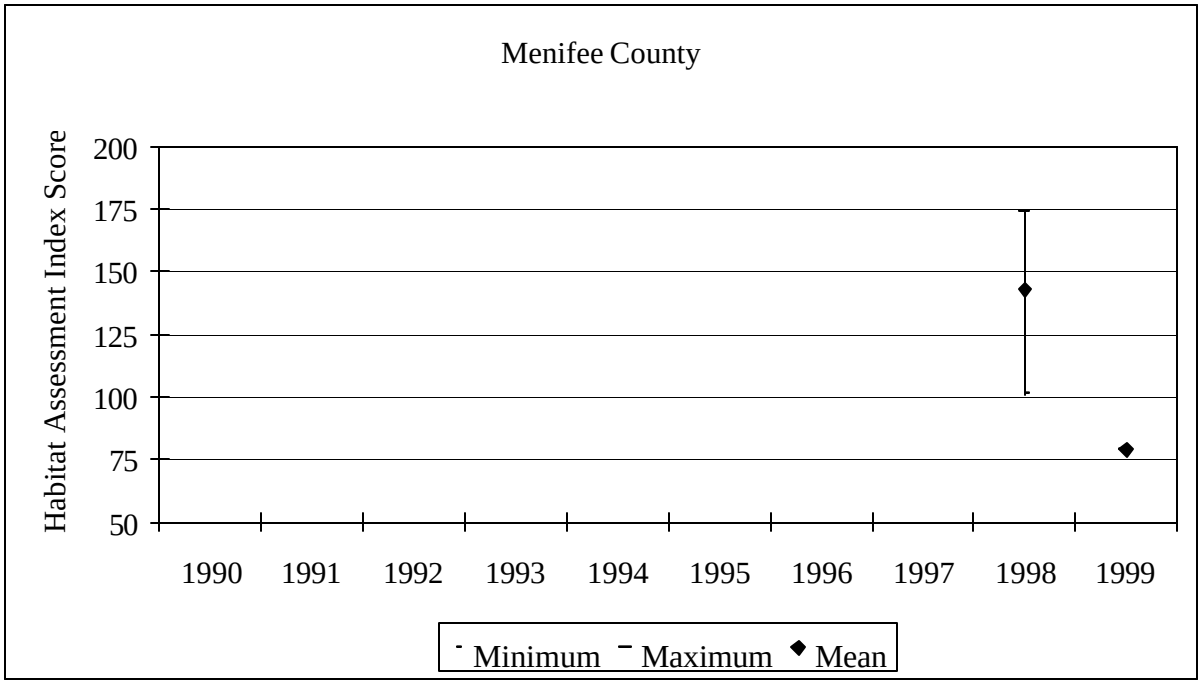

Figure 2.92. Habitat Index Scores for Menifee County

Table 2.80. Habitat Index Scores for Metcalfe County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	152.00	152.00	152.00
1996				
1997				
1998				
1999				

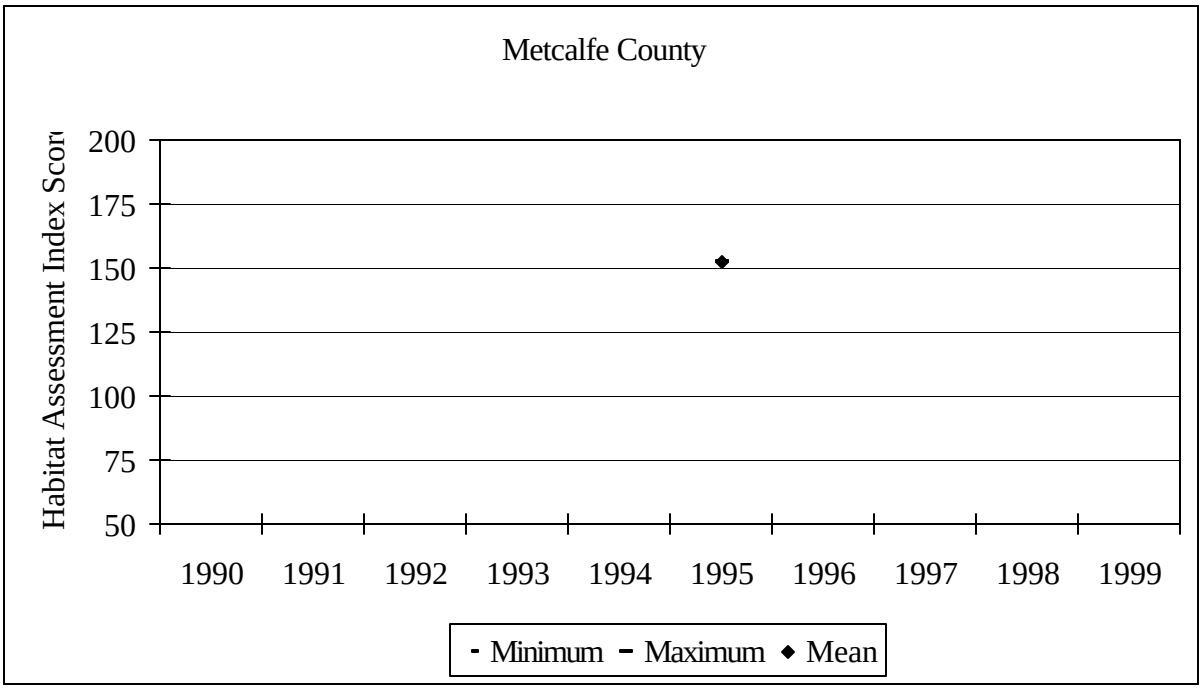

Figure 2.93. Habitat Index Scores for Metcalfe County

Table 2.81. Habitat Index Scores for Morgan County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	3	168.00	178.00	173.67
1993				
1994				
1995				
1996				
1997				
1998				
1999	13	97.00	175.00	130.69

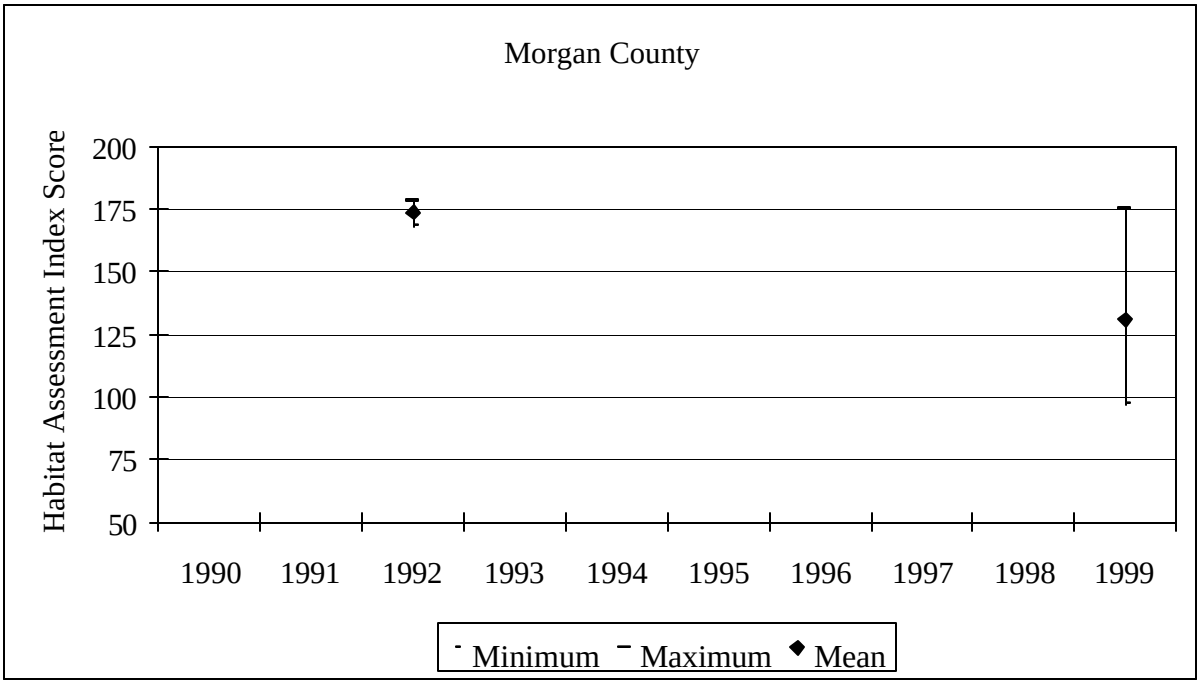

Figure 2.94. Habitat Index Scores for Morgan County

Table 2.82. Habitat Index Scores for Owsley County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	175.00	175.00	175.00
1993				
1994				
1995				
1996				
1997				
1998	4	118.00	174.00	153.75
1999				

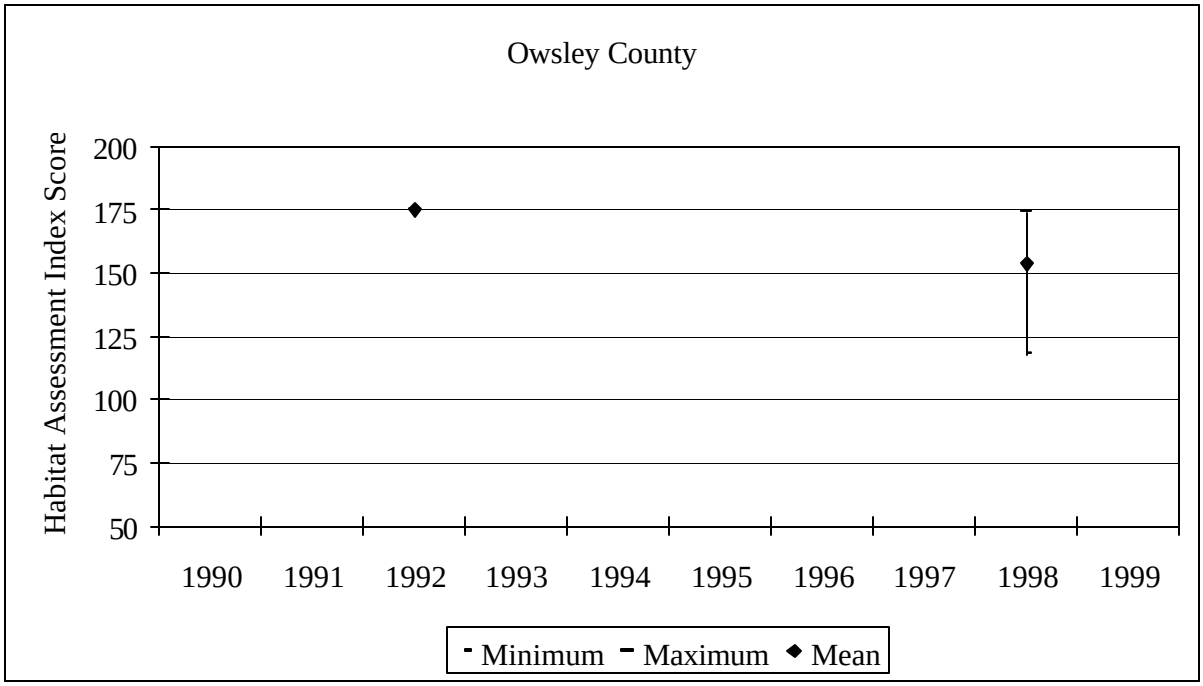

Figure 2.95. Habitat Index Scores for Owsley County

Table 2.83. Habitat Index Scores for Perry County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	9	96.00	165.00	139.22
1999				

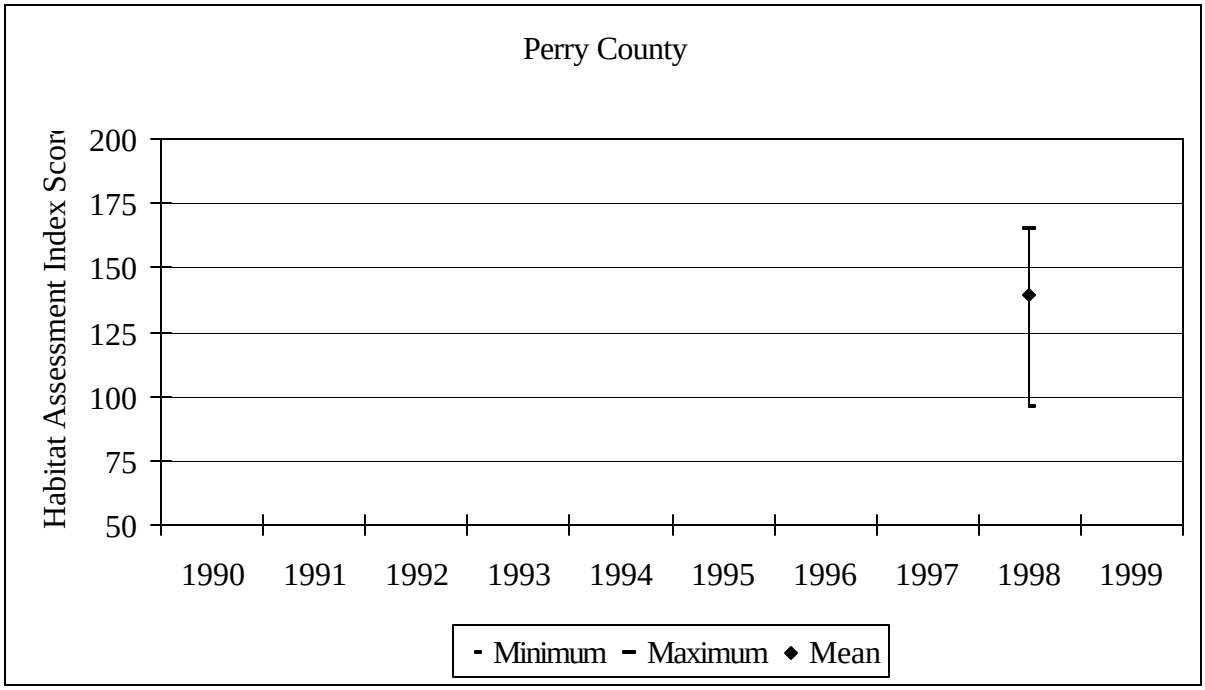

Figure 2.96. Habitat Index Scores for Perry County

Table 2.84. Habitat Index Scores for Pulaski County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	162.00	162.00	162.00
1993				
1994				
1995				
1996				
1997				
1998				
1999				

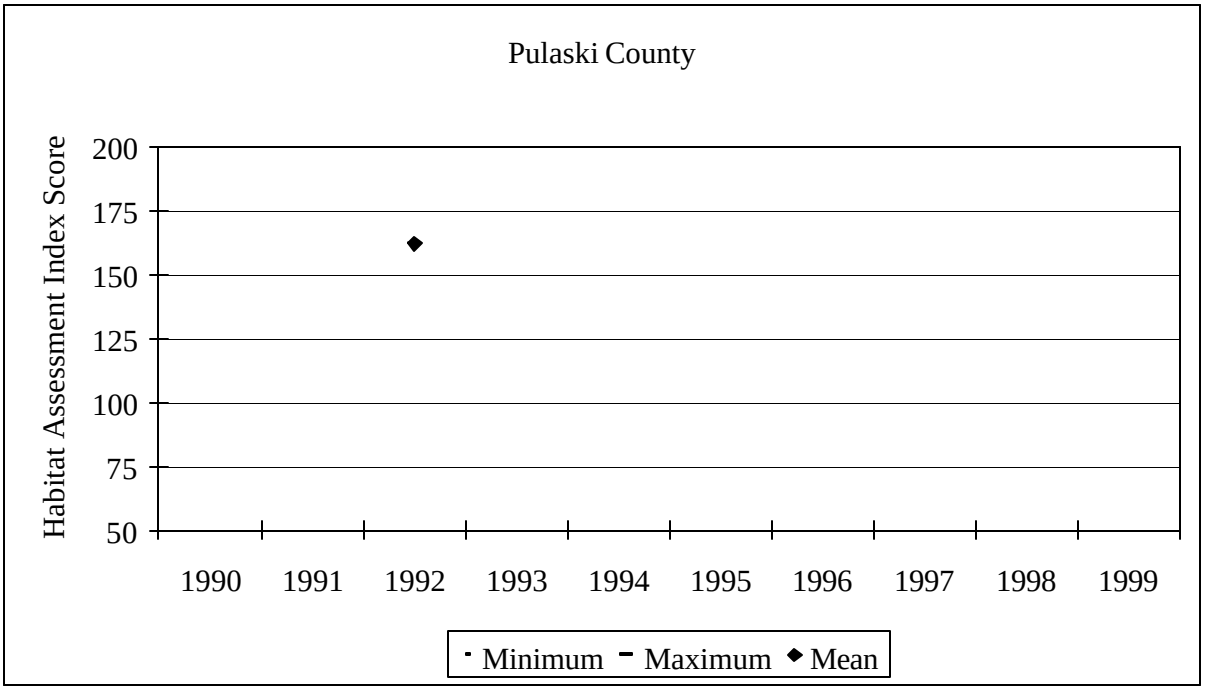

Figure 2.97. Habitat Index Scores for Pulaksi County

Table 2.85. Habitat Index Scores for Rockcastle County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	183.00	183.00	183.00
1993				
1994				
1995				
1996				
1997				
1998	1	123.00	123.00	123.00
1999				

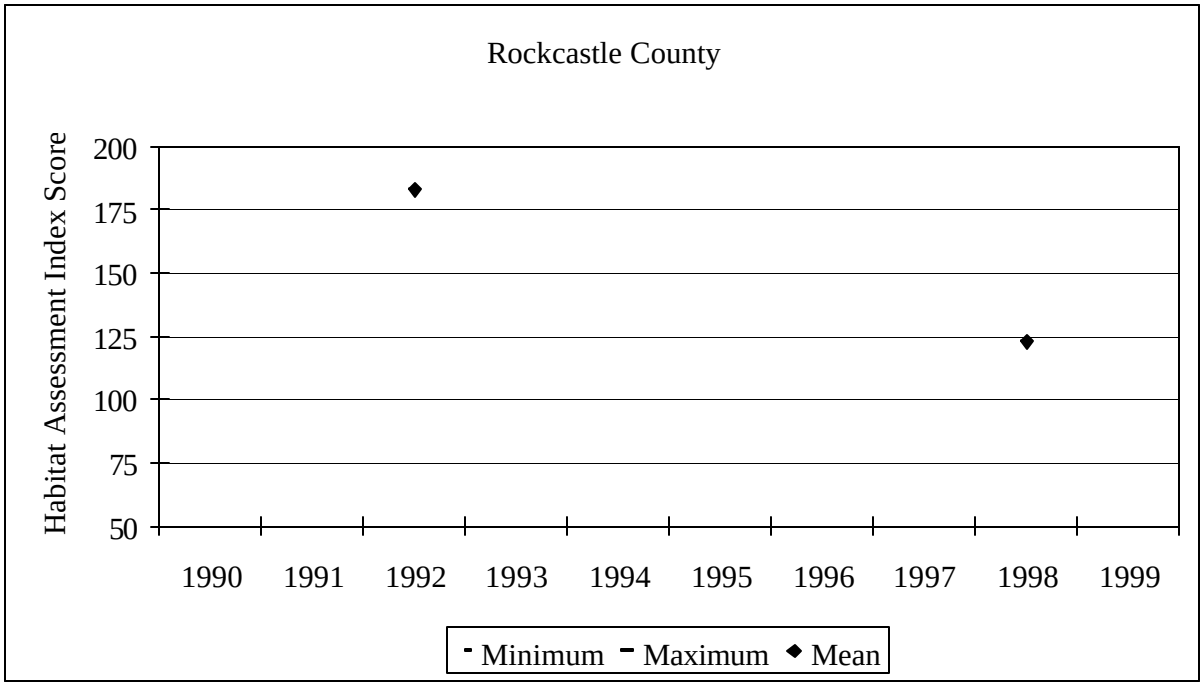

Figure 2.98. Habitat Index Scores for Rockcastle County

Table 2.86. Habitat Index Scores for Whitley County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	2	178.00	188.00	183.00
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				

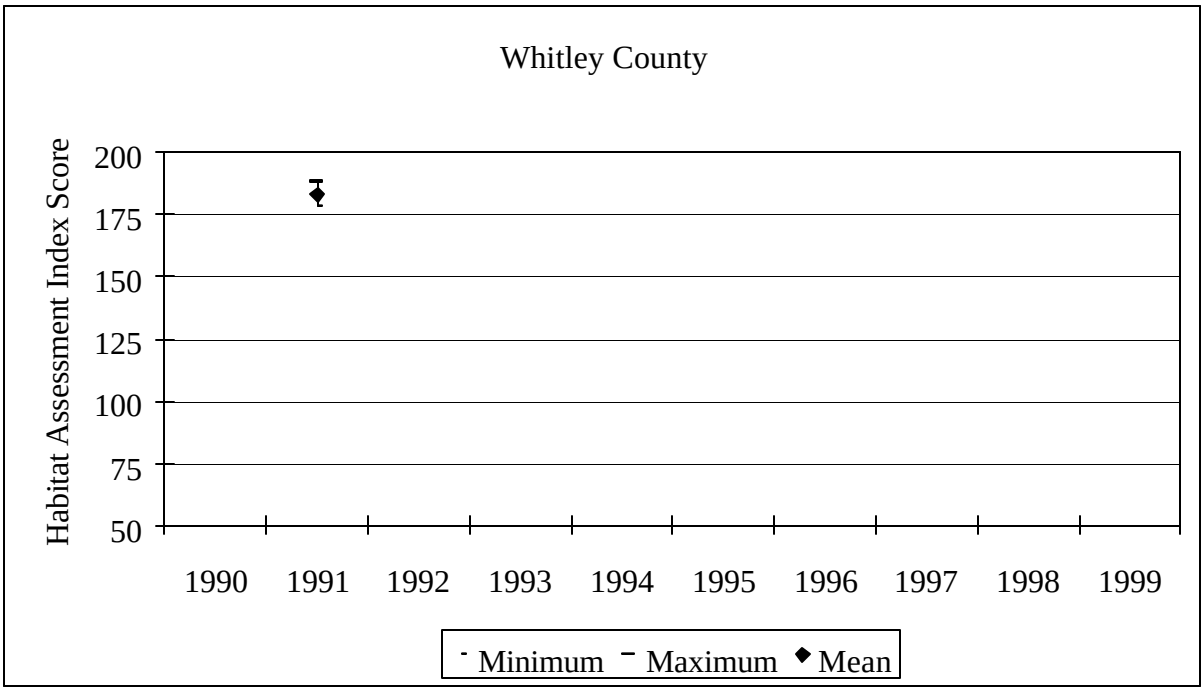

Figure 2.99. Habitat Index Scores for Whitley County

Table 2.87. Habitat Index Scores for Wolfe County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	6	97.00	160.00	128.67
1999				

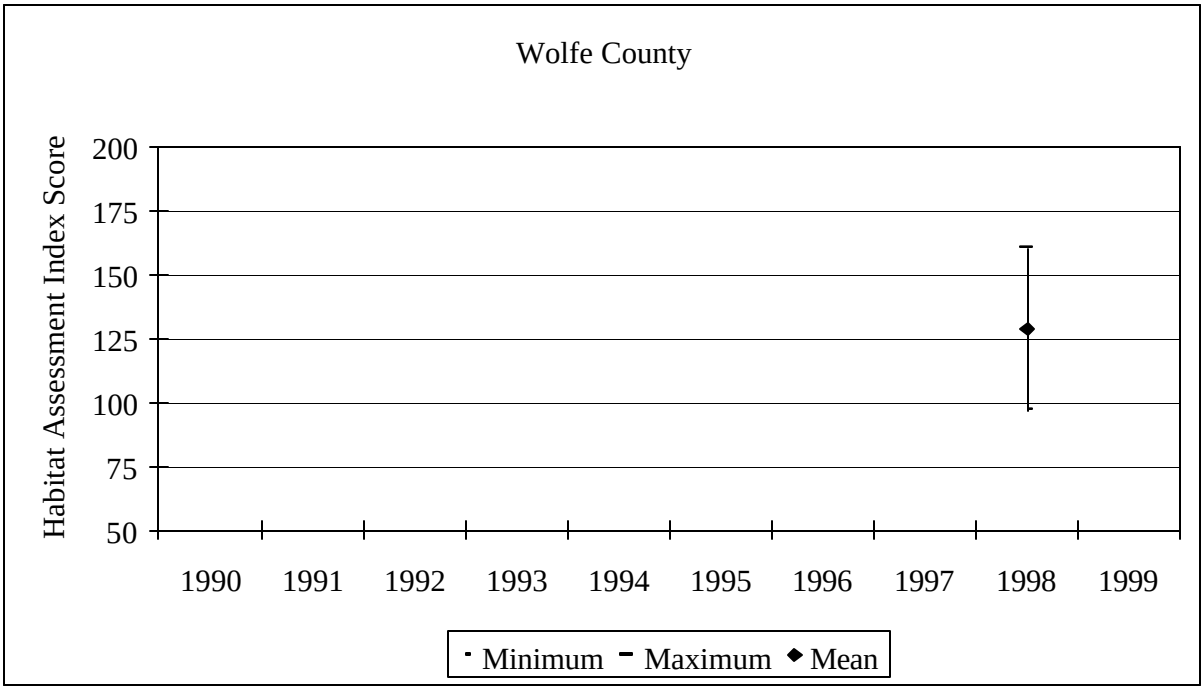

Figure 2.100. Habitat Index Scores for Wolfe County

Table 2.88. Habitat Index Scores for Licking River Basin 05100101 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	3	168.00	178.00	173.67
1993				
1994				
1995				
1996				
1997				
1998				
1999	23	79.00	175.00	125.91

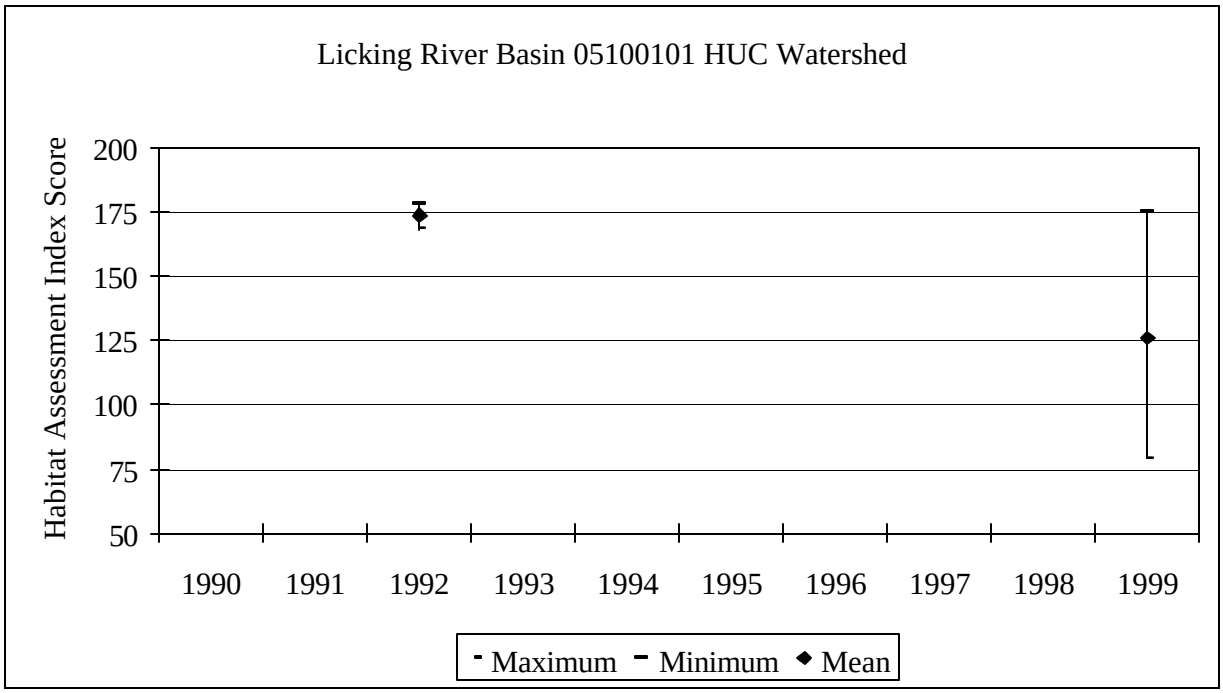

Figure 2.101. Habitat Index Scores for Licking River Basin 05100101 HUC Watershed

Table 2.89. Habitat Index Scores for Kentucky River Basin 05100201 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991	2	173.00	183.00	178.00
1992				
1993				
1994				
1995				
1996				
1997				
1998	32	96.00	178.00	140.22
1999	2	139.00	167.00	153.00

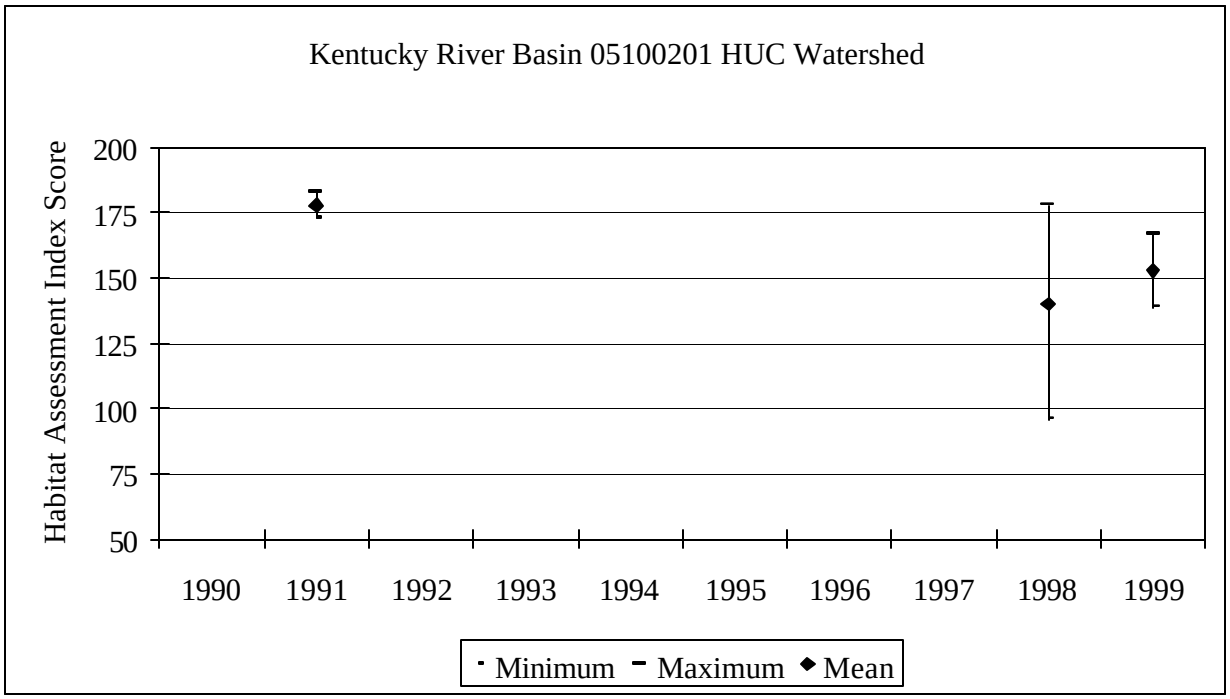

Figure 2.102. Habitat Index Scores for Kentucky River Basin 05100201 HUC Watershed

Table 2.90. Habitat Index Scores for Kentucky River Basin 05100202 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	12	90.00	174.00	137.75
1999				

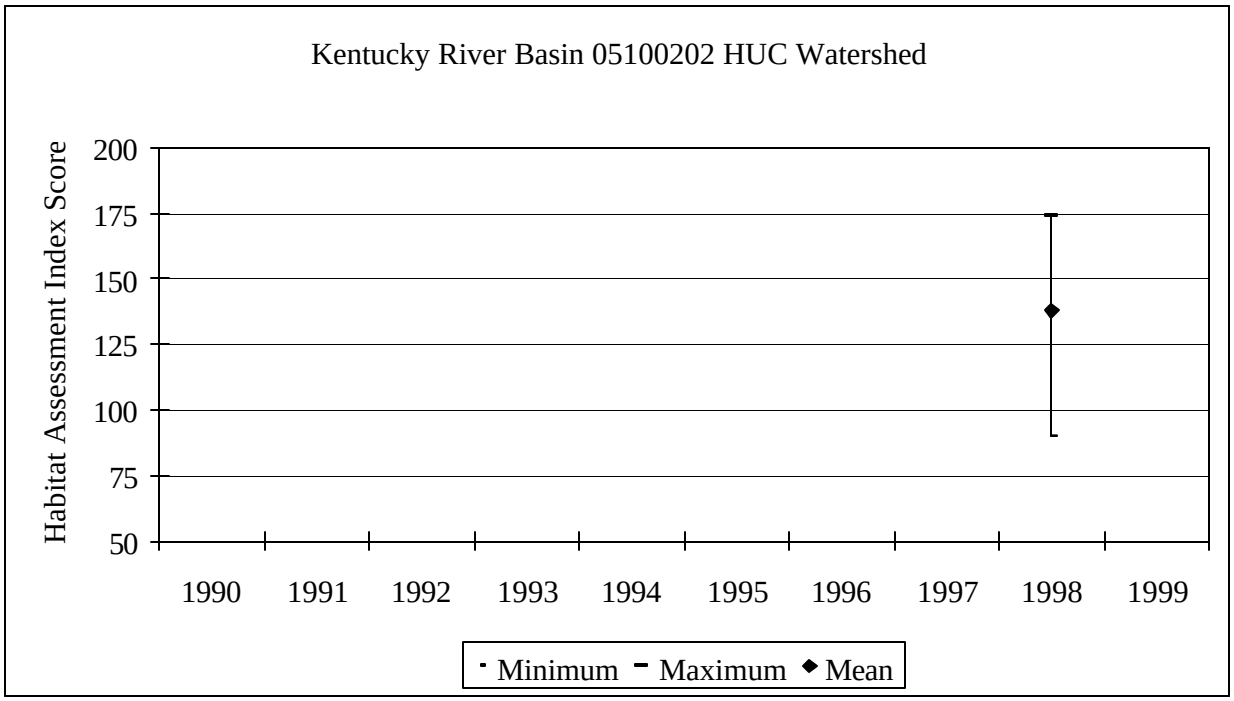

Figure 2.103. Habitat Index Scores for Kentucky River Basin 05100202 HUC Watershed

Table 2.91. Habitat Index Scores for Kentucky River Basin 05100203 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	175.00	175.00	175.00
1993				
1994				
1995				
1996				
1997				
1998	11	84.00	174.00	142.73
1999				

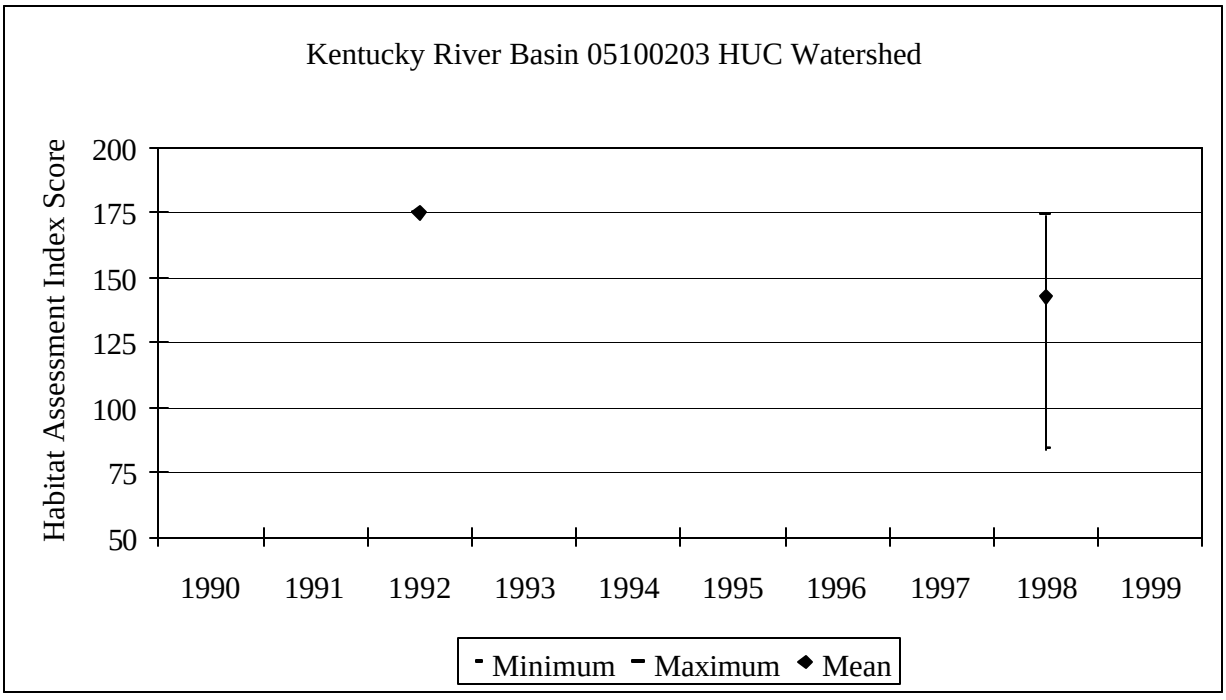

Figure 2.104. Habitat Index Scores for Kentucky River Basin 05100203 HUC Watershed

Table 2.92. Habitat Index Scores for Kentucky River Basin 05100204 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	3	165.00	184.00	172.00
1993				
1994				
1995				
1996				
1997				
1998	17	101.00	174.00	140.71
1999				

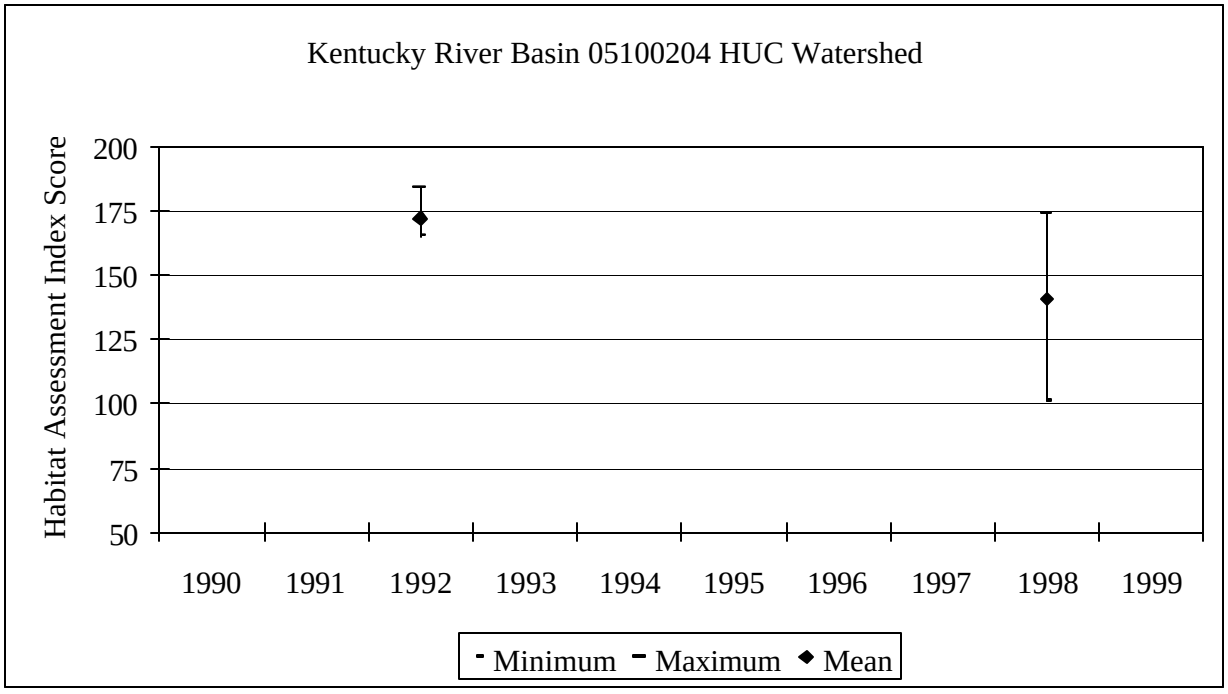

Figure 2.105. Habitat Index Scores for Kentucky River Basin 05100204 HUC Watershed

Table 2.93. Habitat Index Scores for Kentucky River Basin 05100205 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	5	123.00	153.00	134.40
1999				

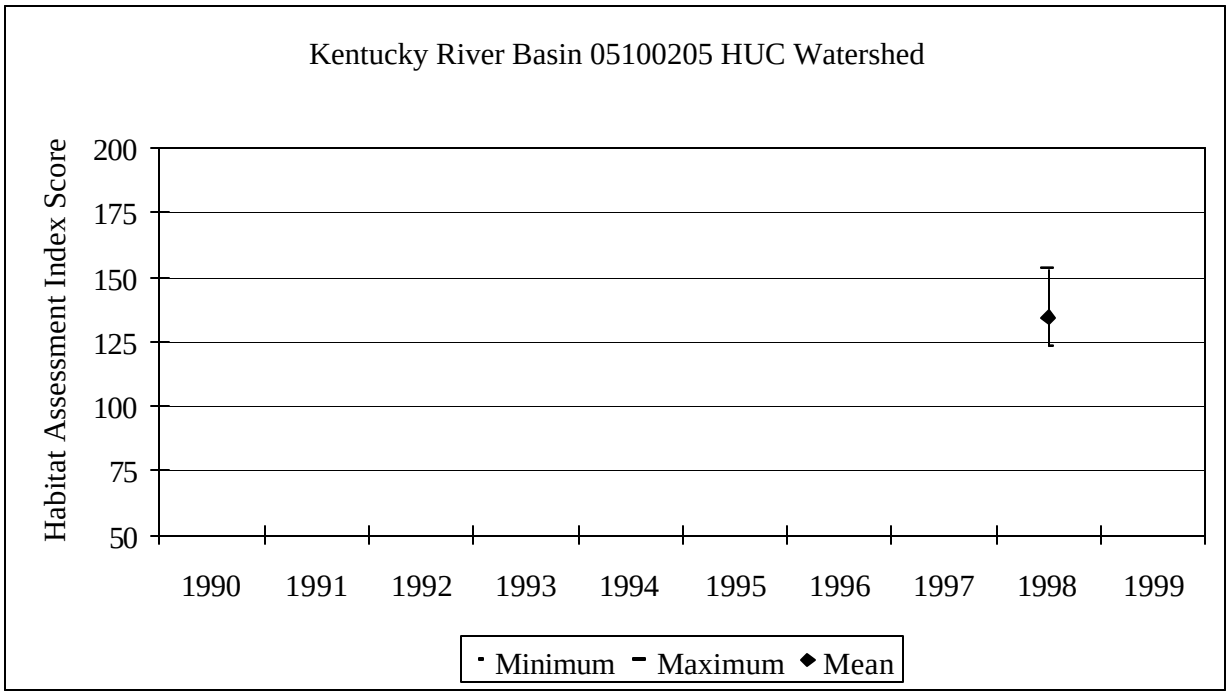

Figure 2.106. Habitat Index Scores for Kentucky River Basin 05100205 HUC Watershed

Table 2.94. Habitat Index Scores for Green River Basin 05110001 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	162.00	163.00	162.50
1993				
1994				
1995				
1996				
1997				
1998	1	166.00	166.00	166.00
1999				

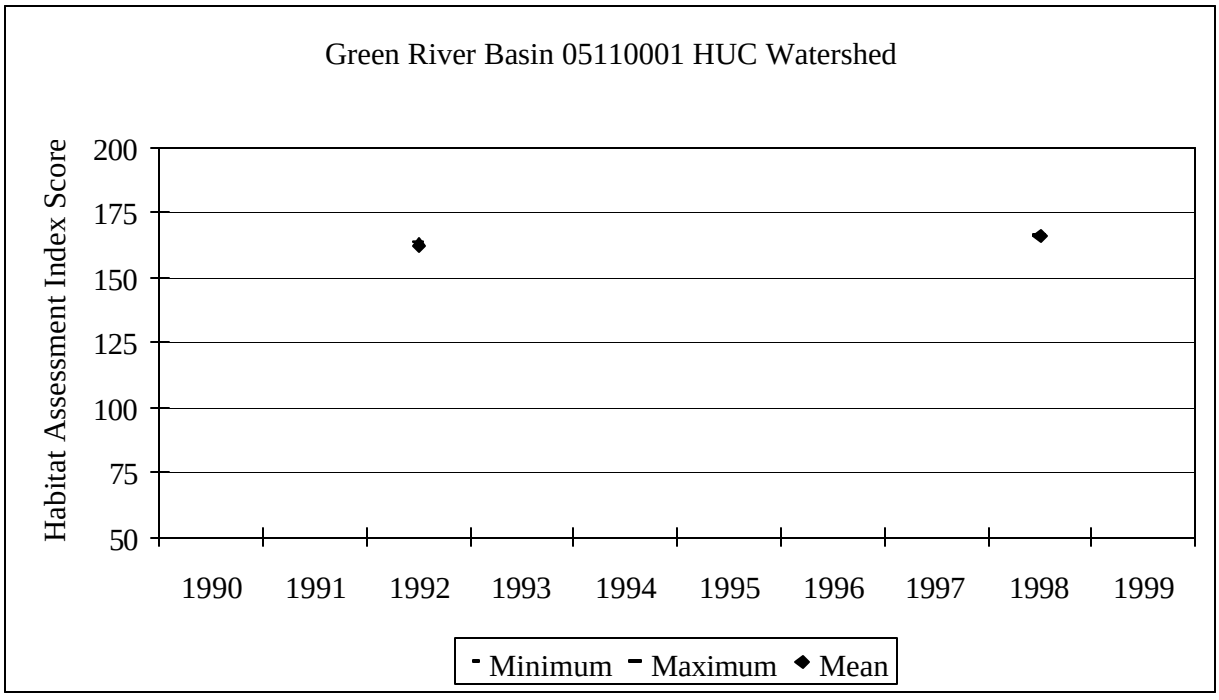

Figure 2.107. Habitat Index Scores for Green River Basin 05110001 HUC Watershed

Table 2.95. Habitat Index Scores for Green River Basin 05110002 HUC Watershed

Year	Samples	Maximum	Minimum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	152.00	152.00	152.00
1996				
1997				
1998				
1999				

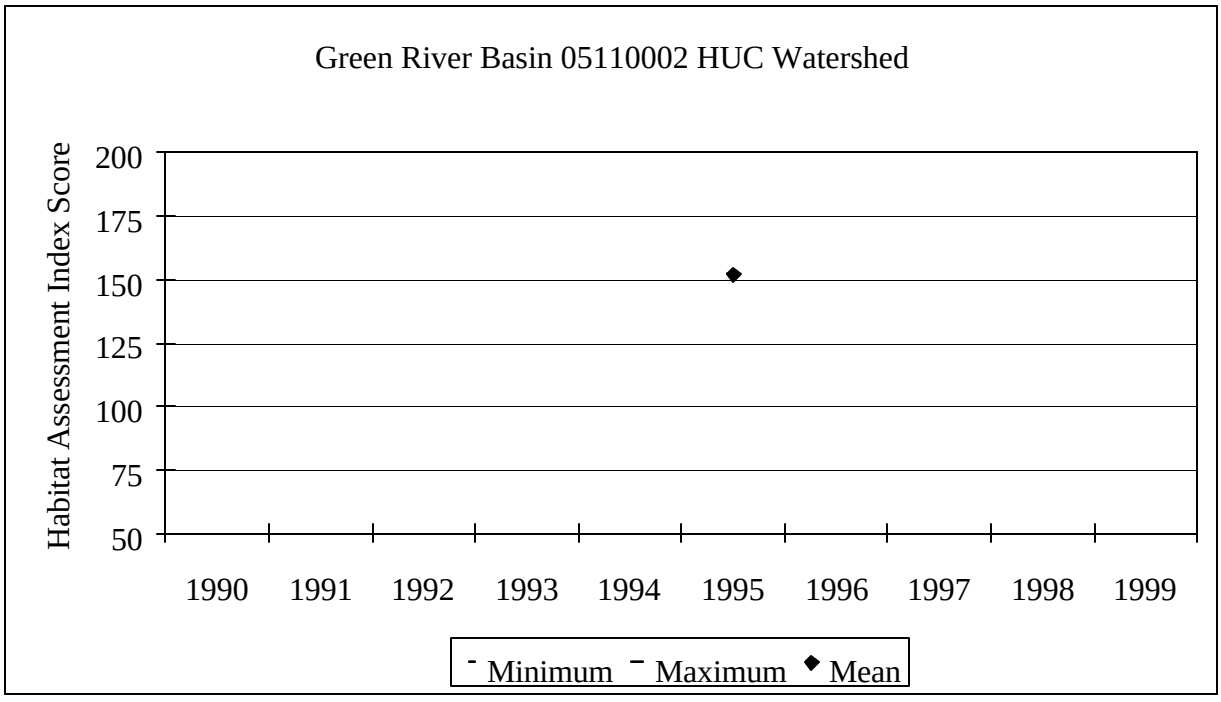

Figure 2.108. Habitat Index Scores for Green River Basin 05110002 HUC Watershed

Table 2.96. Habitat Index Scores for Upper Cumberland River Basin 05130101 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991	3	172.00	188.00	179.33
1992	2	160.00	186.00	173.00
1993				
1994				
1995				
1996				
1997				
1998				
1999				

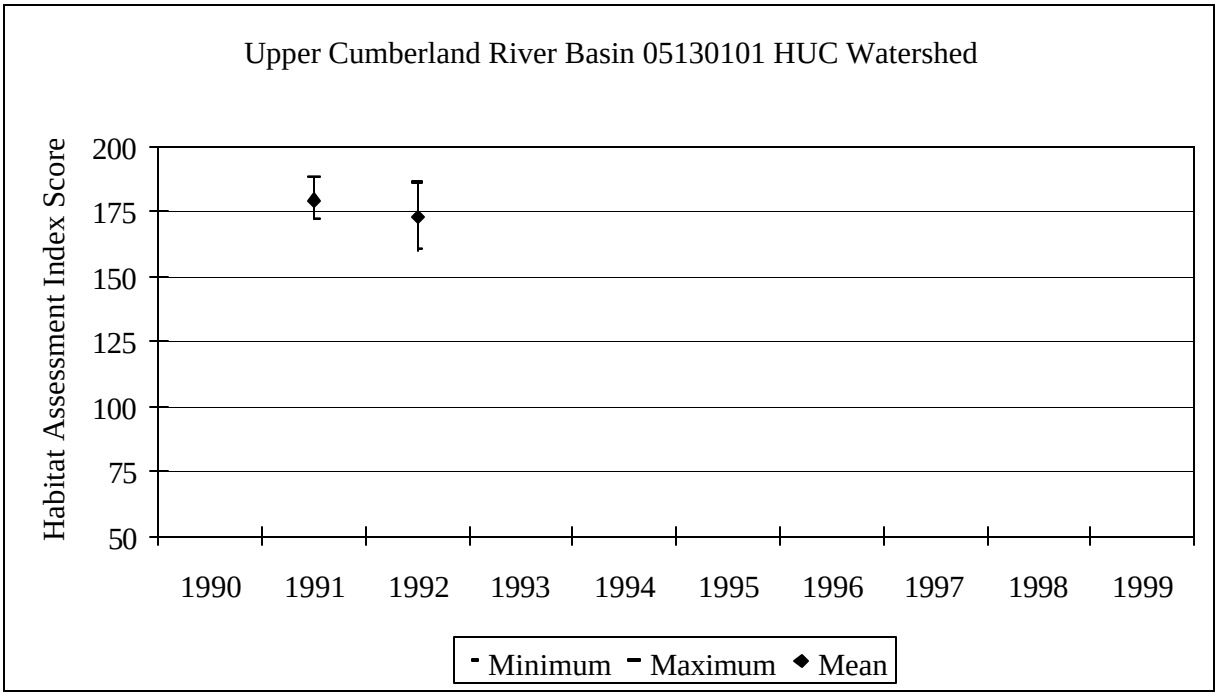

Figure 2.109. Habitat Index Scores for Upper Cumberland River Basin 05130101 HUC Watershed

Table 2.97. Habitat Index Scores for Upper Cumberland River Basin 05130102 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	182.00	183.00	182.50
1993				
1994				
1995				
1996				
1997				
1998				
1999				

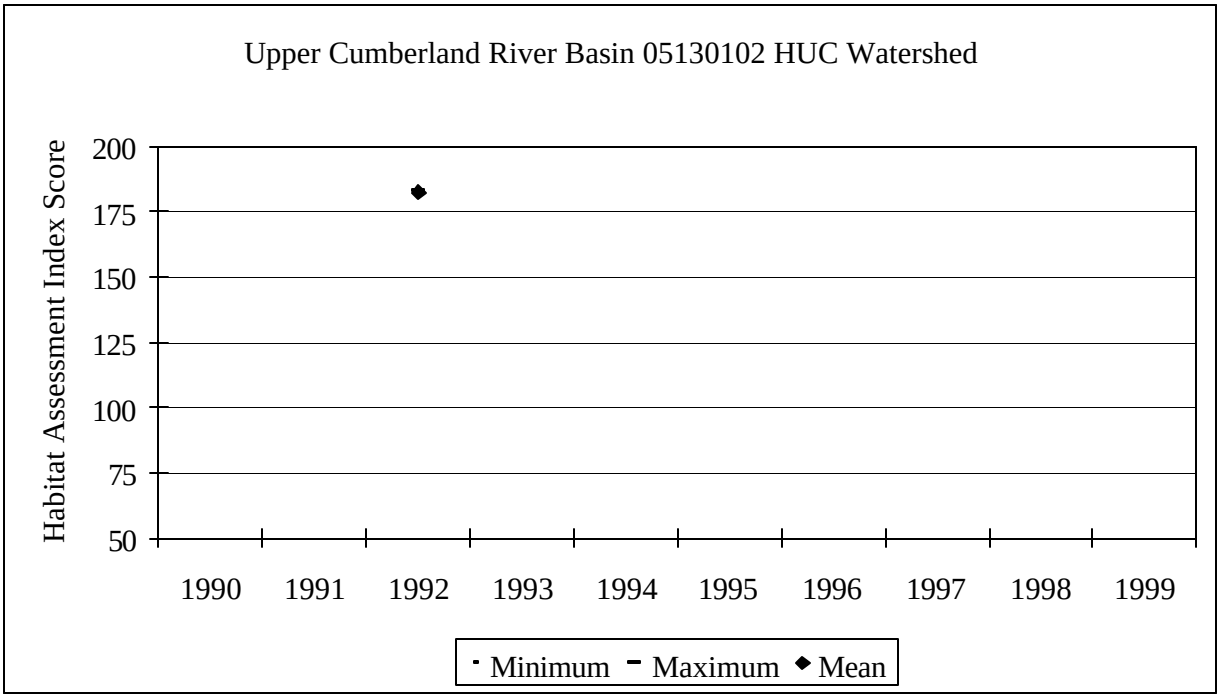

Figure 2.110. Habitat Index Scores for Upper Cumberland River Basin 05130102 HUC Watershed

Table 2.98. Habitat Index Scores for Upper Cumberland River Basin 05130103 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	162.00	162.00	162.00
1993				
1994				
1995				
1996				
1997				
1998				
1999				

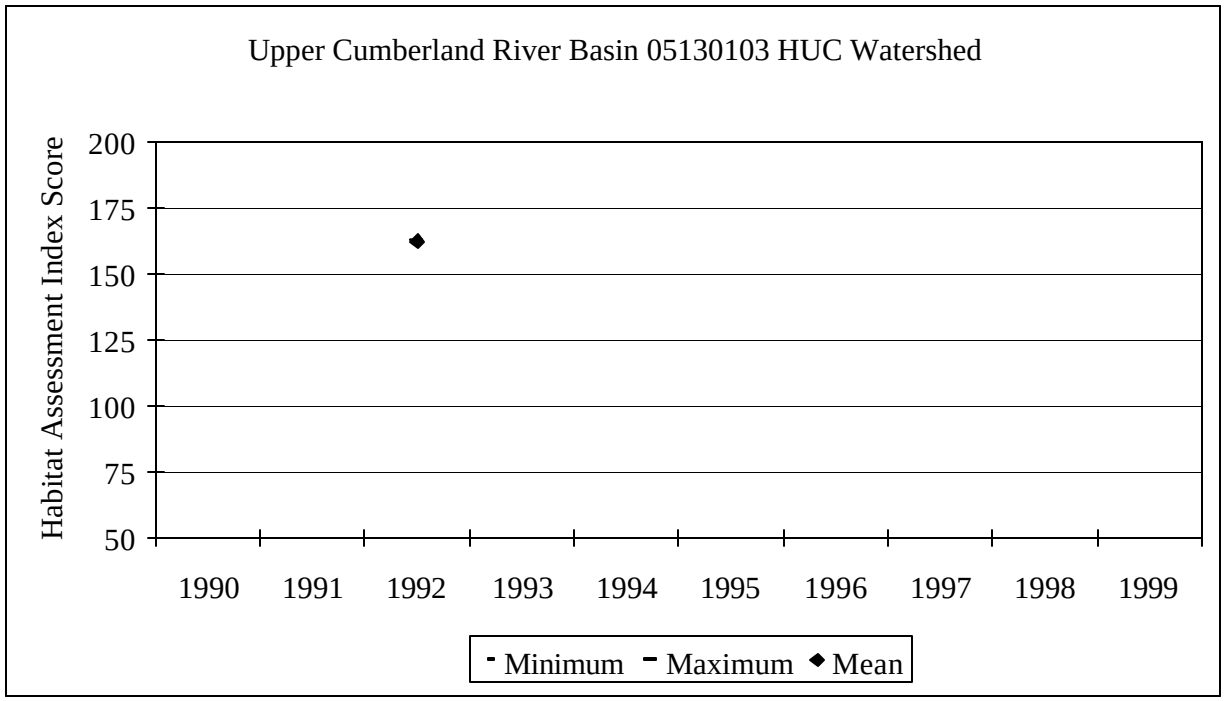

Figure 2.111. Habitat Index Scores for Upper Cumberland River Basin 05130103 HUC Watershed

Table 2.99. Macroinvertebrate Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			3.89	3.26	3.45	3.72				4.73
BELL	4.88									
BREATHITT		3.81		3.36	3.52	4.69			5.56	3.24
CASEY			4.68	4.01	4.42	4.75				
CLAY									5.62	
CLINTON										
CUMBERLAND										
ESTILL			4.00		4.03	7.22			5.71	
FLOYD										
GARRARD	4.41	4.88							5.58	
GREEN		5.18	4.80	4.28						
HARLAN				2.98				3.98		3.04
JACKSON			3.92	4.15	3.93				4.78	
JESSAMINE						6.88			5.87	
JOHNSON										
KNOTT		3.71		4.58	3.54	3.33			5.51	3.89
KNOX										
LAUREL	5.58	6.52	3.89	4.14	3.71	4.36	4.10	4.65		
LAWRENCE			5.59							
LEE	6.27		4.77	3.77	4.04	6.52			4.52	5.33
LESLIE							4.59	8.00	5.28	
LETCHER			2.09	1.09					6.22	
LINCOLN						5.90				
MAGOFFIN										5.61
MARTIN			6.68							
MCCREARY		5.11	4.73	4.14	4.90			5.46		
MENIFEE									5.13	6.62
METCALFE						4.19				
MONROE										
MORGAN			3.37	3.57	4.20		3.92			5.10
OWSLEY			3.76	3.53	3.46	6.69			5.64	
PERRY									4.91	
PIKE			5.34				6.37			
PULASKI	4.58	6.75	4.32	3.78	4.01	4.83				4.63
ROCKCASTLE	5.69		3.26	4.30					6.05	
RUSSELLL										
TAYLOR		5.84				5.59				
WAYNE				4.39						
WHITLEY	4.95	3.59		3.97	2.76			4.98		
WOLFE	5.43	6.67							5.02	

Table 2.100. Maximum Macroinvertebrate Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			4.22	3.72	4.00	3.72				5.01
BELL	6.69									
BREATHITT		4.52		3.90	3.75	6.88			6.68	3.24
CASEY			4.69	4.49	4.89	4.75				
CLAY									6.83	
CLINTON										
CUMBERLAND										
ESTILL			4.39		4.03	7.22			6.89	
FLOYD										
GARRARD	4.41	4.88							5.66	
GREEN		5.18	5.38	5.22						
HARLAN				2.98				4.86		3.04
JACKSON			3.92	4.15	3.93				6.04	
JESSAMINE						6.88			5.87	
JOHNSON										
KNOTT		3.85		4.58	3.54	3.33			6.12	3.89
KNOX										
LAUREL	5.58	6.52	4.21	5.30	3.71	4.36	4.88	4.65		
LAWRENCE			5.59							
LEE	6.27		5.38	3.85	4.22	7.93			5.24	5.33
LESLIE							4.59	8.00	6.49	
LETCHER			2.80	1.09					7.29	
LINCOLN						6.38				
MAGOFFIN										5.61
MARTIN			6.68							
MCCREARY		7.23	6.72	4.98	7.39			6.60		
MENIFEE									5.98	6.62
METCALFE						4.19				
MONROE										
MORGAN			4.25	4.08	5.17		3.92			6.95
OWSLEY			3.99	3.53	3.46	6.69			6.47	
PERRY									4.91	
PIKE			5.34				6.37			
PULASKI	4.58	6.75	4.38	4.16	4.05	5.90				4.74
ROCKCASTLE	7.32		3.58	4.82					6.05	
RUSSELLL										
TAYLOR		6.79				6.34				
WAYNE				4.39						
WHITLEY	4.95	4.66		4.89	2.91			4.98		
WOLFE	5.43	6.67							6.18	

Table 2.101. Minimum Macroinvertebrate Index Scores for Counties

COUNTY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ADAIR			3.46	2.87	2.90	3.72				4.45
BELL	3.17									
BREATHITT		2.99		2.98	3.29	2.49			4.08	3.24
CASEY			4.67	3.53	3.95	4.75				
CLAY									3.93	
CLINTON										
CUMBERLAND										
ESTILL			3.61		4.03	7.22			4.58	
FLOYD										
GARRARD	4.41	4.88							5.50	
GREEN		5.18	4.23	3.66						
HARLAN				2.98				2.74		3.04
JACKSON			3.92	4.15	3.93				3.25	
JESSAMINE						6.88			5.87	
JOHNSON										
KNOTT		3.54		4.58	3.54	3.33			4.91	3.89
KNOX										
LAUREL	5.58	6.52	3.56	2.88	3.71	4.36	3.33	4.65		
LAWRENCE			5.59							
LEE	6.27		4.16	3.69	3.86	5.11			3.47	5.33
LESLIE							4.59	8.00	3.80	
LETCHER			1.37	1.09					4.09	
LINCOLN						5.32				
MAGOFFIN										5.61
MARTIN			6.68							
MCCREARY		2.48	3.39	3.48	3.12			3.76		
MENIFEE									4.31	6.62
METCALFE						4.19				
MONROE										
MORGAN			1.29	3.32	2.94		3.92			4.15
OWSLEY			3.52	3.53	3.46	6.69			5.14	
PERRY									4.91	
PIKE			5.34				6.37			
PULASKI	4.58	6.75	4.25	3.23	3.97	3.95				4.53
ROCKCASTLE	4.64		2.94	3.56					6.05	
RUSSELLL										
TAYLOR		4.89				5.07				
WAYNE				4.39						
WHITLEY	4.95	2.71		2.92	2.61			4.98		
WOLFE	5.43	6.67							4.23	

Table 2.102. Mean Macroinvertebrate Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201			6.68							
05070202										
05070203			5.47				6.37			
05070204										
05100101			3.37	3.57	4.20		3.92			5.39
05100201		3.77		3.60	3.53	4.24			5.64	3.57
05100202						5.11		8.00	5.51	
05100203			3.76	3.53	3.46	6.69	4.59		5.41	
05100204	5.85	6.67	4.29	3.89	4.01	7.58			5.06	5.33
05100205	4.41	4.88				6.15			5.77	
05110001		5.62	4.32	3.90	3.94	5.05				4.73
05110002						4.19				
05130101	4.89	3.57	2.85	3.76	3.54			4.23		3.04
05130102	5.66	6.52	3.57	4.22	3.71	4.36	4.10	4.65		
05130103	4.58	6.75	4.32	3.78	4.01	4.83				4.63
05130104		5.56	4.77	3.94	7.39			5.46		

Table 2.103. Maximum Macroinvertebrate Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201			6.68							
05070202										
05070203			5.59				6.37			
05070204										
05100101			4.25	4.08	5.17		3.92			6.95
05100201		4.52		4.58	3.75	6.88			7.29	3.89
05100202						5.11		8.00	6.49	
05100203			3.99	3.53	3.46	6.69	4.59		6.83	
05100204	6.27	6.67	5.38	4.15	4.22	7.93			6.89	5.33
05100205	4.41	4.88				6.88			6.05	
05110001		6.79	5.38	5.22	4.89	6.34				5.01
05110002						4.19				
05130101	6.69	4.66	4.37	4.98	5.20			4.98		3.04
05130102	7.32	6.52	4.21	5.30	3.71	4.36	4.88	4.65		
05130103	4.58	6.75	4.38	4.16	4.05	5.90				4.74
05130104		7.23	6.72	4.39	7.39			6.60		

Table 2.104. Minimum Macroinvertebrate Index Scores for HUCs

HUC 8	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
05070201			6.68							
05070202										
05070203			5.34				6.37			
05070204										
05100101			1.29	3.32	2.94		3.92			4.15
05100201		2.99		2.98	3.29	2.49			4.08	3.24
05100202						5.11		8.00	4.57	
05100203			3.52	3.53	3.46	6.69	4.59		3.80	
05100204	5.43	6.67	3.61	3.69	3.86	7.22			3.25	5.33
05100205	4.41	4.88				5.32			5.50	
05110001		4.89	3.46	2.87	2.90	3.72				4.45
05110002						4.19				
05130101	3.17	2.71	1.37	1.09	2.61			2.74		3.04
05130102	4.64	6.52	2.94	2.88	3.71	4.36	3.33	4.65		
05130103	4.58	6.75	4.25	3.23	3.97	3.95				4.53
05130104		2.48	3.39	3.62	7.39			3.76		

Table 2.105. Macroinvertebrate Index Scores for Adair County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	4	3.46	4.22	3.89
1993	4	2.87	3.72	3.26
1994	2	2.90	4.00	3.45
1995	1	3.72	3.72	3.72
1996				
1997				
1998				
1999	2	4.45	5.01	4.73

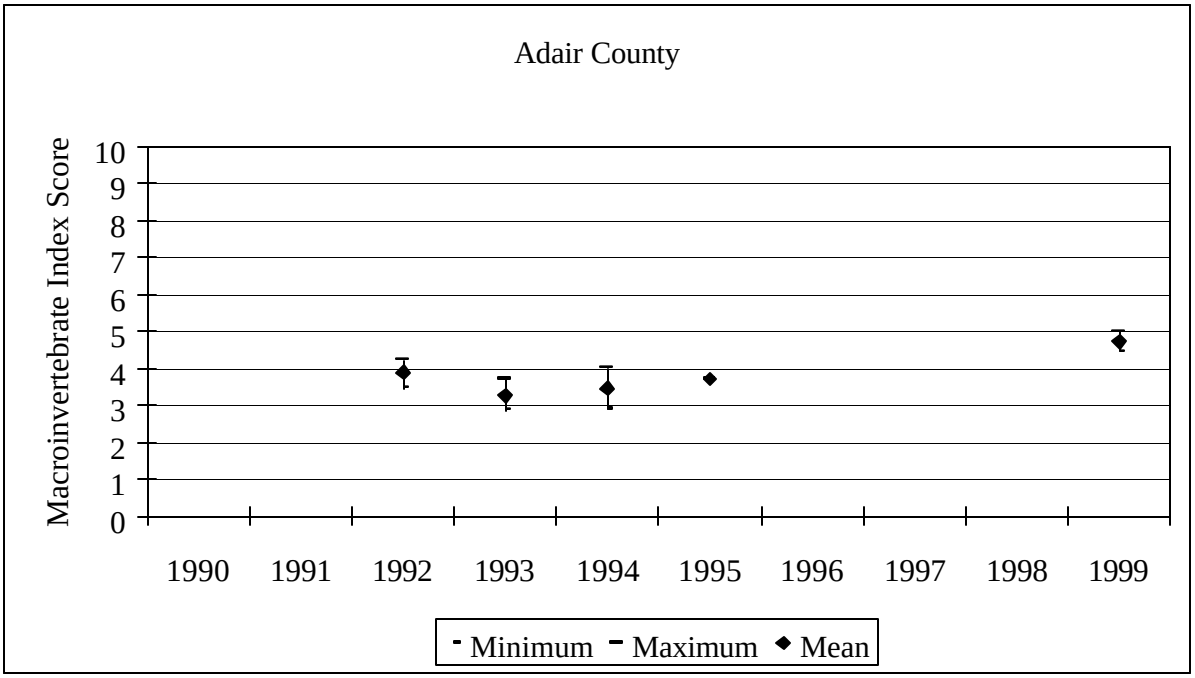

Figure 2.112. Macroinvertebrate Index Scores for Adair County

Table 2.106. Macroinvertebrate Index Scores for Bell County

Year	Samples	Minimum	Maximum	Mean
1990	5	3.17	6.69	4.88
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				

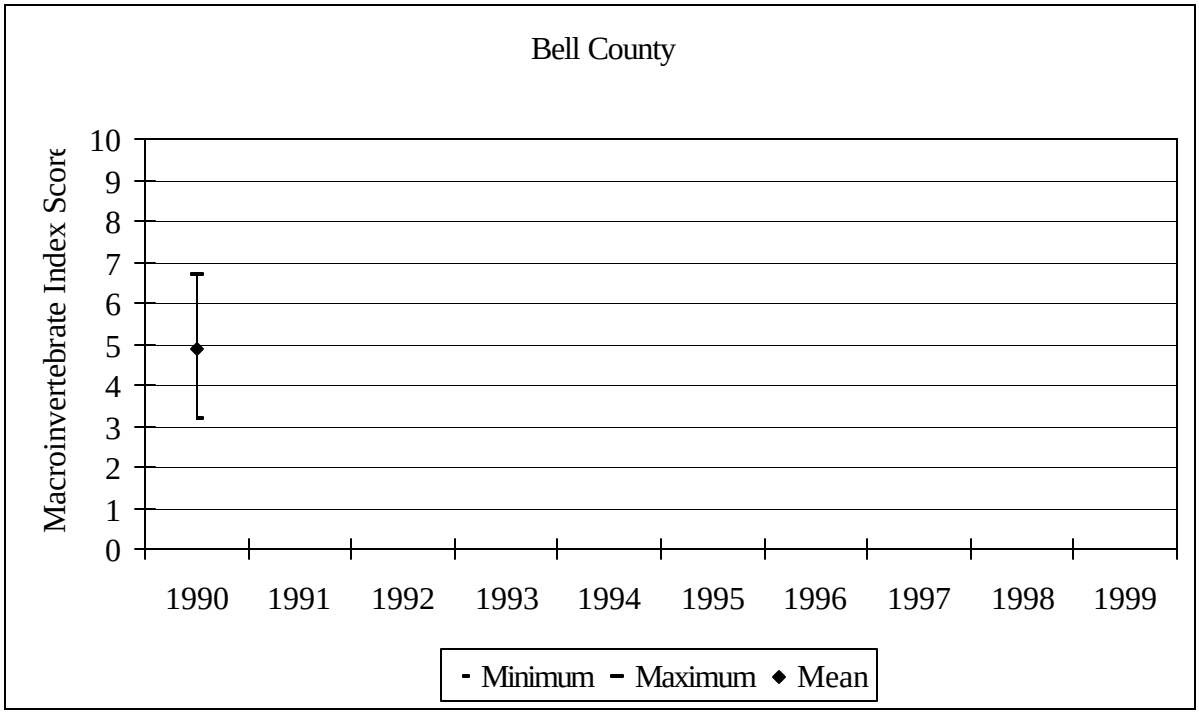

Figure 2.113. Macroinvertebrate Index Scores for Bell County

Table 2.107. Macroinvertebrate Index Scores for Breathitt County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	4	2.99	4.52	3.81
1992				
1993	4	2.98	3.90	3.36
1994	2	3.29	3.75	3.52
1995	2	2.49	6.88	4.69
1996				
1997				
1998	9	4.08	6.68	5.56
1999	1	3.24	3.24	3.24

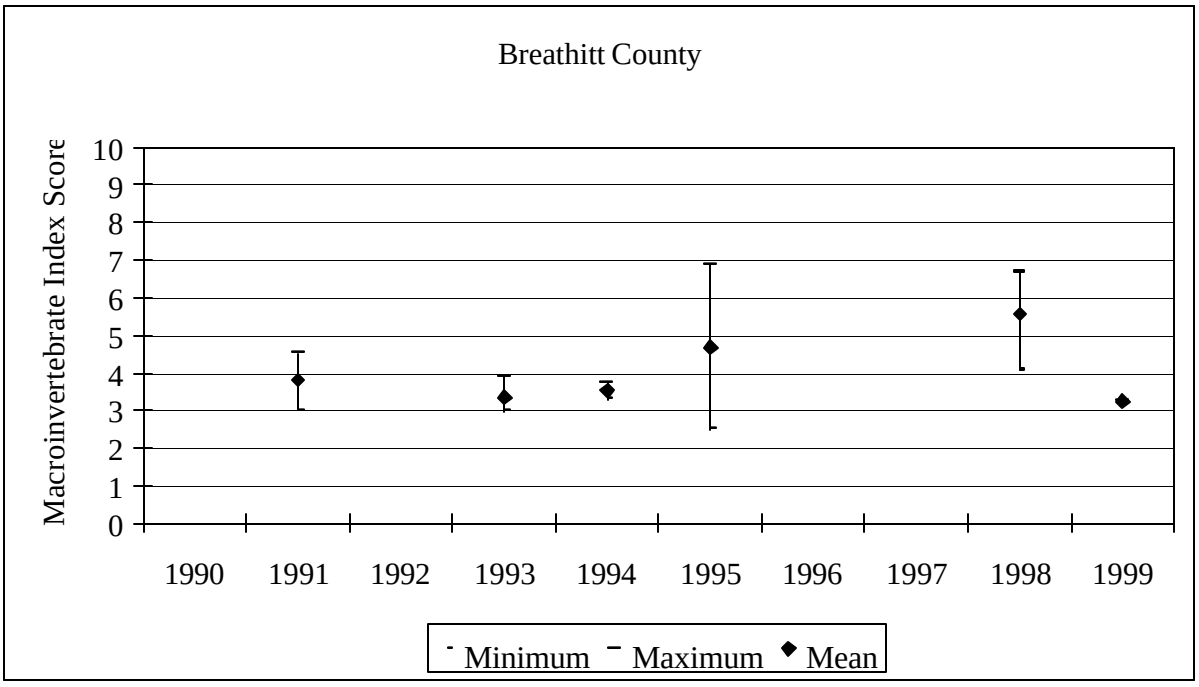

Figure 2.114. Macroinvertebrate Index Scores for Breathitt County

Table 2.108. Macroinvertebrate Index Scores for Casey County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	4.67	4.69	4.68
1993	2	3.53	4.49	4.01
1994	2	3.95	4.89	4.42
1995	1	4.75	4.75	4.75
1996				
1997				
1998				
1999				

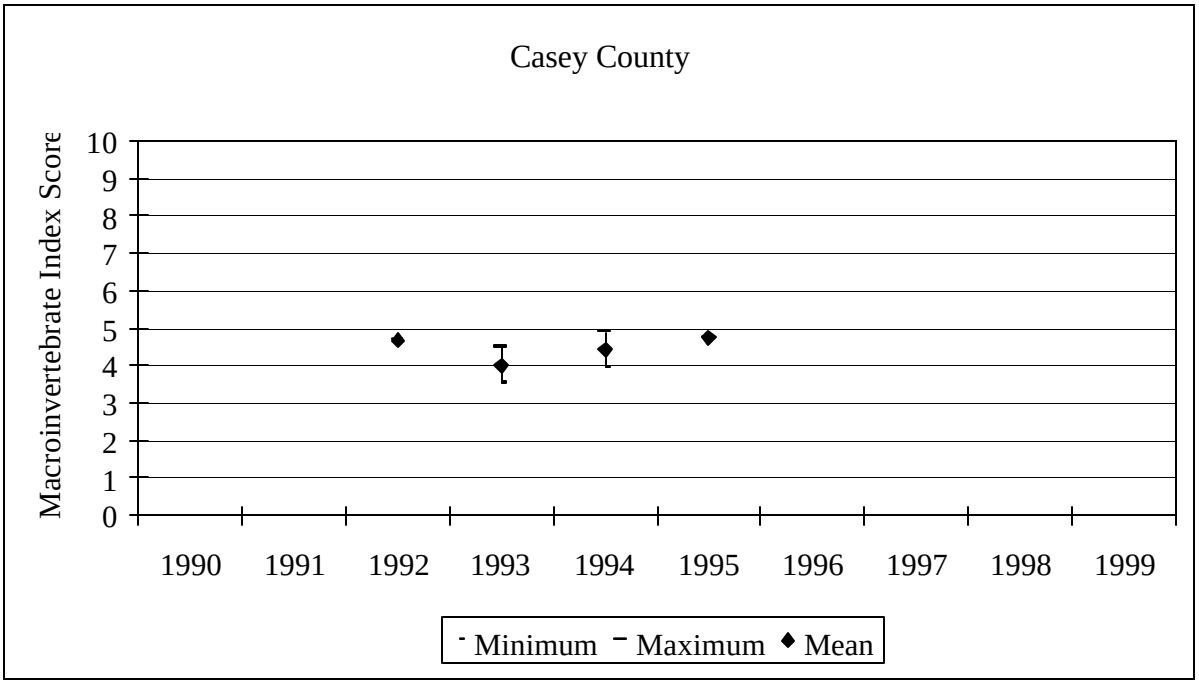

Figure 2.115. Macroinvertebrate Index Scores for Casey County

Table 2.109. Macroinvertebrate Index Scores for Clay County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	10	3.93	6.83	5.62
1999				

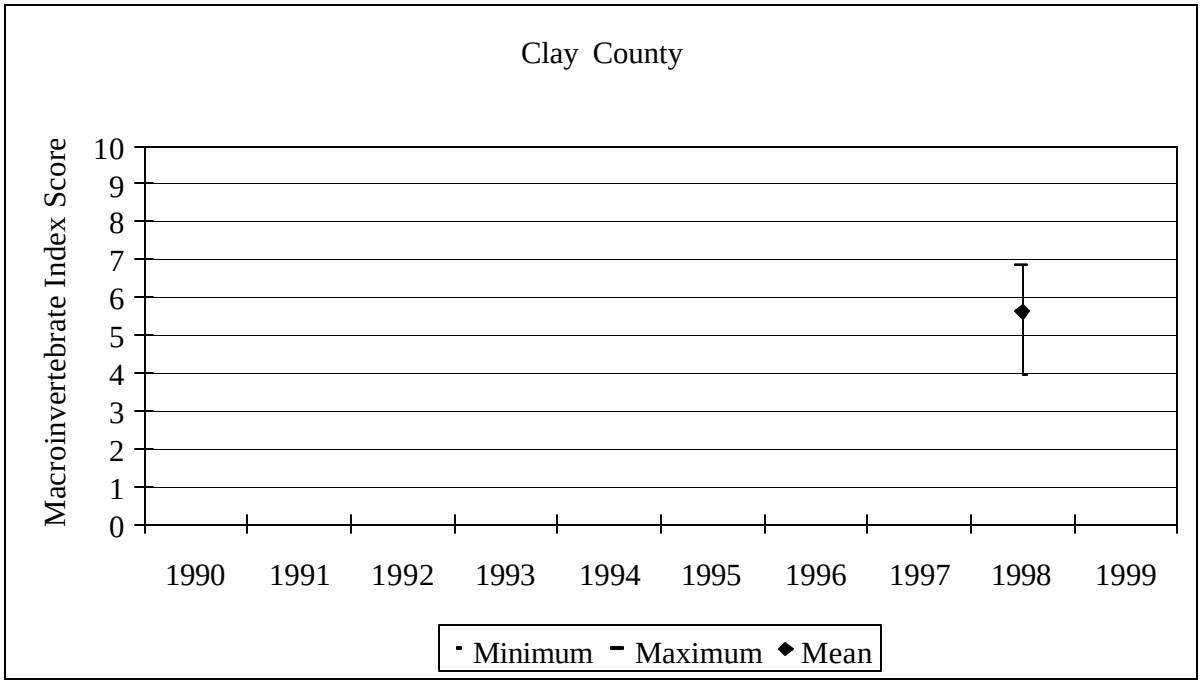

Figure 2.116. Macroinvertebrate Index Scores for Clay County

Table 2.110. Macroinvertebrate Index Scores for Estill County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	3.61	4.39	4.00
1993				
1994	1	4.03	4.03	4.03
1995	1	7.22	7.22	7.22
1996				
1997				
1998	4	4.58	6.89	5.71
1999				

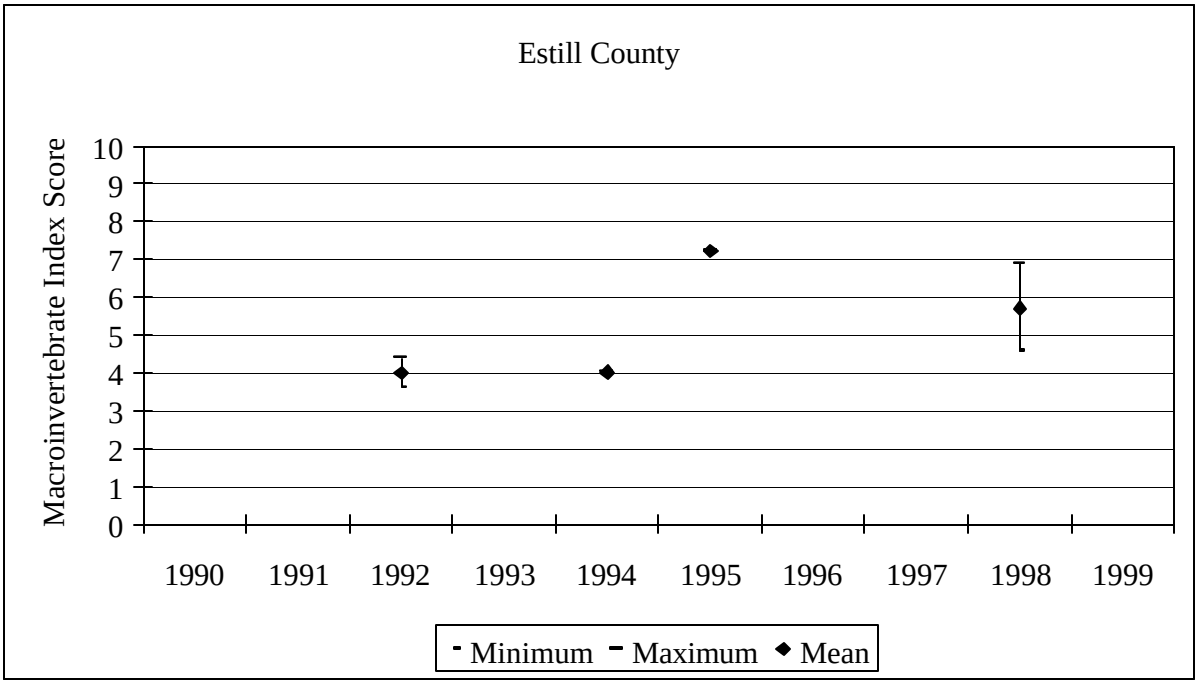

Figure 2.117. Macroinvertebrate Index Scores for Estill County

Table 2.111. Macroinvertebrate Index Scores for Garrard County

Year	Samples	Minimum	Maximum	Mean
1990	1	4.41	4.41	4.41
1991	1	4.88	4.88	4.88
1992				
1993				
1994				
1995				
1996				
1997				
1998	2	5.50	5.66	5.58
1999				

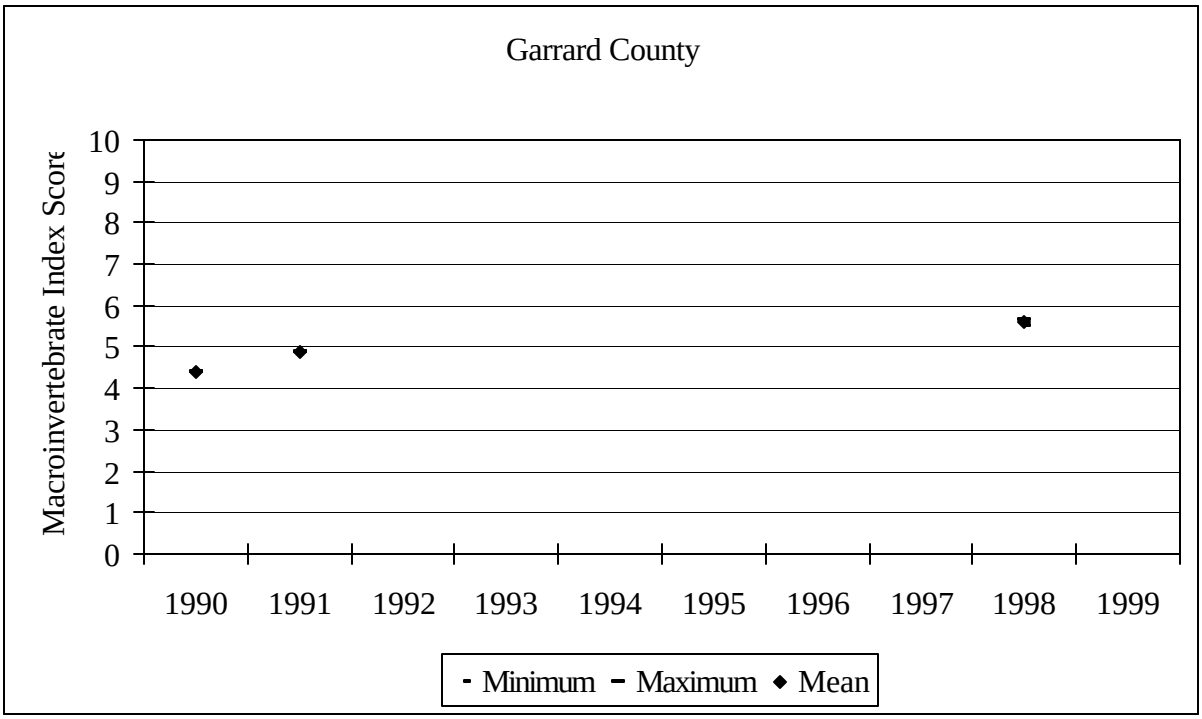

Figure 2.118. Macroinvertebrate Index Scores for Garrard County

Table 2.112. Macroinvertebrate Index Scores for Green County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	1	5.18	5.18	5.18
1992	2	4.23	5.38	4.80
1993	6	3.66	5.22	4.28
1994				
1995				
1996				
1997				
1998				
1999				

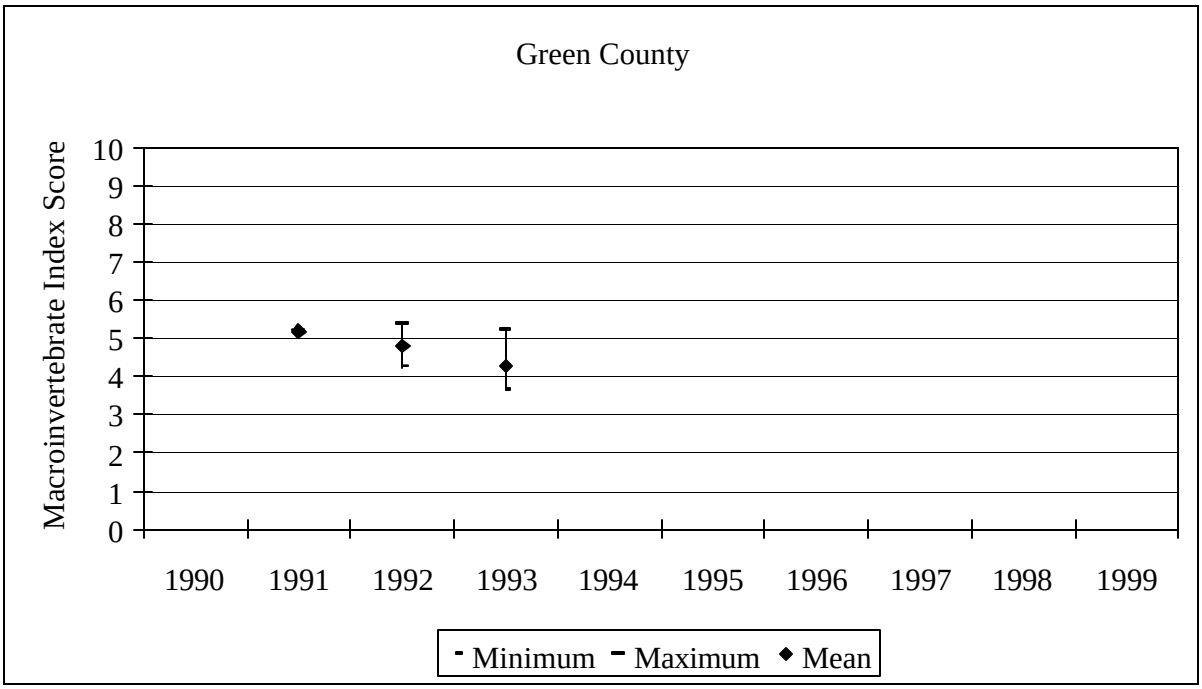

Figure 2.119. Macroinvertebrate Index Scores for Green County

Table 2.113. Macroinvertebrate Index Scores for Harlan County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993	1	2.98	2.98	2.98
1994				
1995				
1996				
1997	3	2.74	4.86	3.98
1998				
1999	1	3.04	3.04	3.04

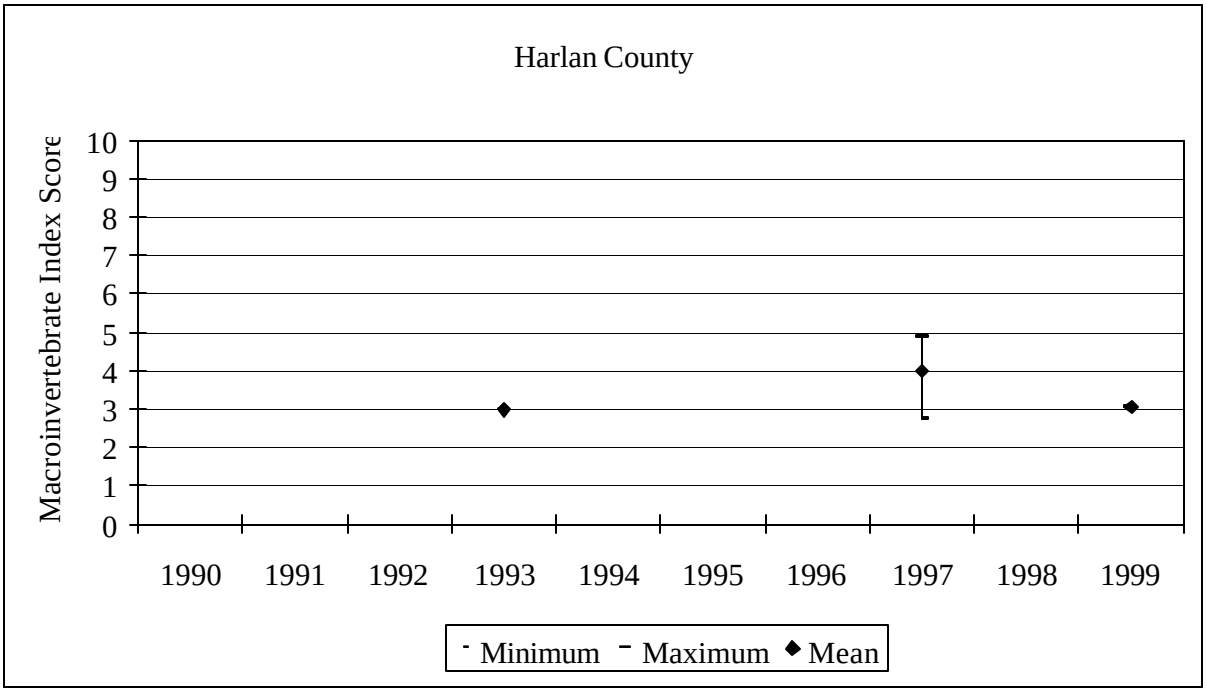

Figure 2.120. Macroinvertebrate Index Scores for Harlan County

Table 2.114. Macroinvertebrate Index Scores for Jackson County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	3.92	3.92	3.92
1993	1	4.15	4.15	4.15
1994	1	3.93	3.93	3.93
1995				
1996				
1997				
1998	4	3.25	6.04	4.78
1999				

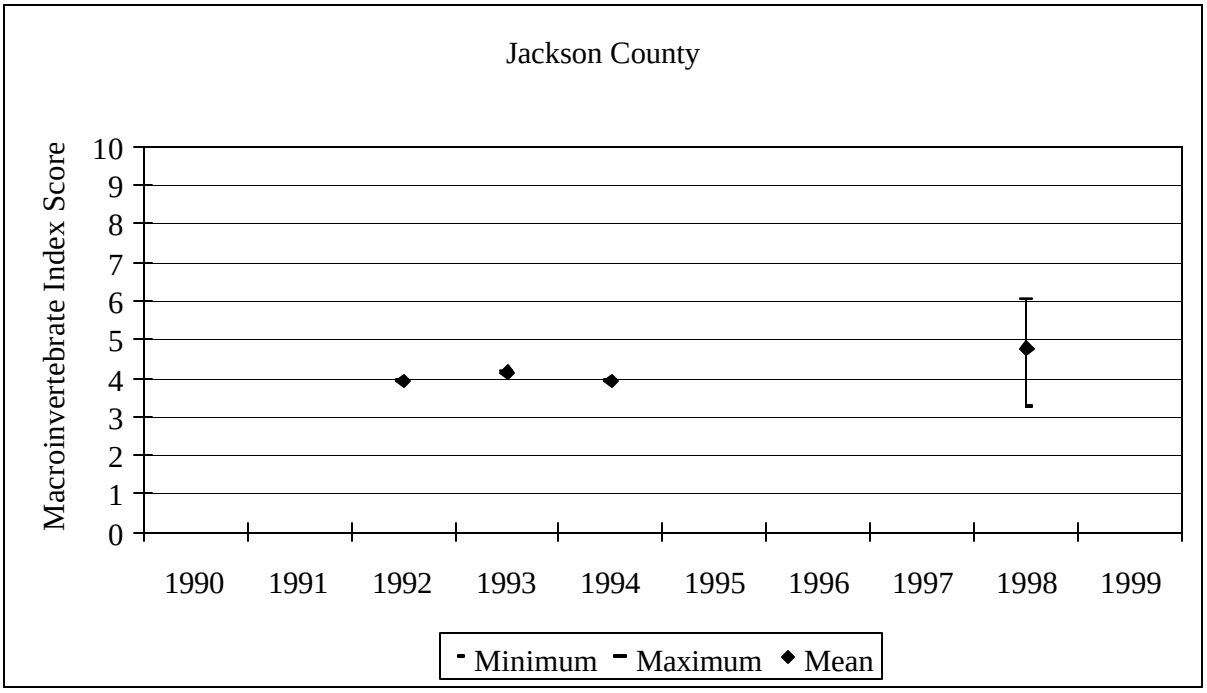

Figure 2.121. Macroinvertebrate Index Scores for Jackson County

Table 2.115. Macroinvertebrate Index Scores for Jessamine County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	6.88	6.88	6.88
1996				
1997				
1998	1	5.87	5.87	5.87
1999				

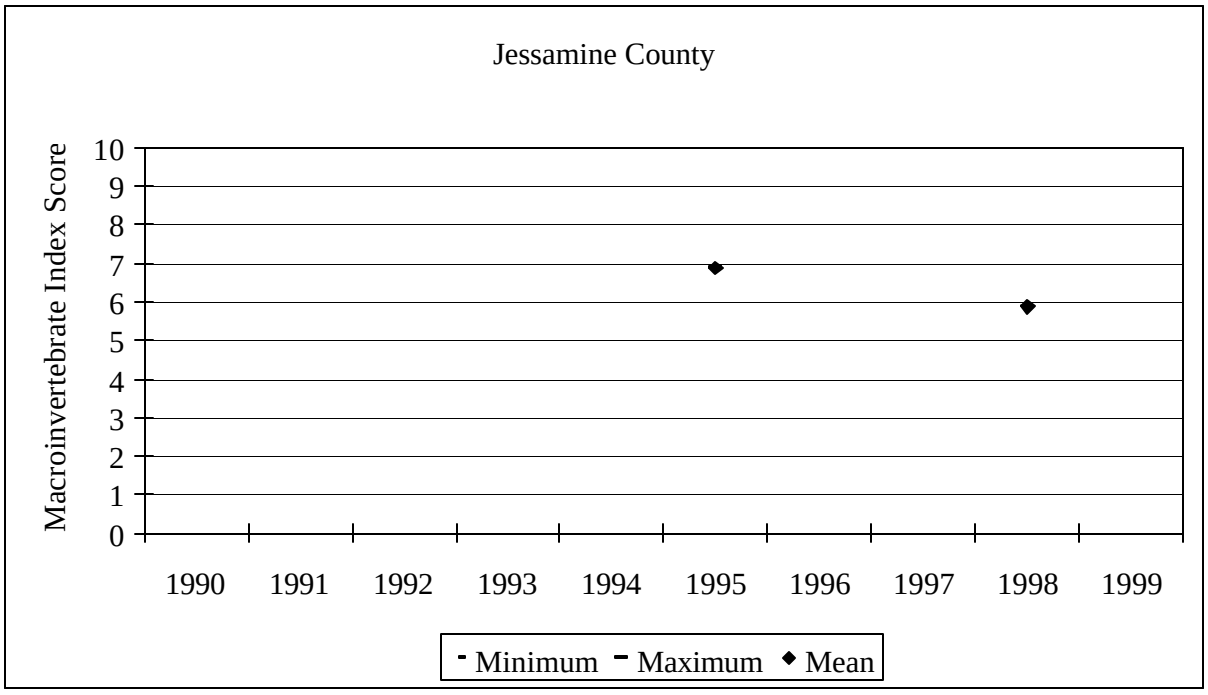

Figure 2.122. Macroinvertebrate Index Scores for Jessamine County

Table 2.116. Macroinvertebrate Index Scores for Knott County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	3	3.54	3.85	3.71
1992				
1993	1	4.58	4.58	4.58
1994	1	3.54	3.54	3.54
1995	1	3.33	3.33	3.33
1996				
1997				
1998	2	4.91	6.12	5.51
1999	1	3.89	3.89	3.89

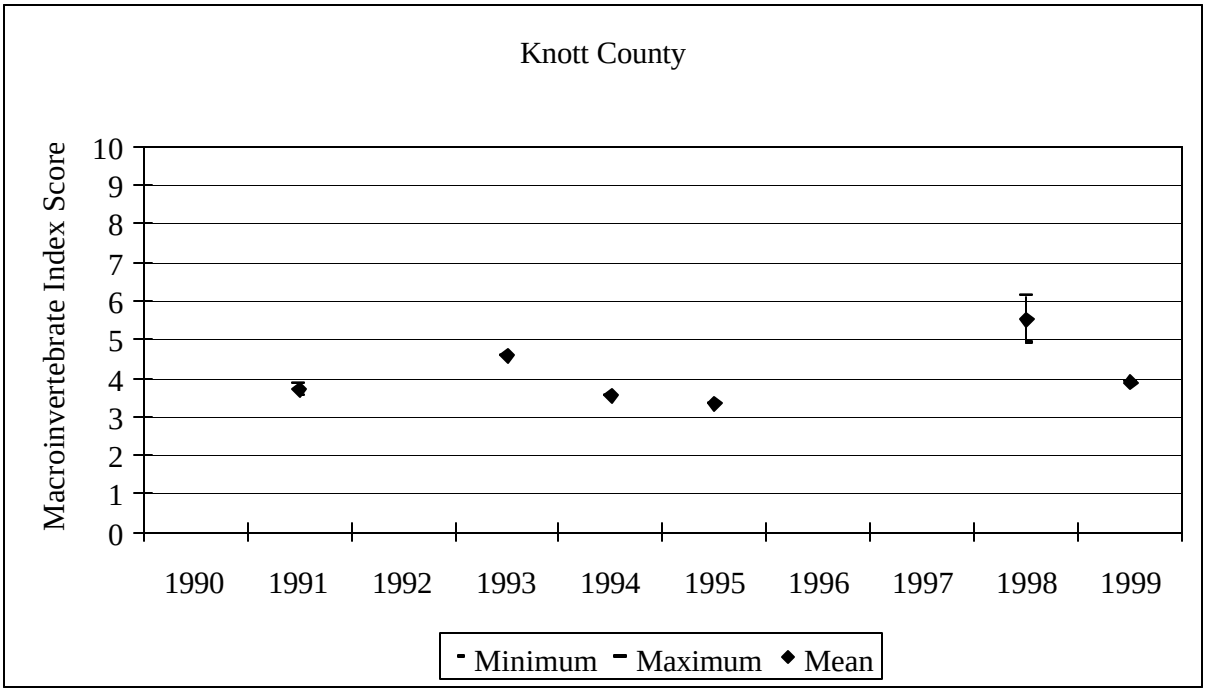

Figure 2.123. Macroinvertebrate Index Scores for Knott County

Table 2.117. Macroinvertebrate Index Scores for Laurel County

Year	Samples	Minimum	Maximum	Mean
1990	1	5.58	5.58	5.58
1991	1	6.52	6.52	6.52
1992	2	3.56	4.21	3.89
1993	3	2.88	5.30	4.14
1994	1	3.71	3.71	3.71
1995	1	4.36	4.36	4.36
1996	2	3.33	4.88	4.10
1997	1	4.65	4.65	4.65
1998				
1999				

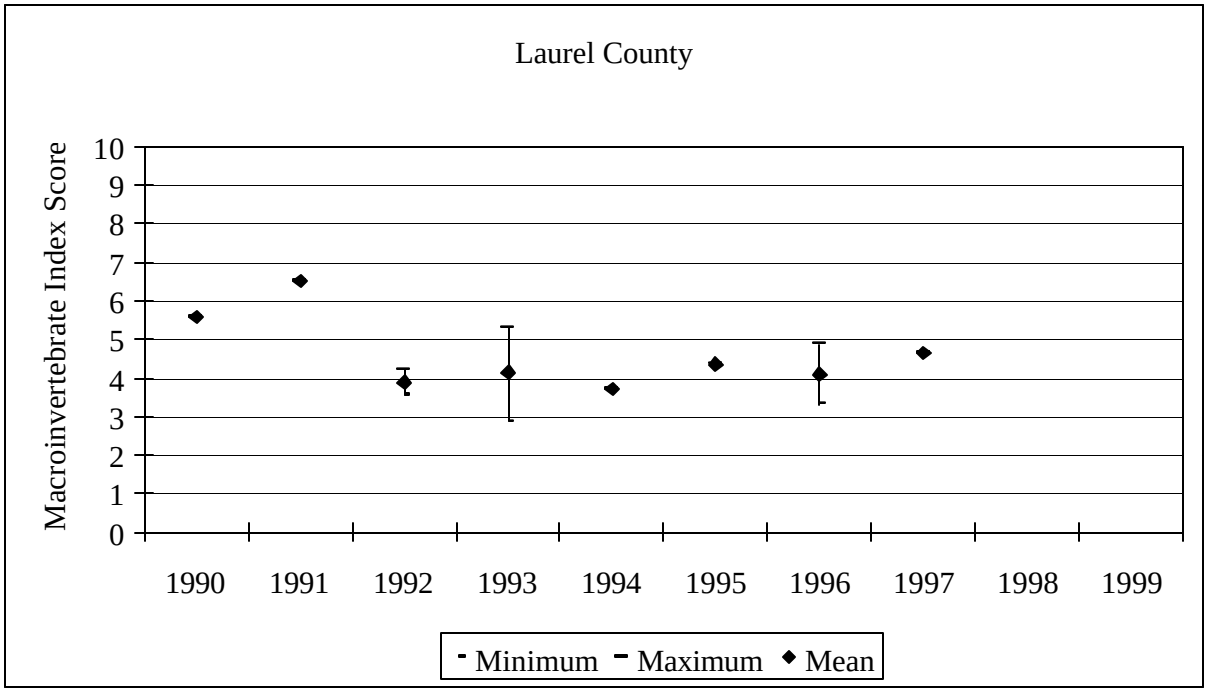

Figure 2.124. Macroinvertebrate Index Scores for Laurel County

Table 2.118. Macroinvertebrate Index Scores for Lawrence County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	5.59	5.59	5.59
1993				
1994				
1995				
1996				
1997				
1998				
1999				

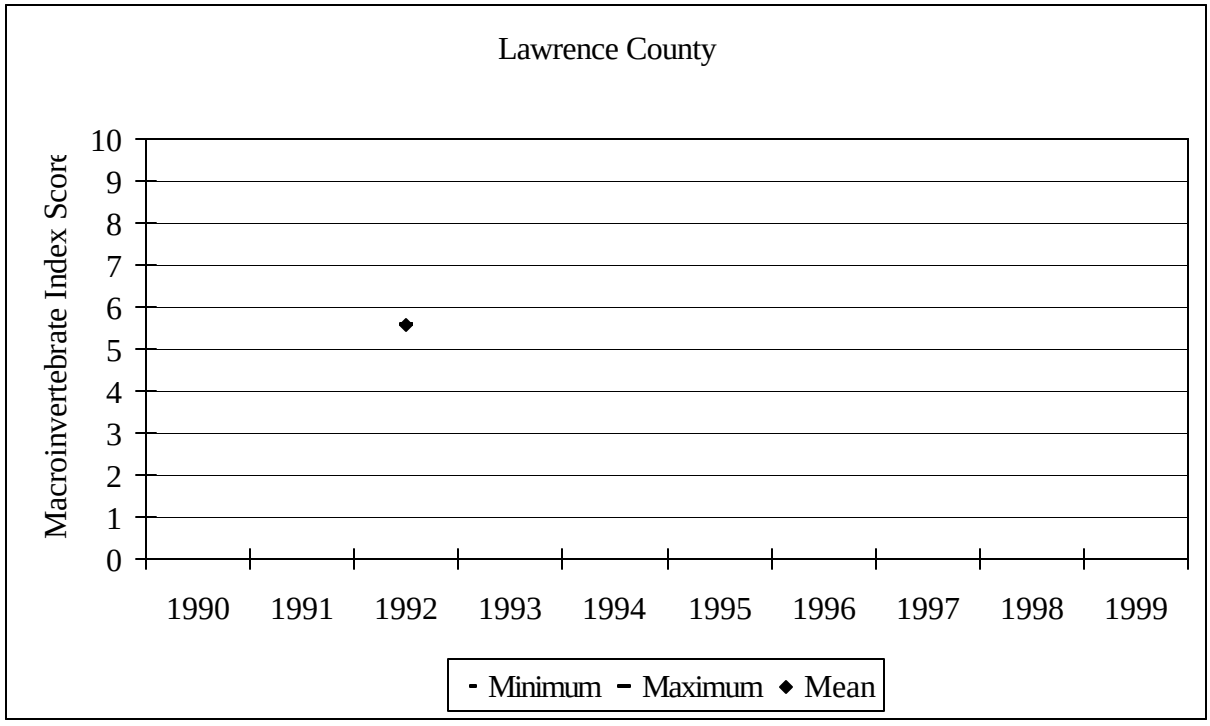

Figure 2.125. Macroinvertebrate Index Scores for Lawrence County

Table 2.119. Macroinvertebrate Index Scores for Lee County

Year	Samples	Minimum	Maximum	Mean
1990	1	6.27	6.27	6.27
1991				
1992	2	4.16	5.38	4.77
1993	2	3.69	3.85	3.77
1994	2	3.86	4.22	4.04
1995	2	5.11	7.93	6.52
1996				
1997				
1998	3	3.47	5.24	4.52
1999	1	5.33	5.33	5.33

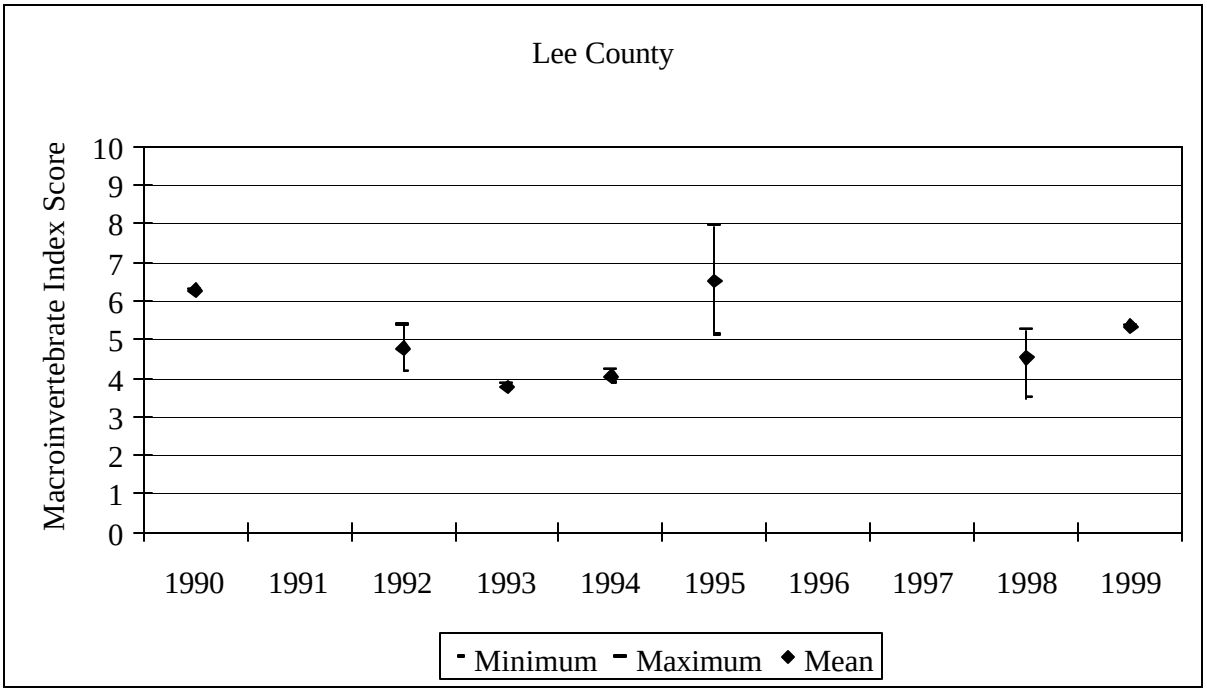

Figure 2.126. Macroinvertebrate Index Scores for Lee County

Table 2.120. Macroinvertebrate Index Scores for Leslie County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996	1	4.59	4.59	4.59
1997	1	8.00	8.00	8.00
1998	17	3.80	6.49	5.28
1999				

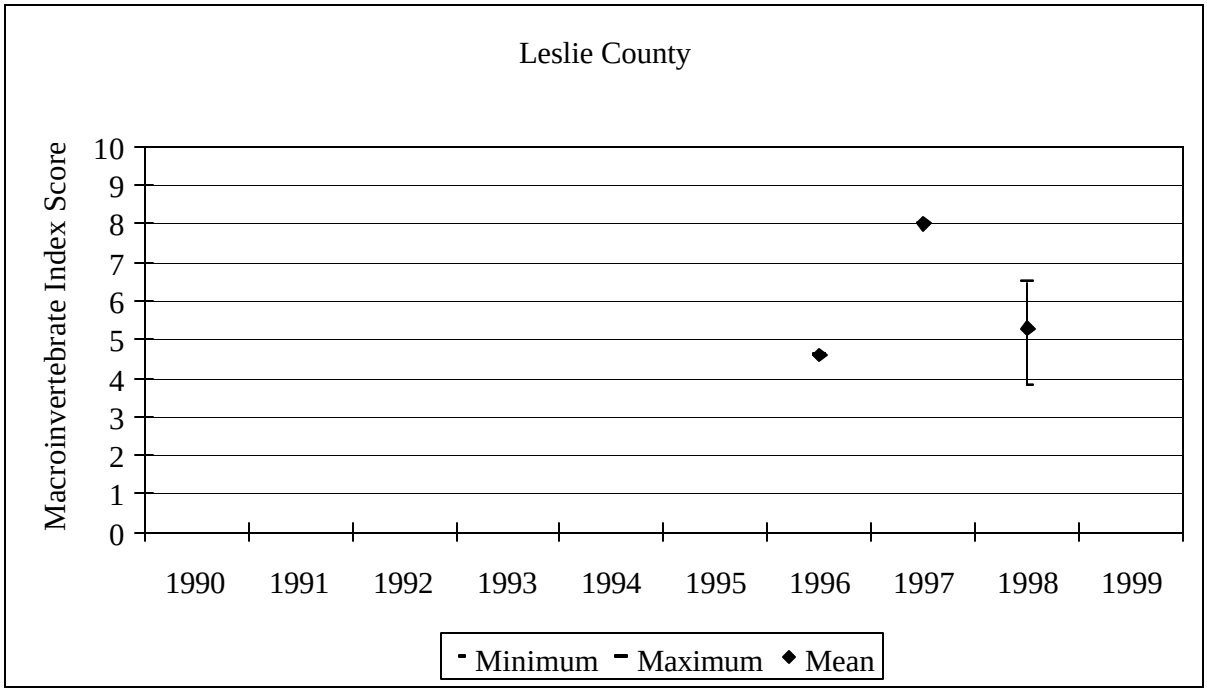

Figure 2.127. Macroinvertebrate Index Scores for Leslie County

Table 2.121. Macroinvertebrate Index Scores for Letcher County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	1.37	2.80	2.09
1993	1	1.09	1.09	1.09
1994				
1995				
1996				
1997				
1998	5	4.09	7.29	6.22
1999				

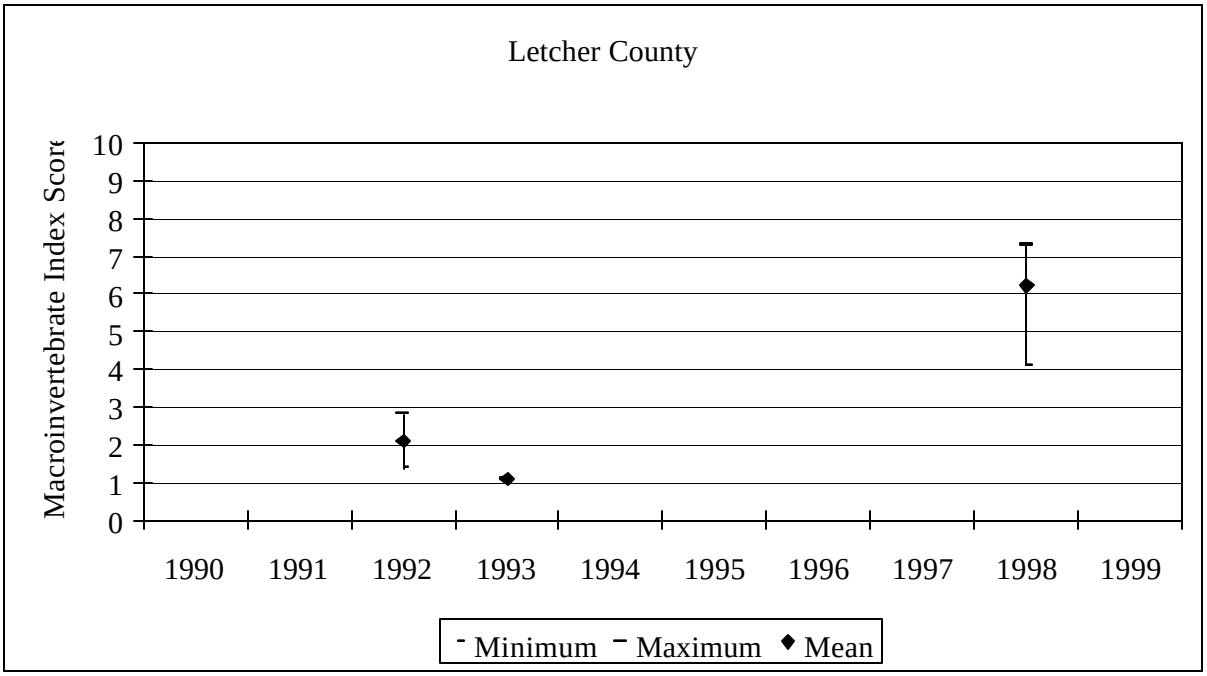

Figure 2.128. Macroinvertebrate Index Scores for Letcher County

Table 2.122. Macroinvertebrate Index Scores for Lincoln County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995	3	5.32	6.38	5.90
1996				
1997				
1998				
1999				

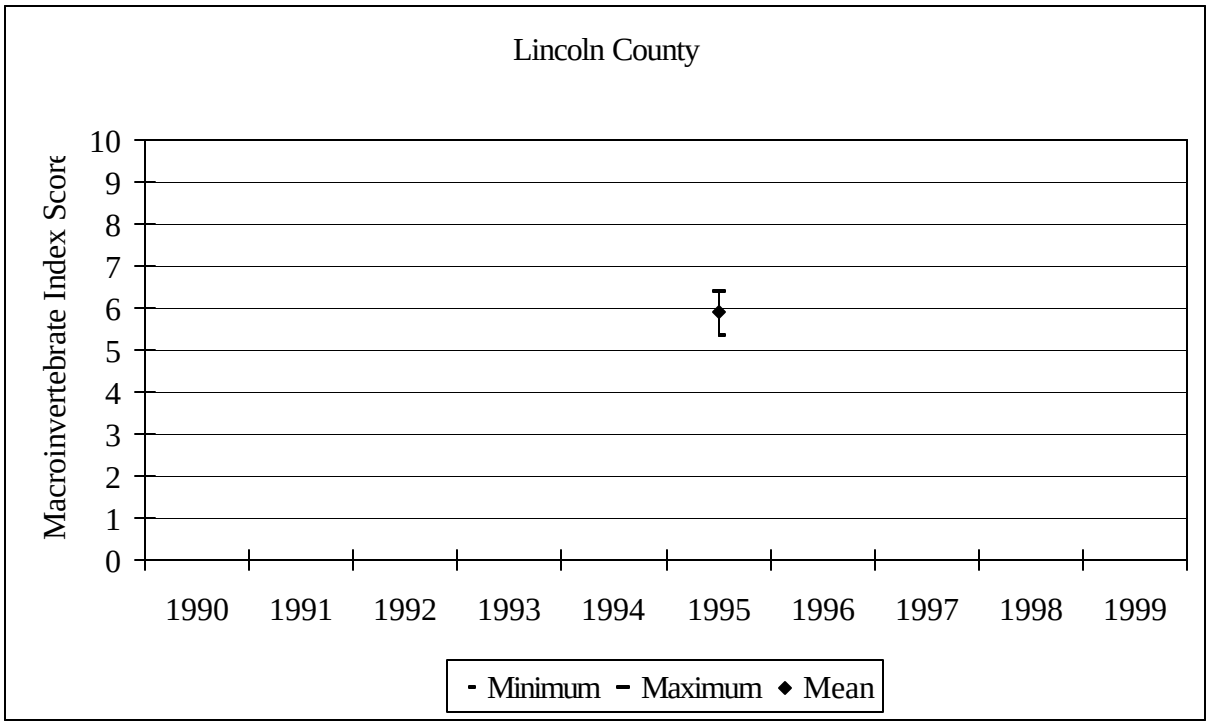

Figure 2.129. Macroinvertebrate Index Scores for Lincoln County

Table 2.123. Macroinvertebrate Index Scores for Magoffin County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999	1	5.61	5.61	5.61

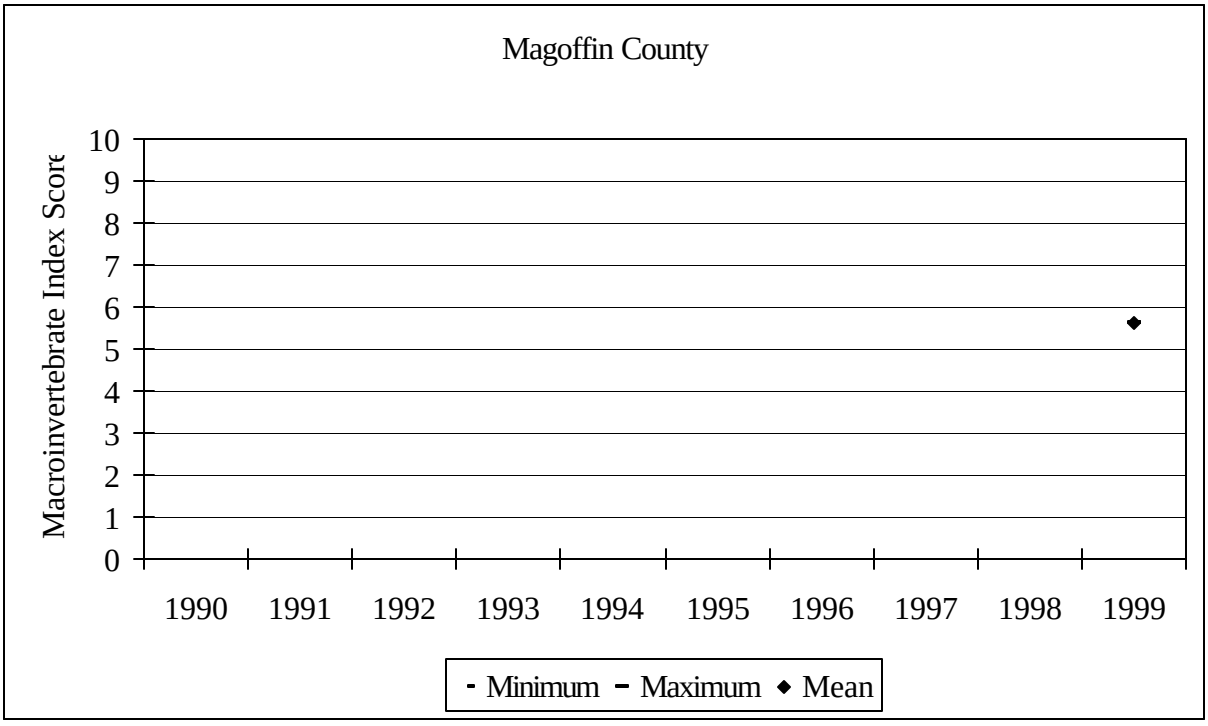

Figure 2.130. Macroinvertebrate Index Scores for Magoffin County

Table 2.124. Macroinvertebrate Index Scores for Martin County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	6.68	6.68	6.68
1993				
1994				
1995				
1996				
1997				
1998				
1999				

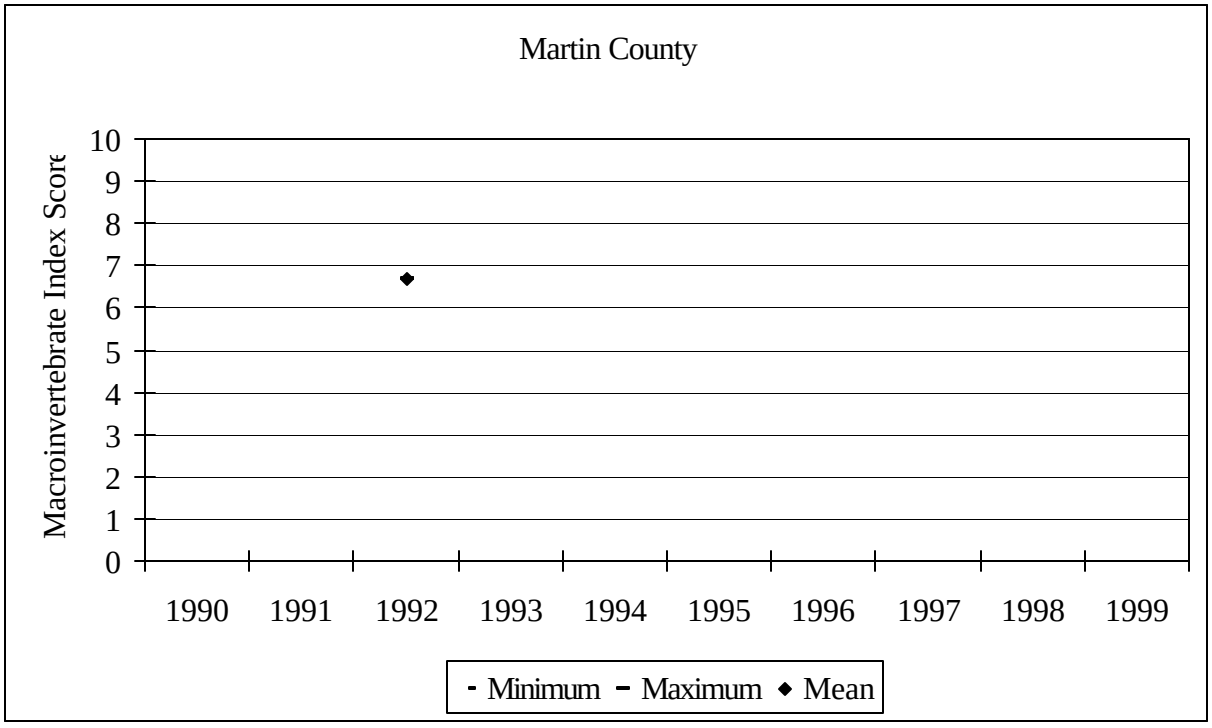

Figure 2.131. Macroinvertebrate Index Scores for Martin County

Table 2.125. Macroinvertebrate Index Scores for McCreary County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	9	2.48	7.23	5.11
1992	10	3.39	6.72	4.73
1993	5	3.48	4.98	4.14
1994	4	3.12	7.39	4.90
1995				
1996				
1997	6	3.76	6.60	5.46
1998				
1999				

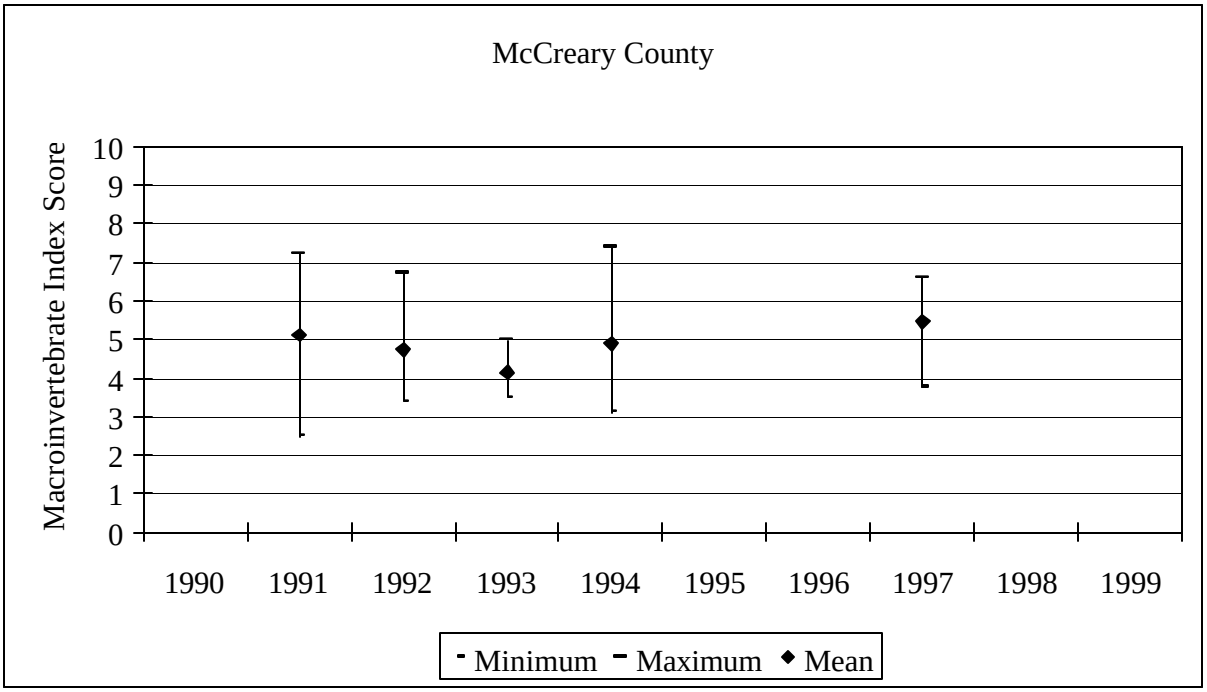

Figure 2.132. Macroinvertebrate Index Scores for McCreary County

Table 2.126. Macroinvertebrate Index Scores for Menifee County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	4	4.31	5.98	5.13
1999	1	6.62	6.62	6.62

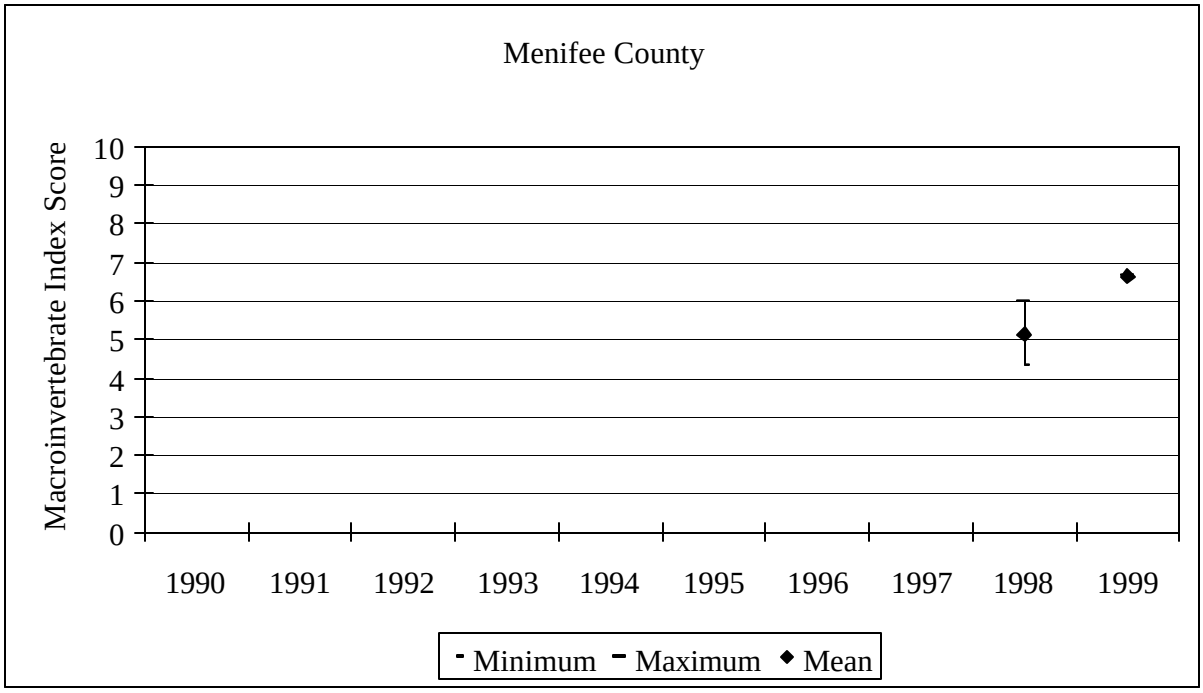

Figure 2.133. Macroinvertebrate Index Scores for Menifee County

Table 2.127. Macroinvertebrate Index Scores for Metcalfe County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	4.19	4.19	4.19
1996				
1997				
1998				
1999				

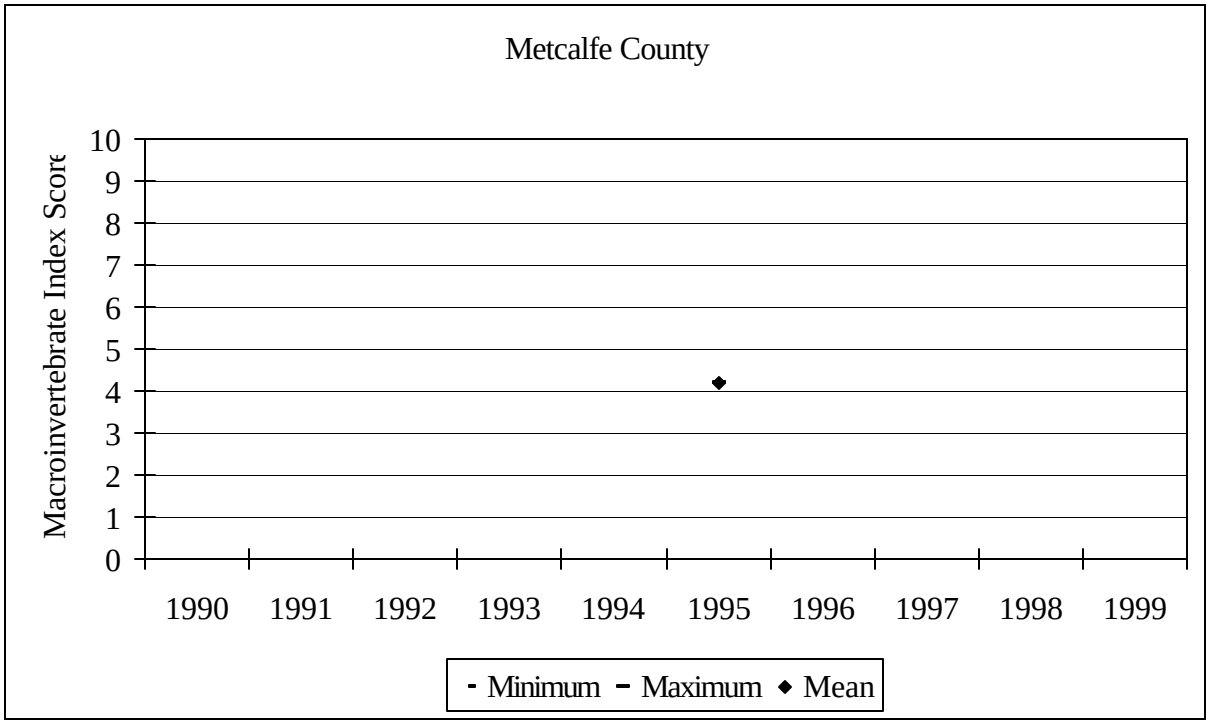

Figure 2.134. Macroinvertebrate Index Scores for Metcalfe County

Table 2.128. Macroinvertebrate Index Scores for Morgan County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	6	1.29	4.25	3.37
1993	4	3.32	4.08	3.57
1994	5	2.94	5.17	4.20
1995				
1996	1	3.92	3.92	3.92
1997				
1998				
1999	5	4.15	6.95	5.10

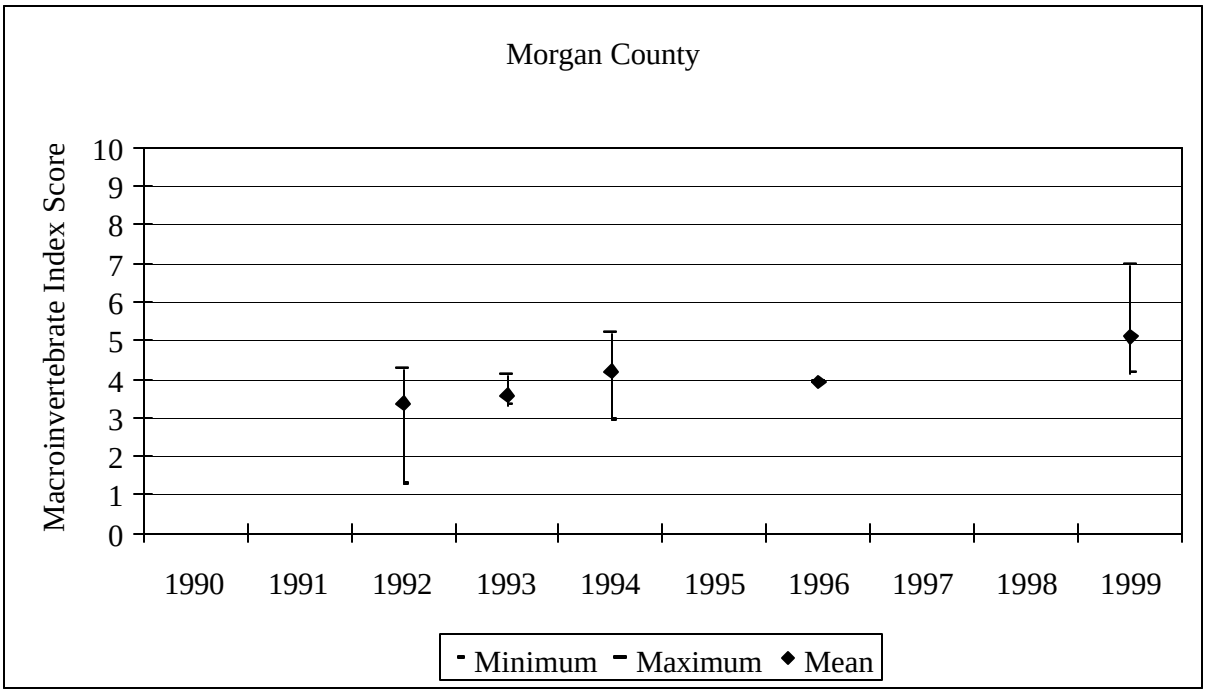

Figure 2.135. Macroinvertebrate Index Scores for Morgan County

Table 2.129. Macroinvertebrate Index Scores for Owsley County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	3.52	3.99	3.76
1993	1	3.53	3.53	3.53
1994	1	3.46	3.46	3.46
1995	1	6.69	6.69	6.69
1996				
1997				
1998	3	5.14	6.47	5.64
1999				

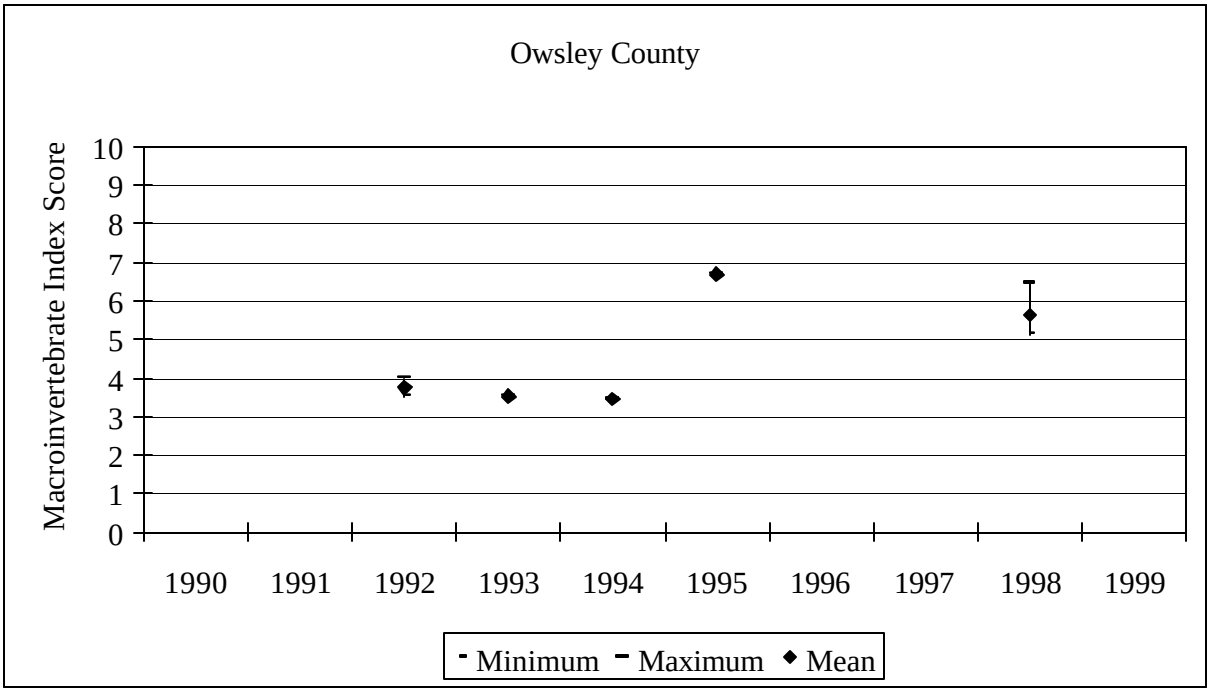

Figure 2.136. Macroinvertebrate Index Scores for Owsley County

Table 2.130. Macroinvertebrate Index Scores for Perry County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998	1	4.91	4.91	4.91
1999				

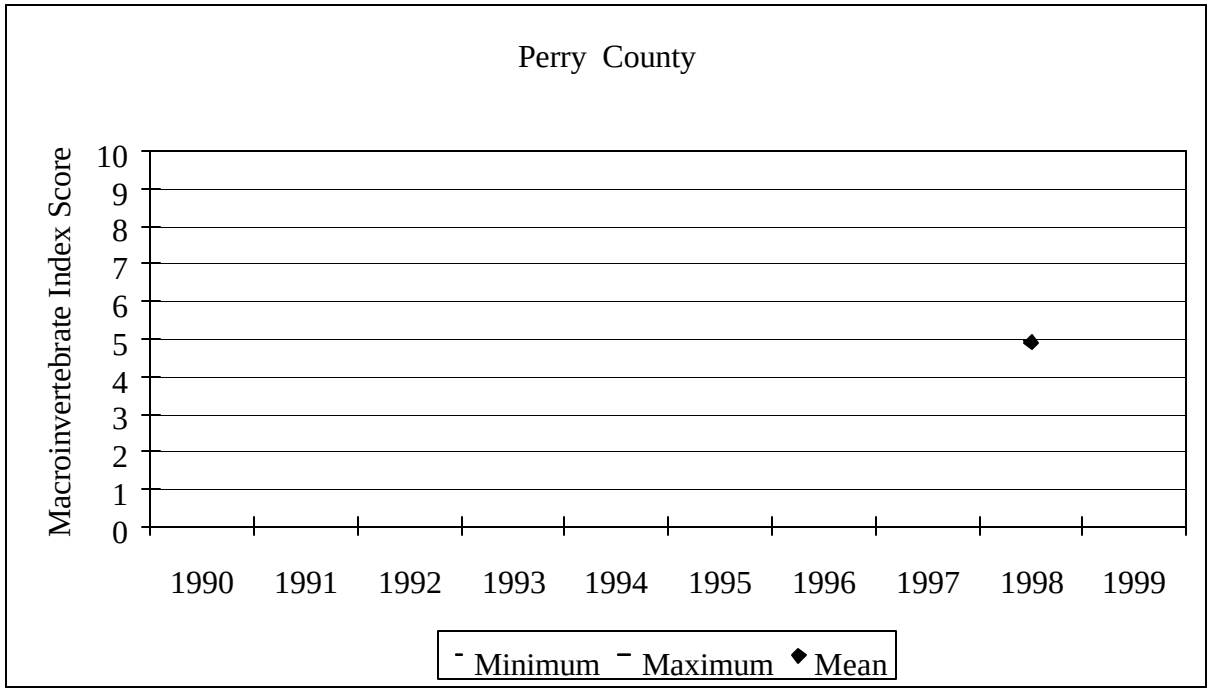

Figure 2.137. Macroinvertebrate Index Scores for Perry County

Table 2.131. Macroinvertebrate Index Scores for Pike County

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	1	5.34	5.34	5.34
1993				
1994				
1995				
1996	1	6.37	6.37	6.37
1997				
1998				
1999				

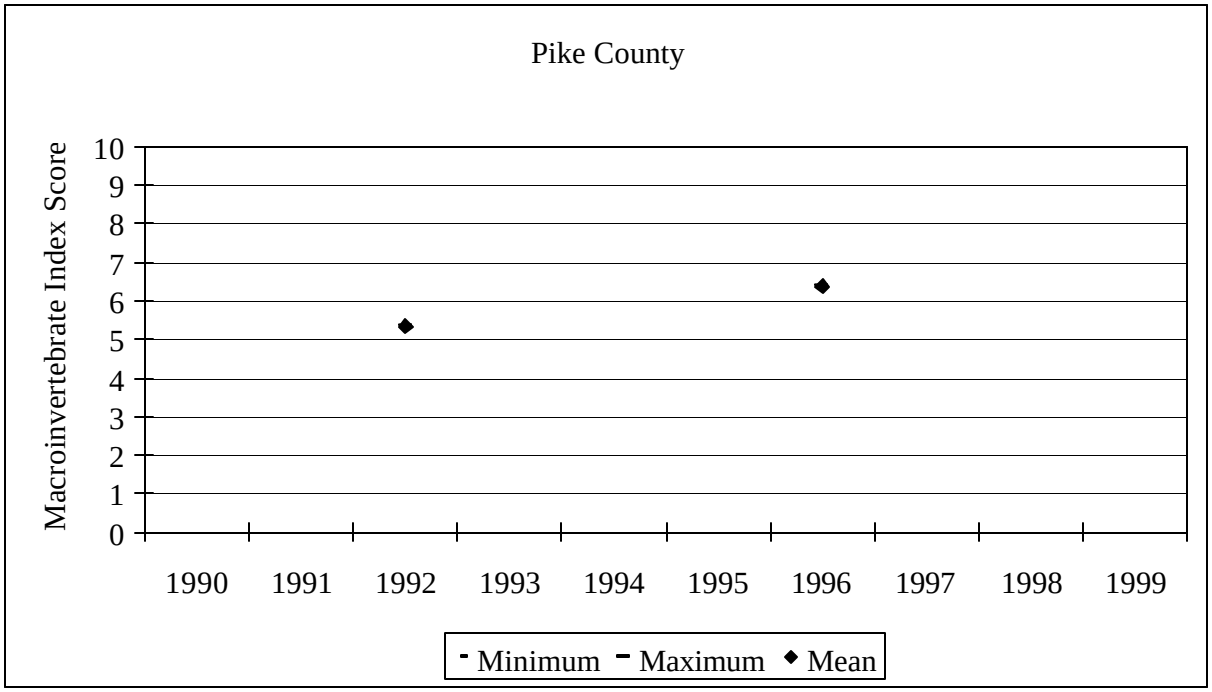

Figure 2.138. Macroinvertebrate Index Scores for Pike County

Table 2.132. Macroinvertebrate Index Scores for Pulaski County

Year	Samples	Minimum	Maximum	Mean
1990	1	4.58	4.58	4.58
1991	1	6.75	6.75	6.75
1992	2	4.25	4.38	4.32
1993	3	3.23	4.16	3.78
1994	2	3.97	4.05	4.01
1995	4	3.95	5.90	4.83
1996				
1997				
1998				
1999	2	4.53	4.74	4.63

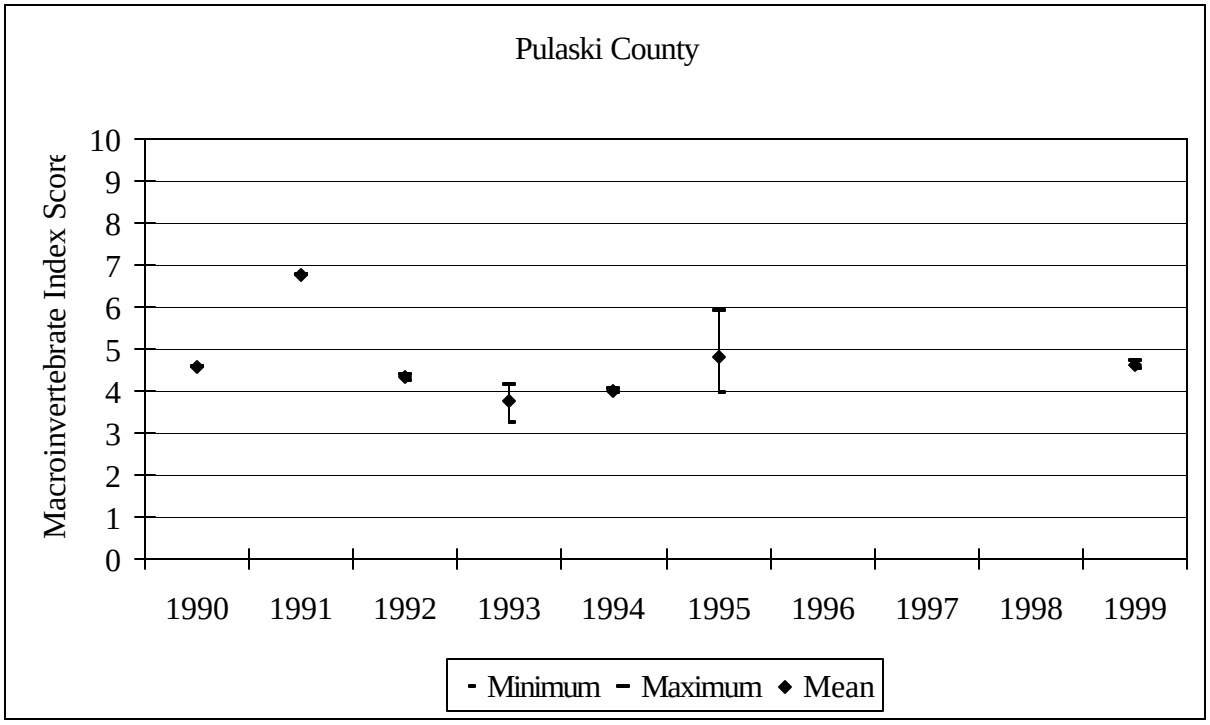

Figure 2.139. Macroinvertebrate Index Scores for Pulaski County

Table 2.133. Macroinvertebrate Index Scores for Rockcastle County

Year	Samples	Minimum	Maximum	Mean
1990	3	4.64	7.32	5.69
1991				
1992	2	2.94	3.58	3.26
1993	3	3.56	4.82	4.30
1994				
1995				
1996				
1997				
1998	1	6.05	6.05	6.05
1999				

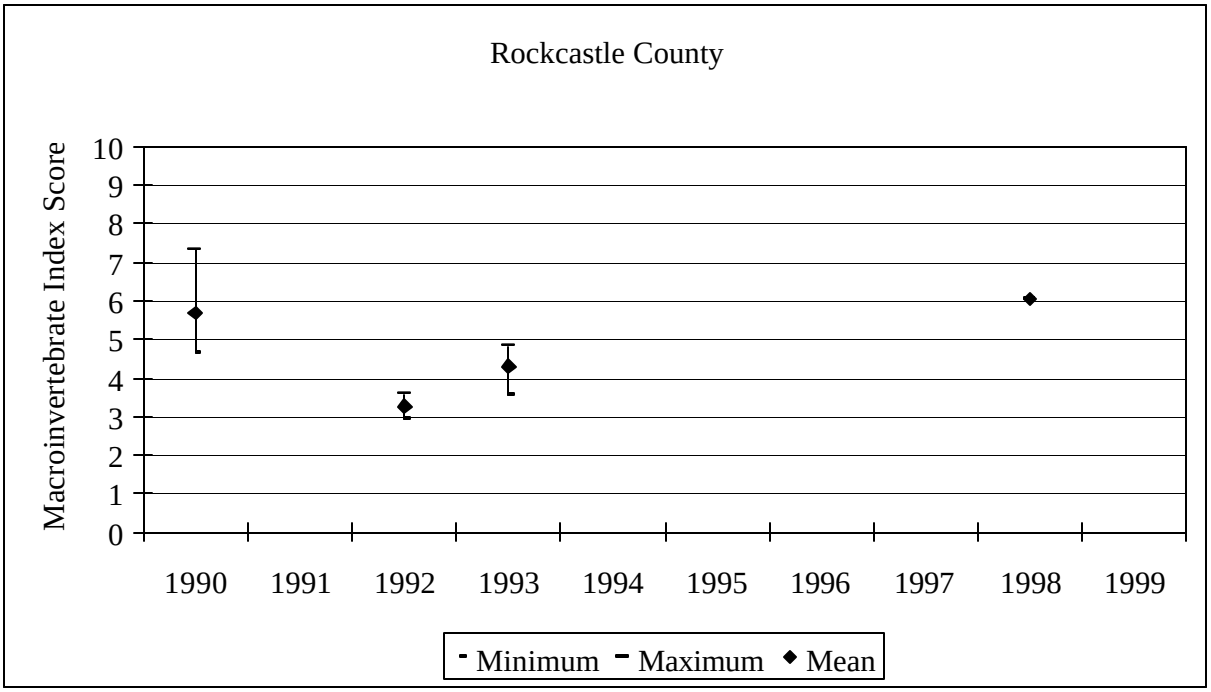

Figure 2.140. Macroinvertebrate Index Scores for Rockcastle County

Table 2.134. Macroinvertebrate Index Scores for Taylor County

Year	Samples	Minimum	Maximum	Mean
1990				
1991	2	4.89	6.79	5.84
1992				
1993				
1994				
1995	3	5.07	6.34	5.59
1996				
1997				
1998				
1999				

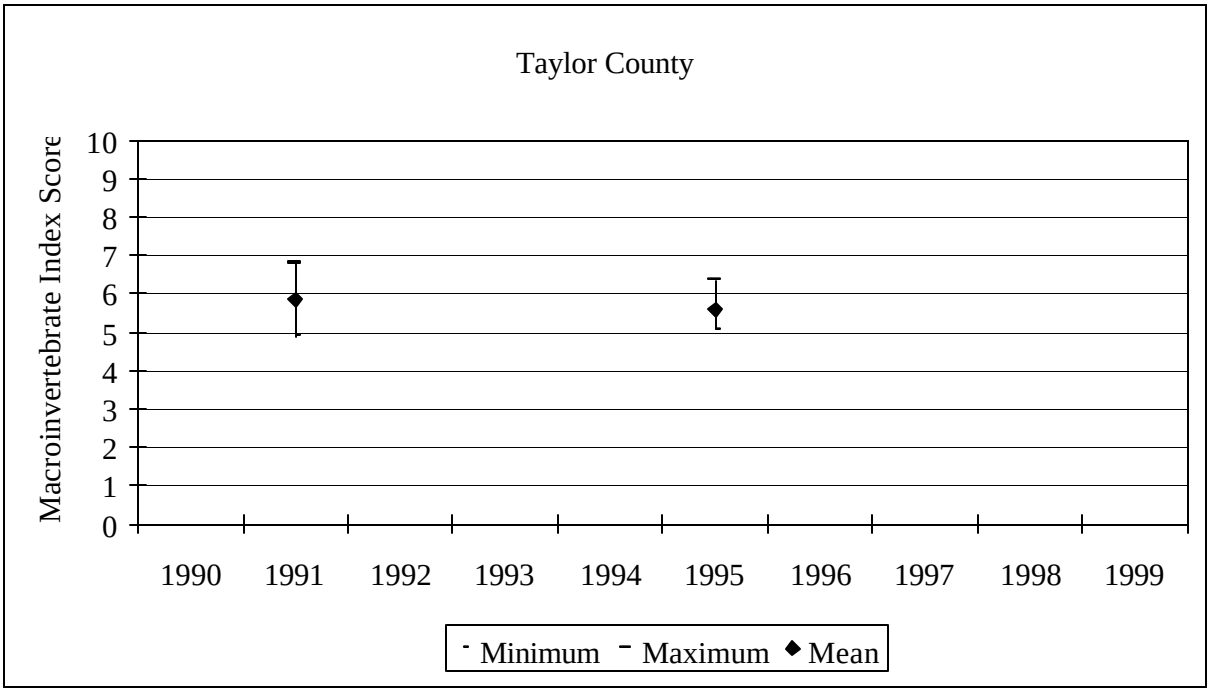

Figure 2.141. Macroinvertebrate Index Scores for Taylor County

Table 2.135. Macroinvertebrate Index Scores for Wayne County

Year	Sample	Minimum	Maximum	Mean
1990				
1991				
1992				
1993	1	4.39	4.39	4.39
1994				
1995				
1996				
1997				
1998				
1999				

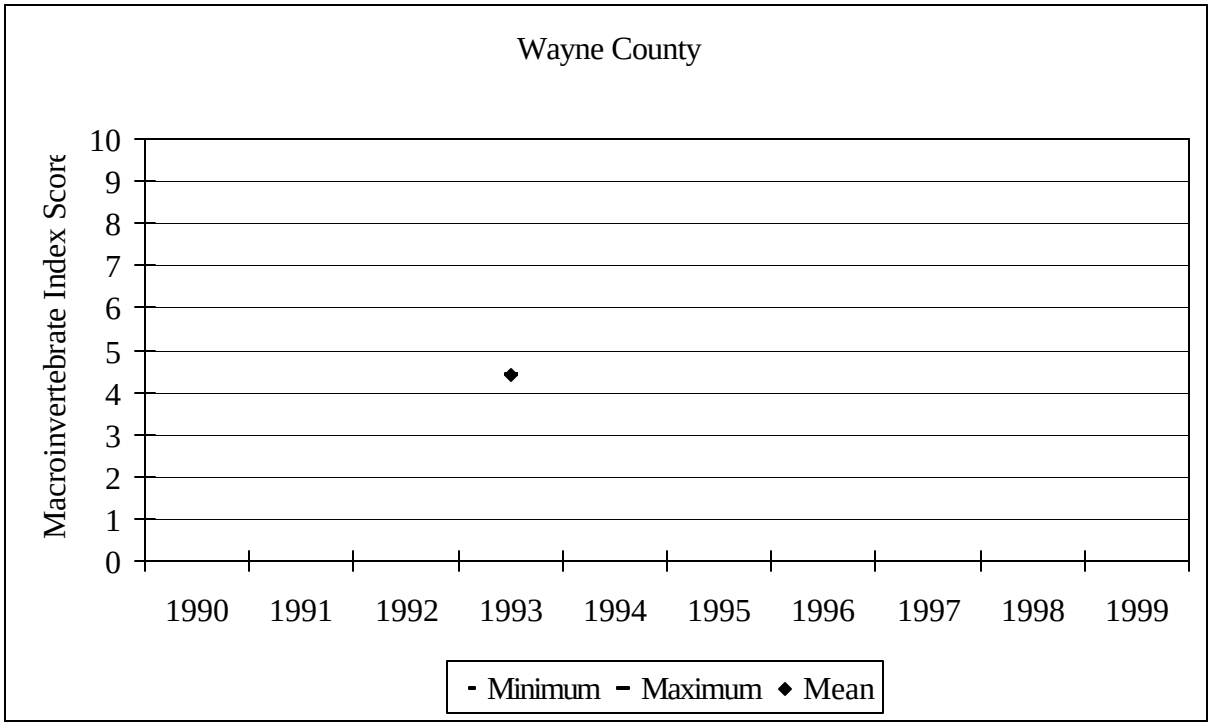

Figure 2.142. Macroinvertebrate Index Scores for Wayne County

Table 2.136. Macroinvertebrate Index Scores for Whitley County

Year	Samples	Minimum	Maximum	Mean
1990	1	4.95	4.95	4.95
1991	5	2.71	4.66	3.59
1992				
1993	7	2.92	4.89	3.97
1994	2	2.61	2.91	2.76
1995				
1996				
1997	1	4.98	4.98	4.98
1998				
1999				

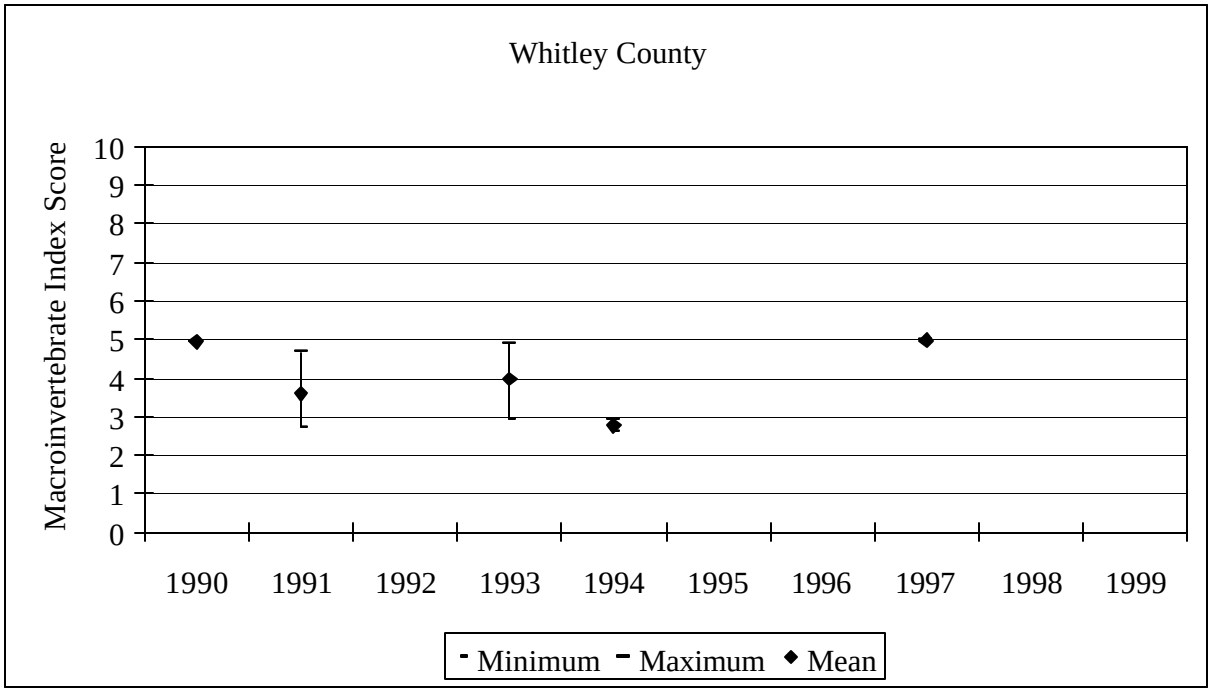

Figure 2.143. Macroinvertebrate Index Scores for Whitley County

Table 2.137. Macroinvertebrate Index Scores for Wolfe County

Year	Samples	Minimum	Maximum	Mean
1990	1	5.43	5.43	5.43
1991	1	6.67	6.67	6.67
1992				
1993				
1994				
1995				
1996				
1997				
1998	6	4.23	6.18	5.02
1999				

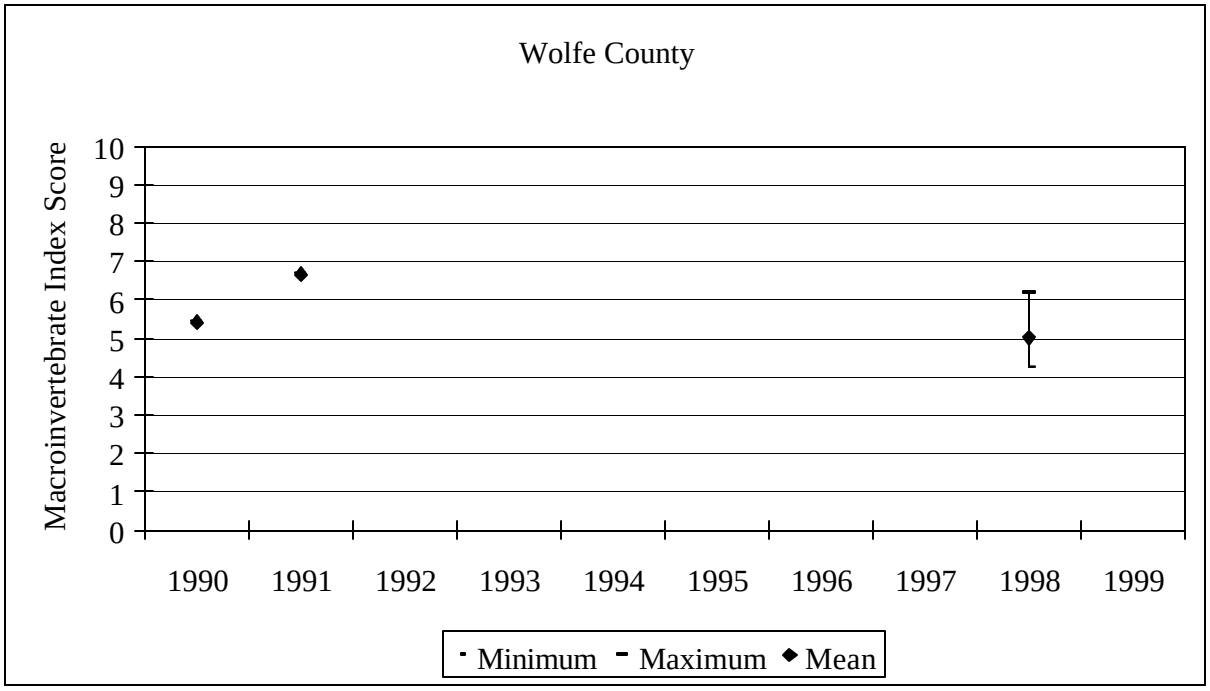

Figure 2.144. Macroinvertebrate Index Scores for Wolfe County

Table 2.138. Macroinvertebrate Index Scores for Big Sandy River Basin 05070201 HUC Watershed

Year	Samples	Maximum	Minimum	Mean
1990				
1991				
1992	1	6.68	6.68	6.68
1993				
1994				
1995				
1996				
1997				
1998				
1999				

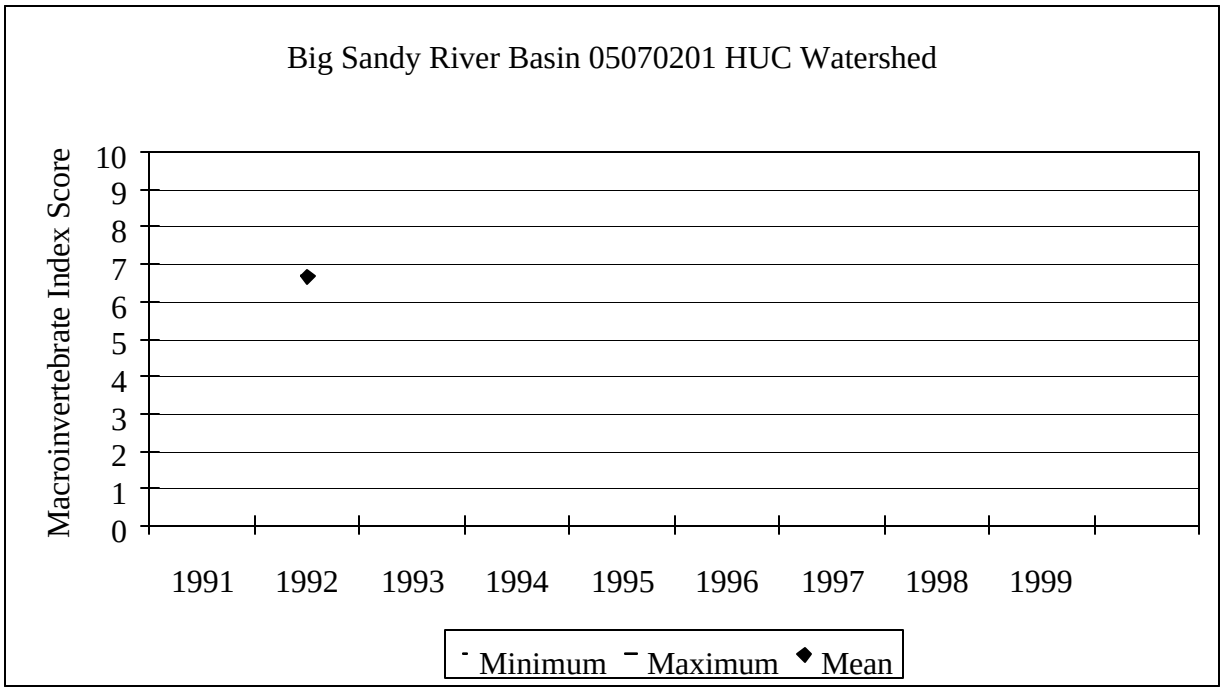

Figure 2.145. Macroinvertebrate Index Scores for Big Sandy River Basin 05070201 HUC Watershed

Table 2.139. Macroinvertebrate Index Scores for Big Sandy River Basin 05070203 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	5.34	5.59	5.47
1993				
1994				
1995				
1996	1	6.37	6.37	6.37
1997				
1998				
1999				

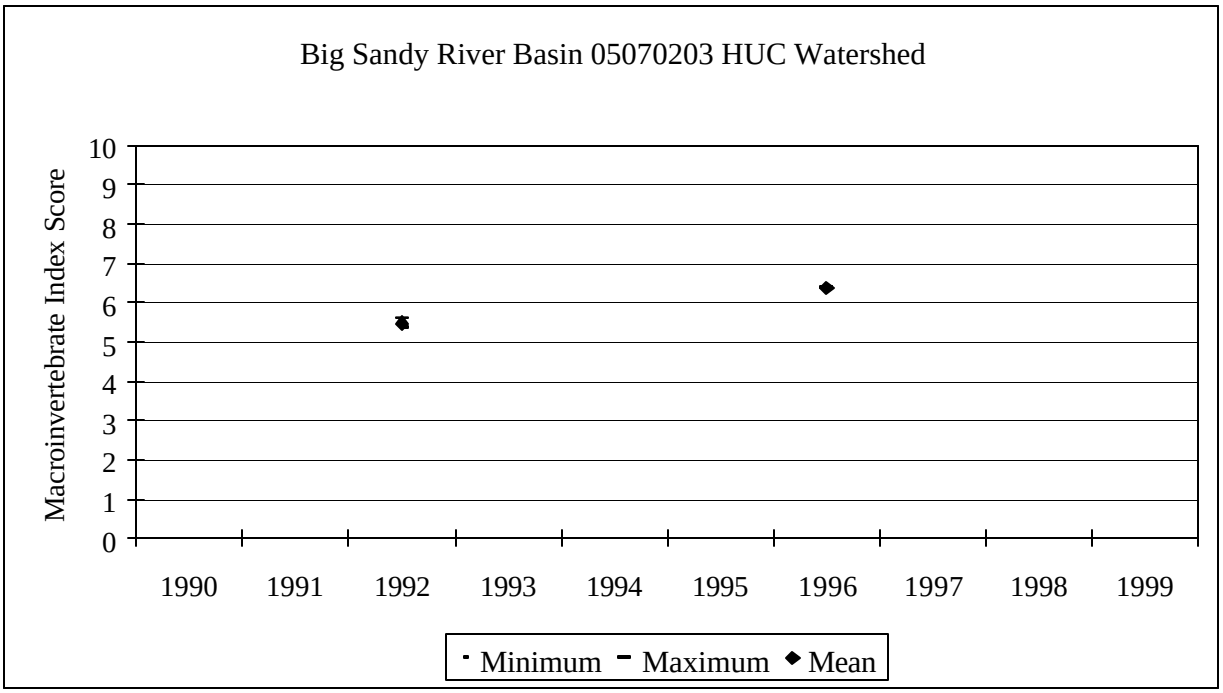

Figure 2.146. Macroinvertebrate Index Scores for Big Sandy River Basin 05070203 HUC Watershed

Table 2.140. Macroinvertebrate Index Scores for Licking River Basin 05100101 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	6	1.29	4.25	3.37
1993	4	3.32	4.08	3.57
1994	5	2.94	5.17	4.20
1995				
1996	1	3.92	3.92	3.92
1997				
1998				
1999	7	4.15	6.95	5.39

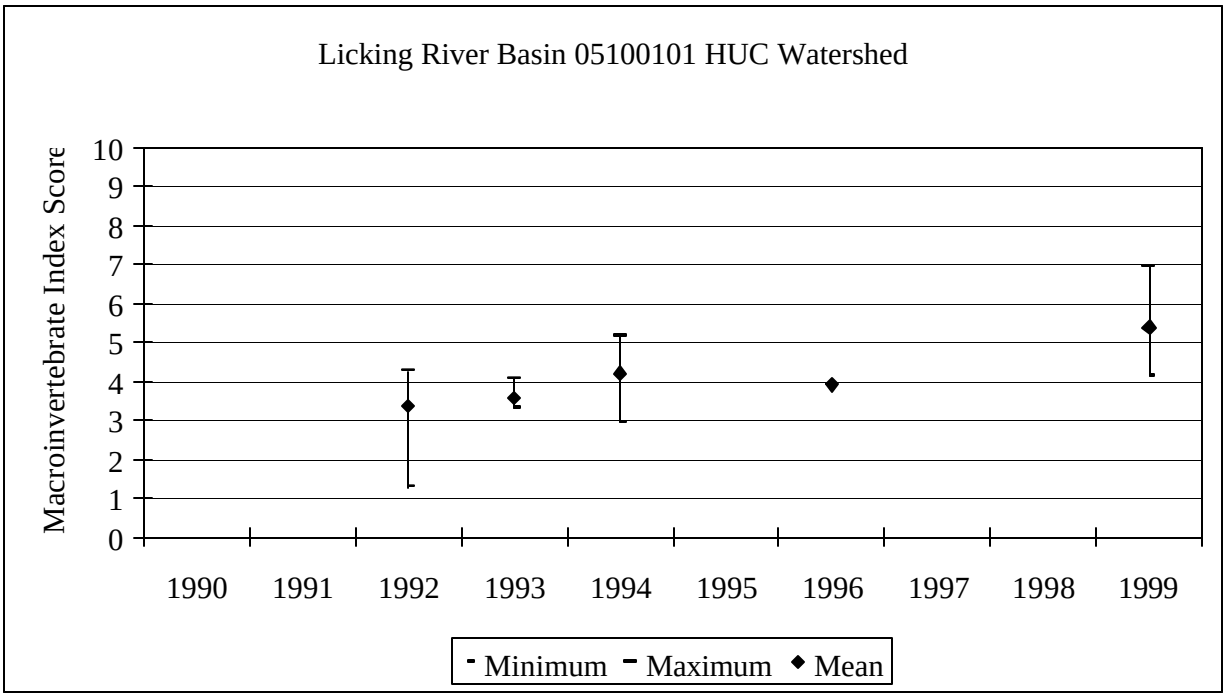

Figure 2.147. Macroinvertebrate Index Scores for Licking River Basin 05100101 HUC Watershed

Table 2.141. Macroinvertebrate Index Scores for Kentucky River Basin 05100201 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991	7	2.99	4.52	3.77
1992				
1993	5	2.98	4.58	3.60
1994	3	3.29	3.75	3.53
1995	3	2.49	6.88	4.24
1996				
1997				
1998	14	4.08	7.29	5.64
1999	2	3.24	3.89	3.57

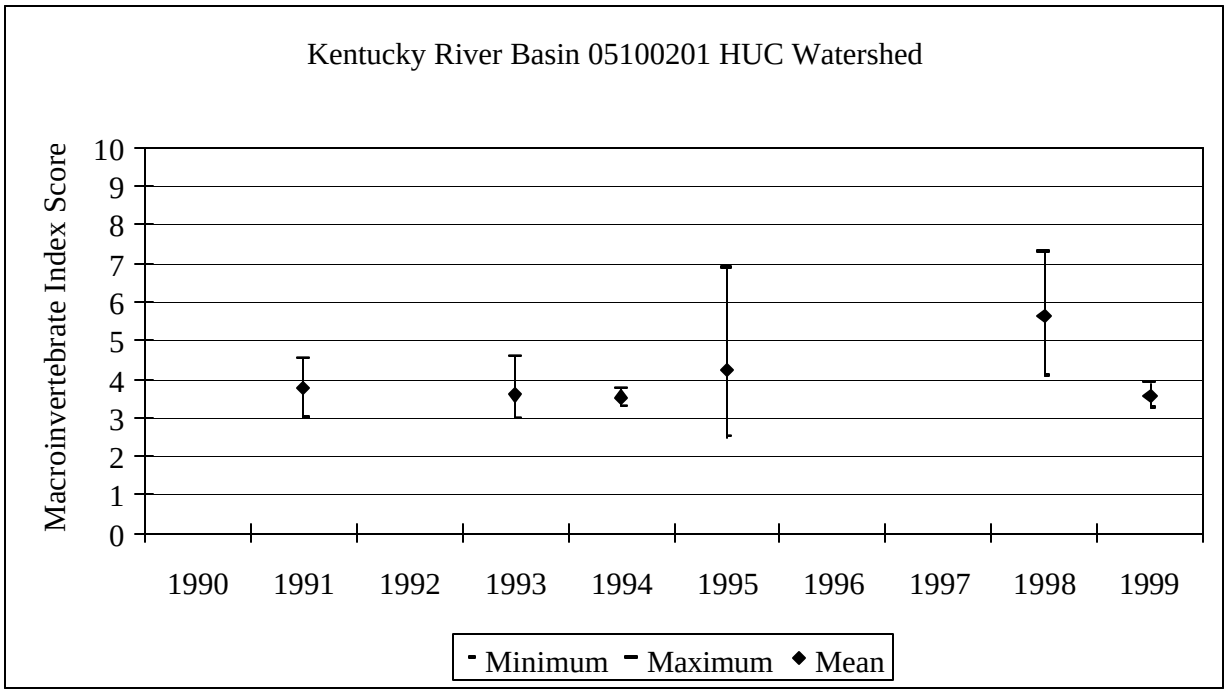

Figure 2.148. Macroinvertebrate Index Scores for Kentucky River Basin 05100201 HUC Watershed

Table 2.142. Macroinvertebrate Index Scores for Kentucky River Basin 05100202 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	5.11	5.11	5.11
1996				
1997	1	8.00	8.00	8.00
1998	19	4.57	6.49	5.51
1999				

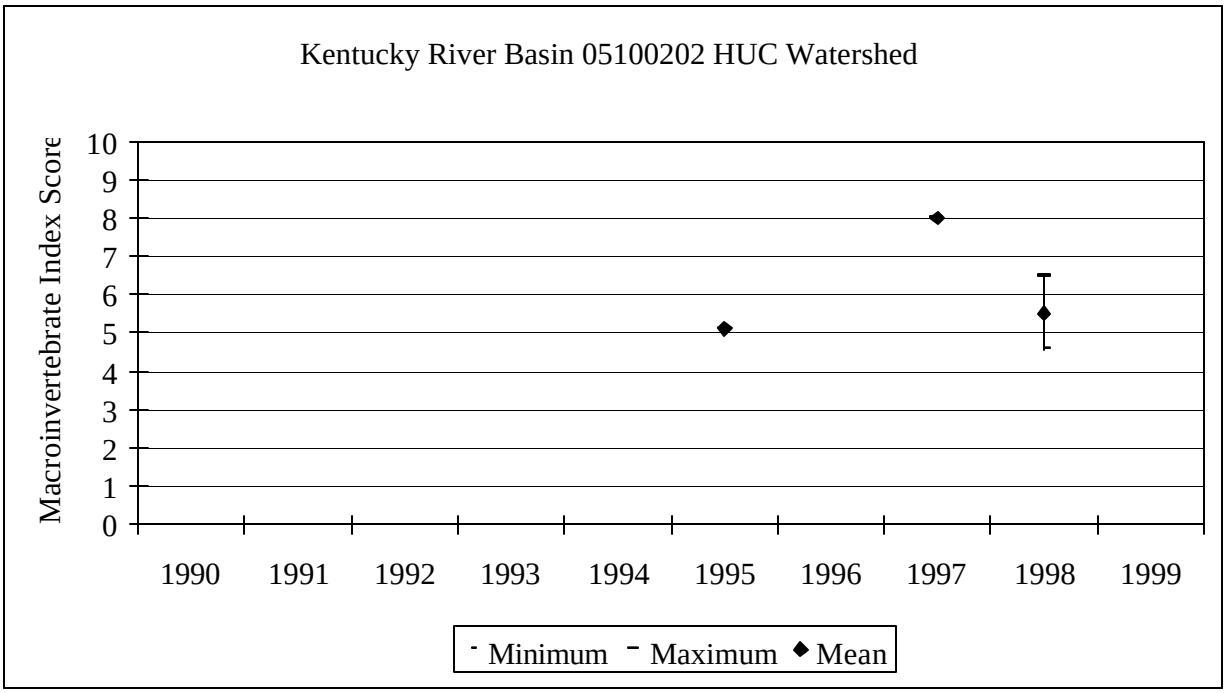

Figure 2.149. Macroinvertebrate Index Scores for Kentucky River Basin 05100202 HUC Watershed

Table 2.143. Macroinvertebrate Index Scores for Kentucky River Basin 05100203 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991				
1992	2	3.52	3.99	3.76
1993	1	3.53	3.53	3.53
1994	1	3.46	3.46	3.46
1995	1	6.69	6.69	6.69
1996	1	4.59	4.59	4.59
1997				
1998	16	3.80	6.83	5.41
1999				

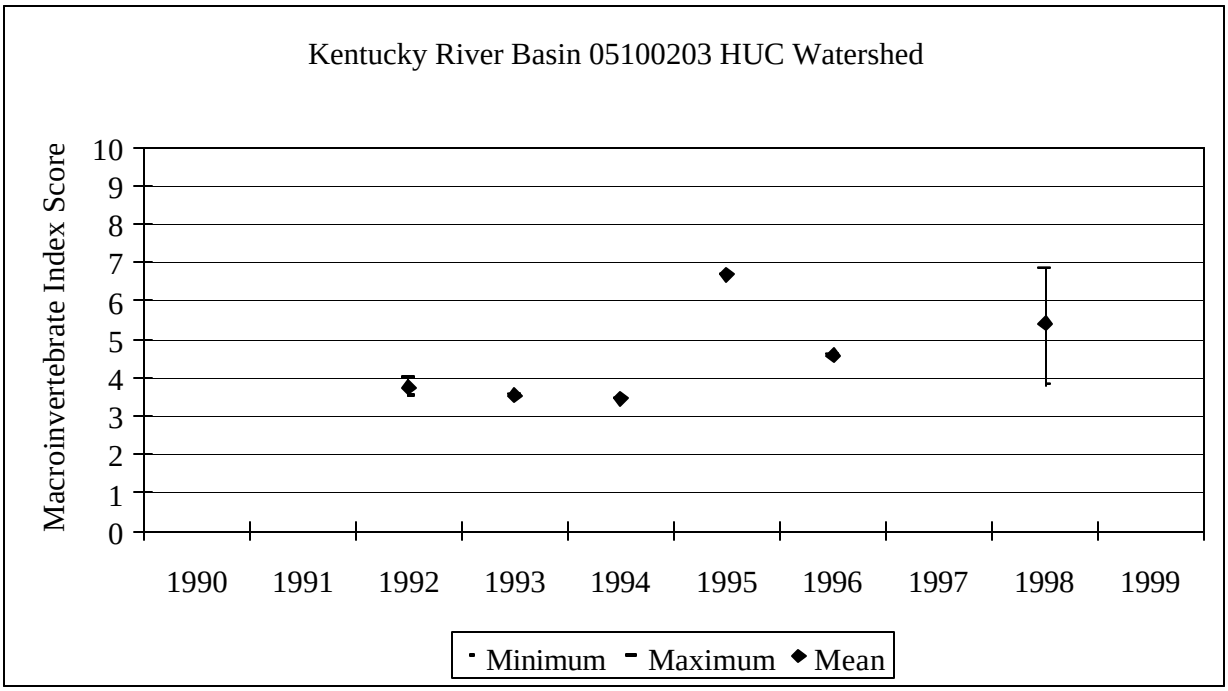

Figure 2.150. Macroinvertebrate Index Scores for Kentucky River Basin 05100203 HUC Watershed

Table 2.144. Macroinvertebrate Index Scores for Kentucky River Basin 05100204 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990	2	5.43	6.27	5.85
1991	1	6.67	6.67	6.67
1992	5	3.61	5.38	4.29
1993	3	3.69	4.15	3.89
1994	4	3.86	4.22	4.01
1995	2	7.22	7.93	7.58
1996				
1997				
1998	19	3.25	6.89	5.06
1999	1	5.33	5.33	5.33

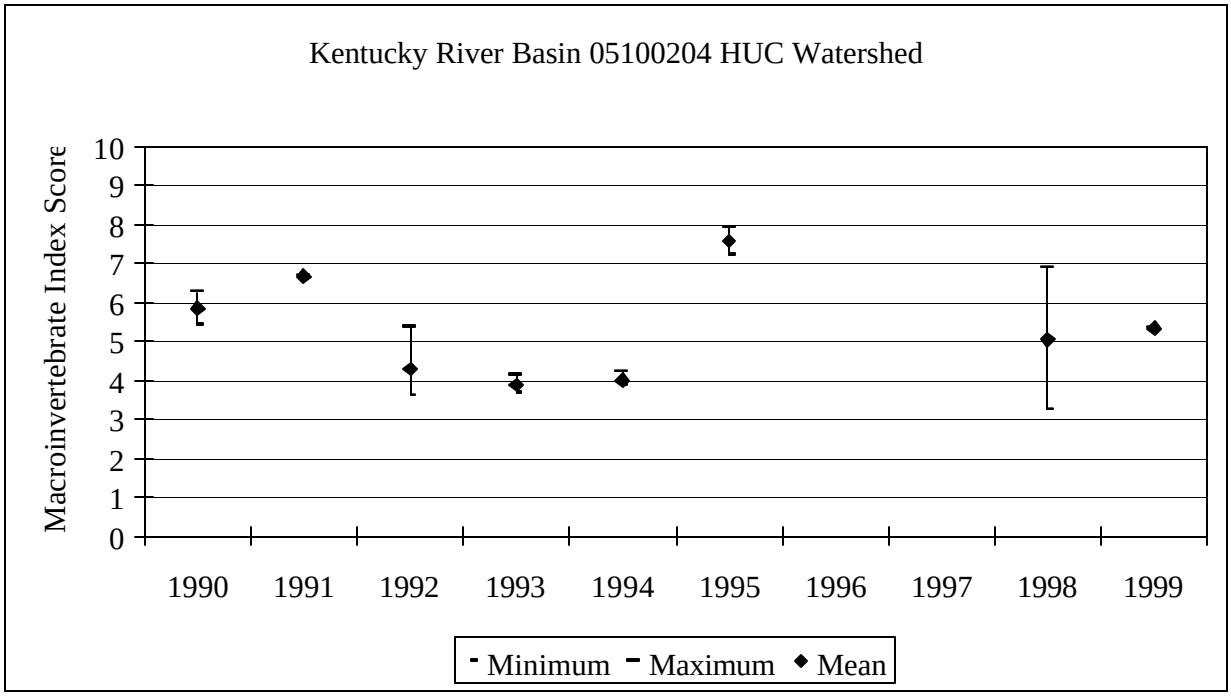

Figure 2.151. Macroinvertebrate Index Scores for Kentucky River Basin 05100204 HUC Watershed

Table 2.145. Macroinvertebrate Index Scores for Kentucky River Basin 05100205 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990	1	4.41	4.41	4.41
1991	1	4.88	4.88	4.88
1992				
1993				
1994				
1995	4	5.32	6.88	6.15
1996				
1997				
1998	4	5.50	6.05	5.77
1999				

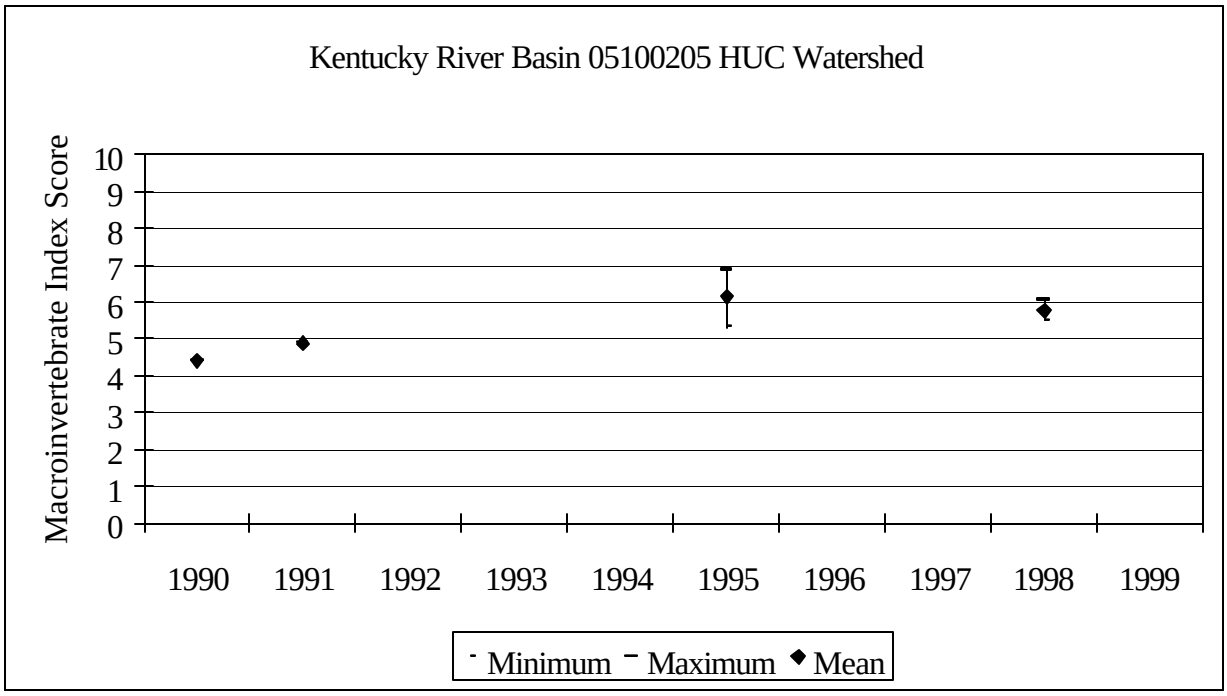

Figure 2.152. Macroinvertebrate Index Scores for Kentucky River Basin 05100205 HUC Watershed

Table 2.146. Macroinvertebrate Index Scores for Green River Basin 05110001 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991	3	4.89	6.79	5.62
1992	8	3.46	5.38	4.32
1993	12	2.87	5.22	3.90
1994	4	2.90	4.89	3.94
1995	5	3.72	6.34	5.05
1996				
1997				
1998				
1999	2	4.45	5.01	4.73

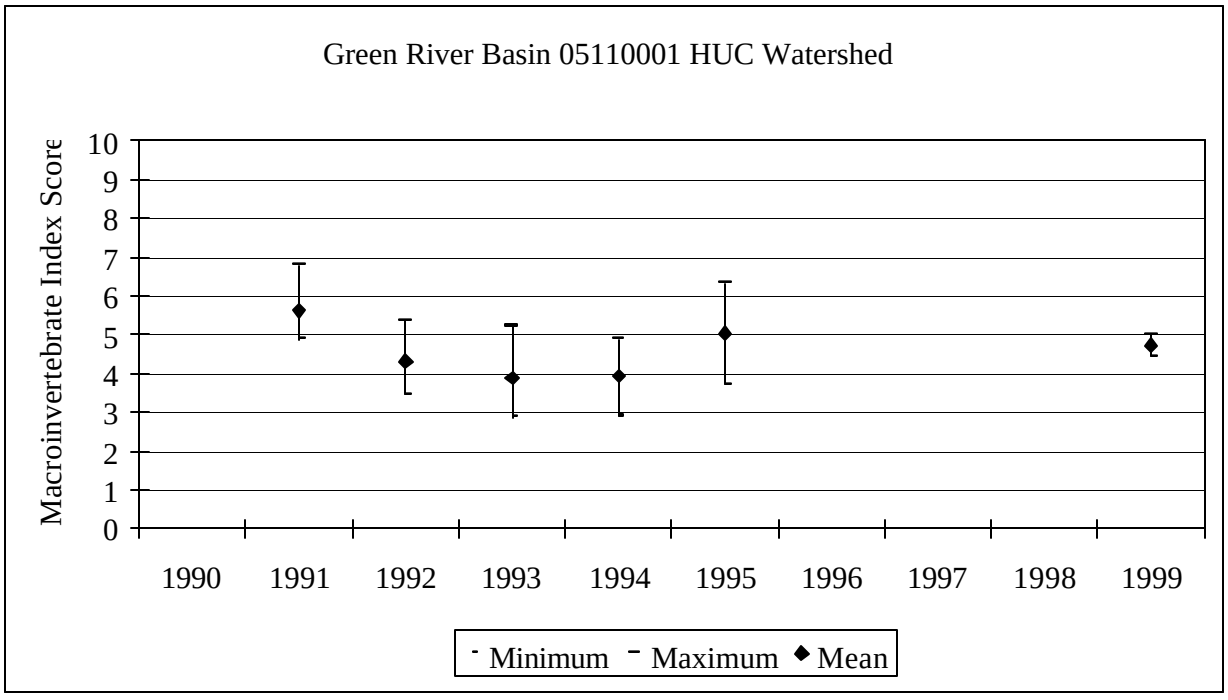

Figure 2.153. Macroinvertebrate Index Scores for Green River Basin 05110001 HUC Watershed

Table 2.147. Macroinvertebrate Index Scores for Green River Basin 05110002 HUC Watershed

Year	Samples	Maximum	Minimum	Mean
1990				
1991				
1992				
1993				
1994				
1995	1	4.19	4.19	4.19
1996				
1997				
1998				
1999				

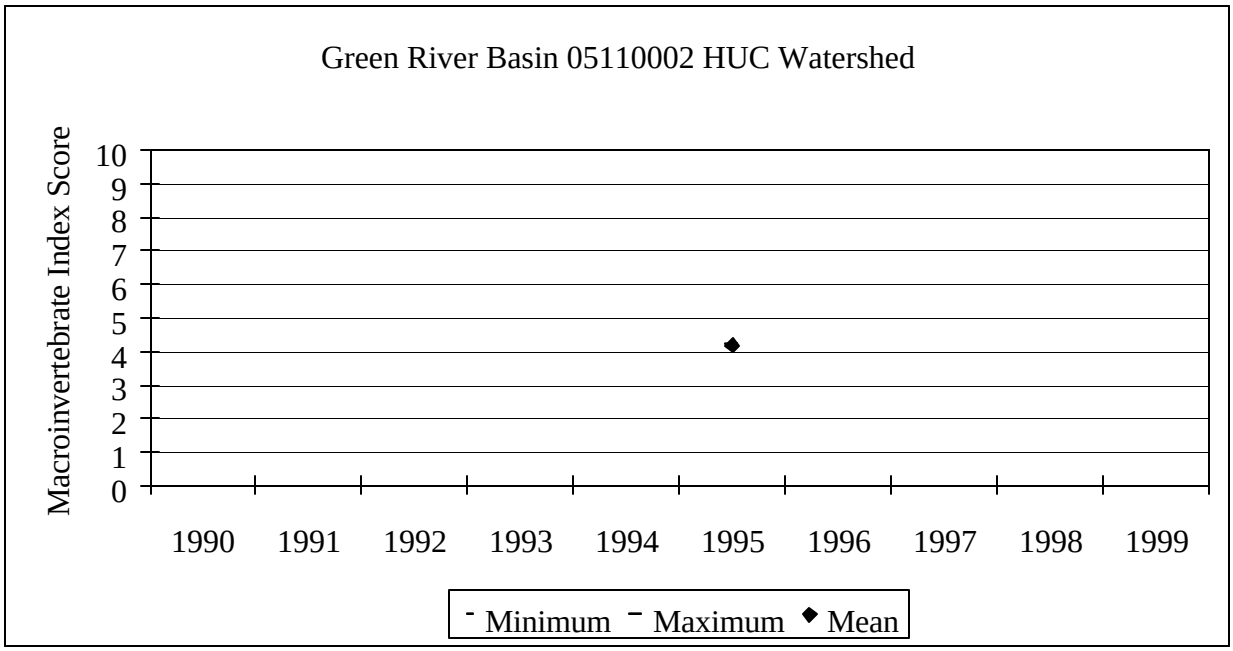

Figure 2.154. Macroinvertebrate Index Scores for Green River Basin 05110002 HUC Watershed

Table 2.148. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130101 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990	6	3.17	6.69	4.89
1991	7	2.71	4.66	3.57
1992	3	1.37	4.37	2.85
1993	12	1.09	4.98	3.76
1994	5	2.61	5.20	3.54
1995				
1996				
1997	4	2.74	4.98	4.23
1998				
1999	1	3.04	3.04	3.04

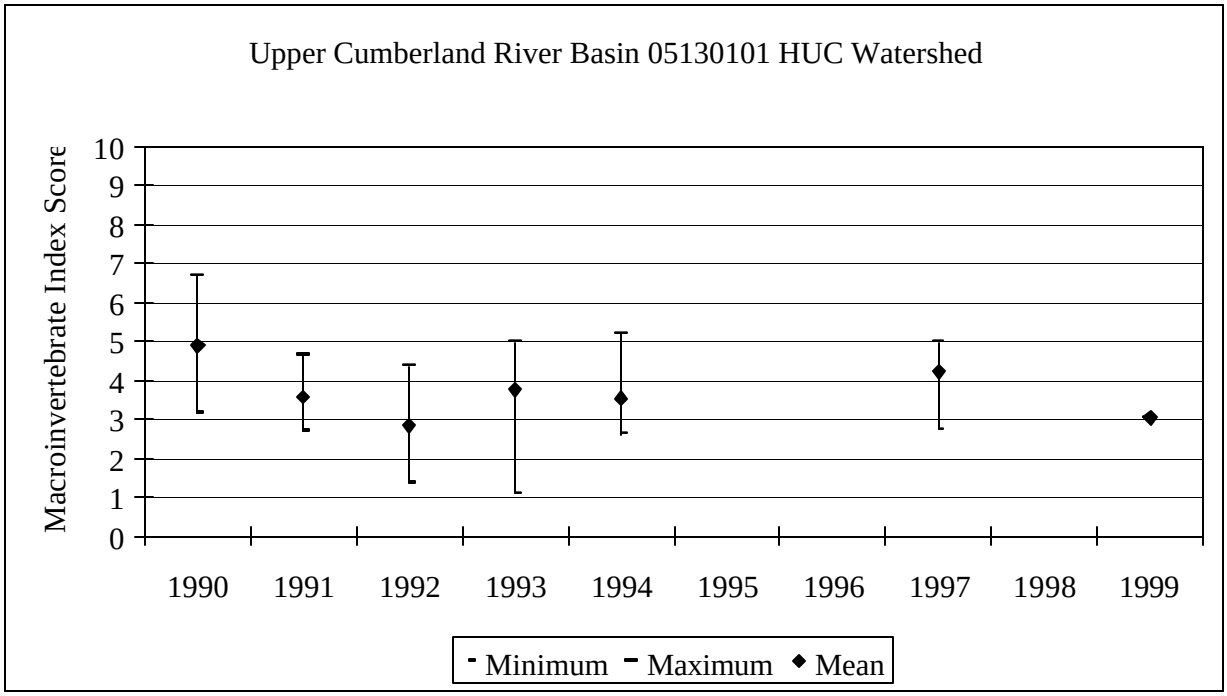

Figure 2.155. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130101 HUC Watershed

Table 2.149. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130102 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990	4	4.64	7.32	5.66
1991	1	6.52	6.52	6.52
1992	4	2.94	4.21	3.57
1993	6	2.88	5.30	4.22
1994	1	3.71	3.71	3.71
1995	1	4.36	4.36	4.36
1996	2	3.33	4.88	4.10
1997	1	4.65	4.65	4.65
1998				
1999				

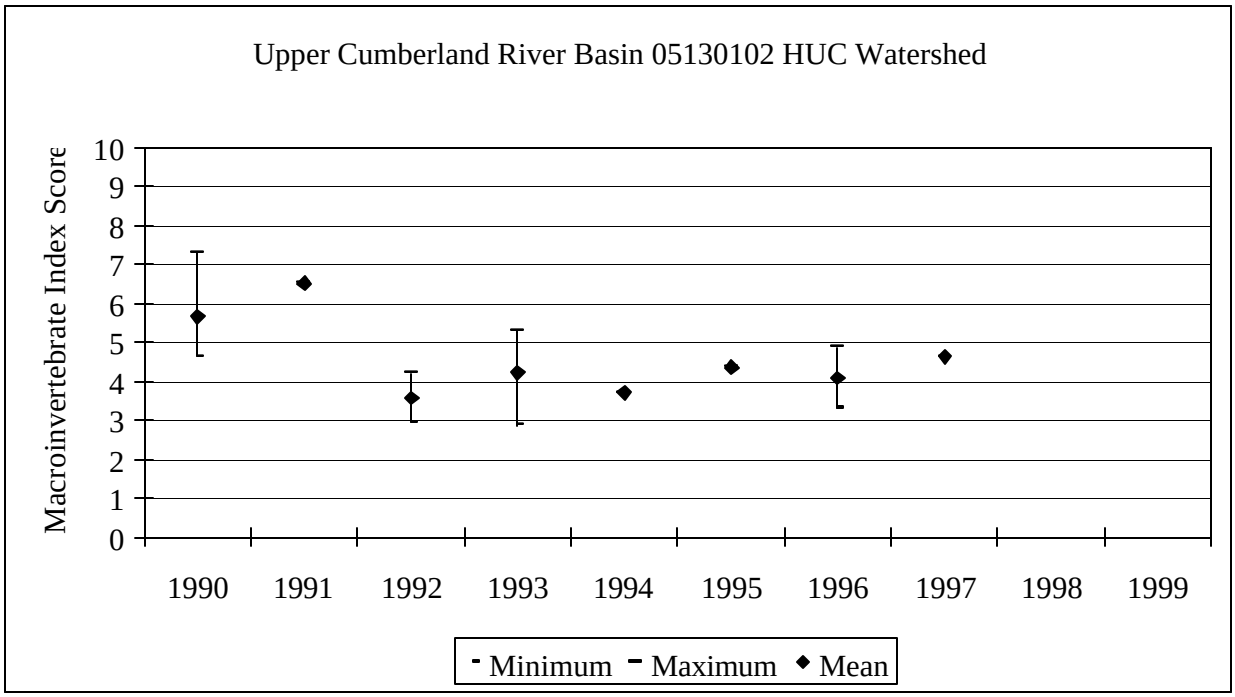

Figure 2.156. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130102 HUC Watershed

Table 2.150. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130103 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990	1	4.58	4.58	4.58
1991	1	6.75	6.75	6.75
1992	2	4.25	4.38	4.32
1993	3	3.23	4.16	3.78
1994	2	3.97	4.05	4.01
1995	4	3.95	5.90	4.83
1996				
1997				
1998				
1999	2	4.53	4.74	4.63

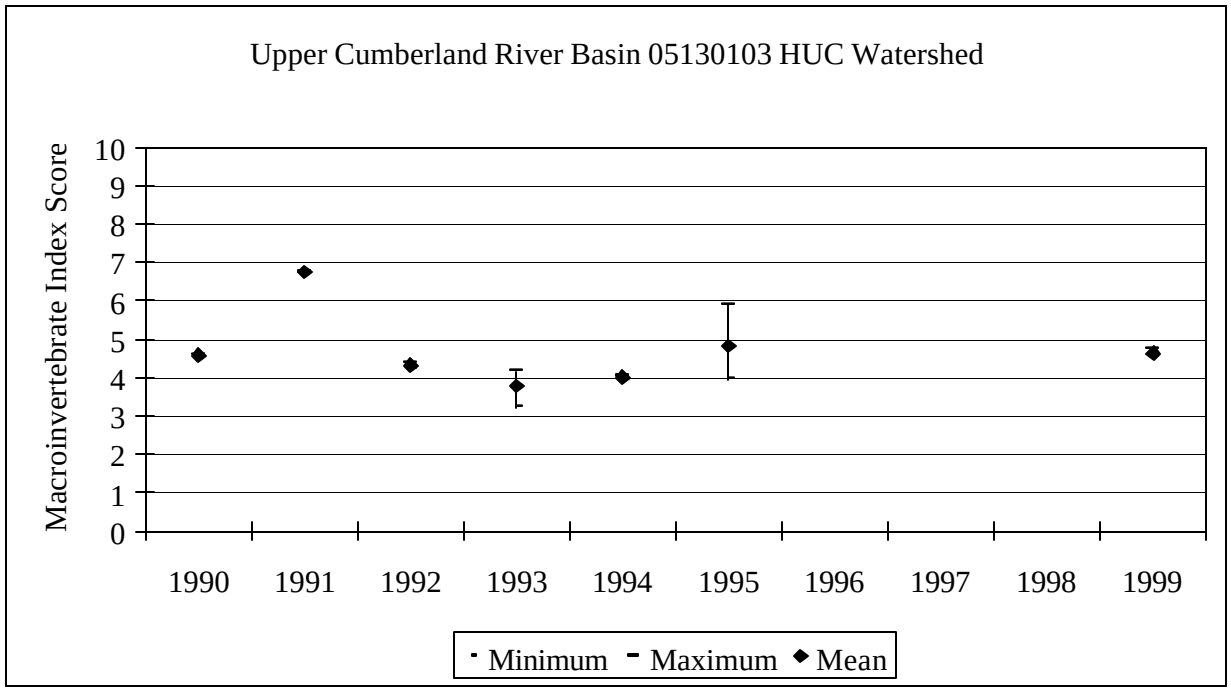

Figure 2.157. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130103 HUC Watershed

Table 2.151. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130104 HUC Watershed

Year	Samples	Minimum	Maximum	Mean
1990				
1991	7	2.48	7.23	5.56
1992	9	3.39	6.72	4.77
1993	3	3.62	4.39	3.94
1994	1	7.39	7.39	7.39
1995				
1996				
1997	6	3.76	6.60	5.46
1998				
1999				

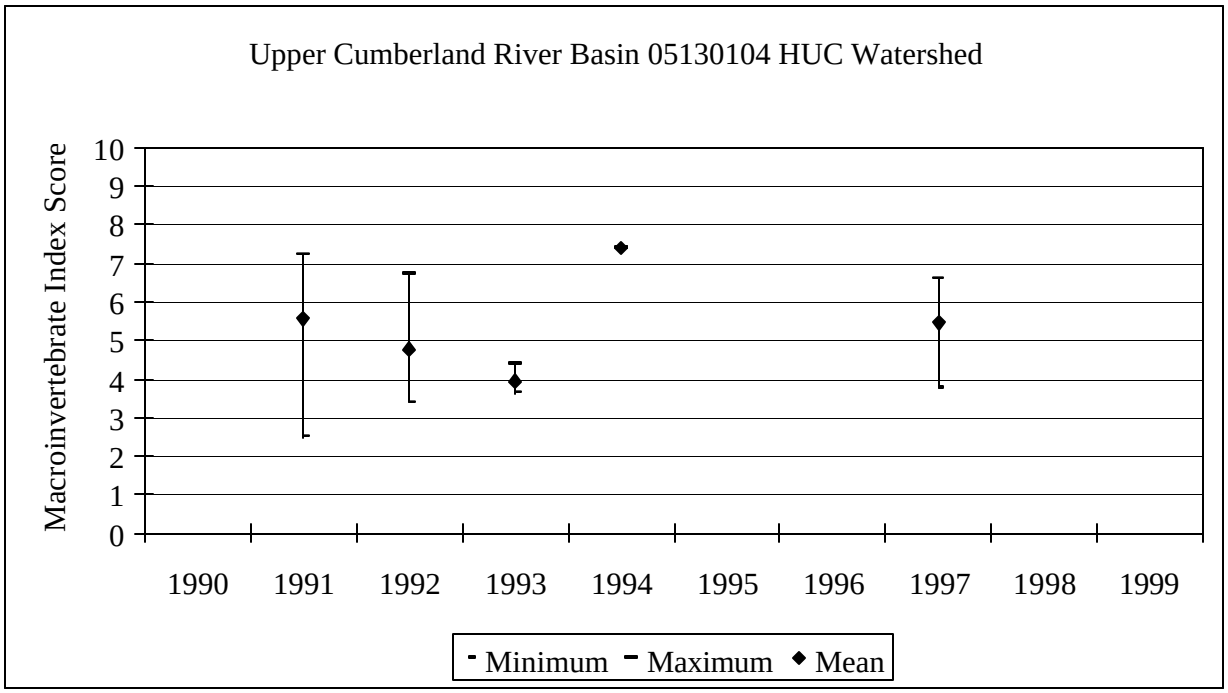

Figure 2.158. Macroinvertebrate Index Scores for Upper Cumberland River Basin 05130104 HUC Watershed

3.0. SUMMARY AND RECOMMENDATIONS

The efficient utilization of federal funds in improving the water quality and aquatic habitat of the region requires a mechanism for assessing and evaluating the impacts of the proposed and ongoing projects as well as some mechanism for prioritizing the allocation of additional funds. In order to evaluate the effectiveness of these projects it is important to provide a formal monitoring and assessment program based on sound scientific principles. This report provides an initial 10 year baseline assessment of the existing water quality conditions in the 40 county PRIDE region for the purpose of evaluating the impacts of the PRIDE programs in the region and the extent to which such programs are satisfying their stated objectives of cleaning up the region's rivers and streams. For this study, assessment parameters included measurements of pH, fecal coliform, macro-invertebrates, and general aquatic habitat.

In general pH problems are fairly localized to three counties: McCreary, Whitley, and Pulaski. However, fecal coliform problems are much more extensive. Those counties most severely impacted include: Floyd County, Harlan County, Johnson County, Letcher County, and Perry County. Other counties that have had less severe although significant problems include Bell, Breathitt, Garrard, Jessamine, and Lawrence Counties. Several counties have no historical fecal data and indicate areas where additional sampling is needed. These include: Casey, Clinton, Knott, Martin, Metcalfe, and Taylor counties. Because of the lack of and variability of the fecal data, it was hard to draw any definitive conclusions with regard to general trends. However, it does appear that general fecal levels are beginning to decrease in Bell, Harlan, Letcher, and Perry counties. An evaluation of the fecal data on a watershed basis revealed similar impacts. As expected, the north Fork of the Kentucky River watershed and the Upper Cumberland watershed showed the most severe fecal impacts.

In an attempt to provide a historical baseline of stream habitat in the region, a statistical analyses of the Kentucky ERDAS habitat database was performed on both a county basis and a watershed basis. In general, most counties scored fair to poor. General trends were difficult to determine given the sparsity of the data. However, where available, the data do tend to show a decrease in habitat scores over the last 10 years. Minimum habitat scores were obtained in Clay, Leslie, Magoffin, Menifee, Morgan, Perry, and Wolfe Counties. On a watershed basis, the most severely impacted habitats appear to be associated with the Kentucky River Basin and the Licking River Basin, however this observations may be biased on the basis of the increased biological sampling that has taken place in these two basins as part of the Kentucky Watershed Management Framework initiative.

In addition to a general habitat assessment, the Kentucky ERDAS database was also used to perform a macro-invertebrate assessment on both a county basis and a watershed basis. The macro-invertebrate data were much more comprehensive than the habitat data. In general, it was found that most counties are in a fair condition. This is also true for most of the watersheds as well. General trends are difficult to determine

given the scarcity and variability of the data. In general, no overall trends were observed across the region.

Where available, the historical data has revealed significant fecal coliform impacts across the region. It is expected that these data sets will provide the basis for a general assessment of the PRIDE program over the next several years. However, there remain several counties and even a few watersheds where no assessment data is available. This situation is even more acute with regard to habitat assessment sites. As a result, it is highly recommended that additional monitoring stations be placed in these areas to provide a more thorough basis for future project assessment. In addition, many monitoring stations are not located in specific watersheds where PRIDE projects are proposed or ongoing. As a result, it is also recommend that additional monitoring stations be placed in these watersheds as well. Such sites to address both of these concerns are proposed in the companion report: *PRIDE Water Quality Assessment Report III: Existing and Proposed Monitoring Network*

4.0 REFERENCES

Beck, Gary, 1998, Removing fecal pollution from the upper Cumberland River drainage: Water Quality Branch, Kentucky Division of Water, 54 p.

Beck, Gary, 1994, Removing fecal pollution from the North Fork Kentucky River Drainage: Water Quality Branch, Kentucky Division of Water, 42 p.

Beck, Gary, 1997, North Fork Kentucky River summary: Water Quality Branch, Kentucky Division of Water, 16 p.

Beck, Gary, 1998, 1998 North Fork Kentucky River swimming advisory update and summary: Water Quality Branch, Kentucky Division of Water, 7 p.

Beck, Gary, 1999, 1999 North Fork Kentucky River swimming advisory update: Water Quality Branch, Kentucky Division of Water, 11 p.

Griffin, M.S., Martin, G.R., and White, K.D., 1994, Surface-water-quality assessment of the Kentucky River Basin, Kentucky – Fixed station network and selected water-qaulity data, April 1987 through August 1991: U.S. Geological Survey Water-Resources Investigations Report 94-4029, 149 p.

Haag, K.H., and Porter, S.D., 1995, Water-quality assessment of the Kentucky River Basin, Kentucky – Nutrients, sediments and Pesticides in streams, 1987-90: U.S. Geological Survey Water-Resources Investigation Report 94-4227, 135 p.

Haag, K.H., Garcia, R., Jarrett, G.L., and Porter, S.D., 1995, Water-quality assessment of the Kentucky River Basin, Kentucky: Results of investigations of surface-water quality, 1987-90: U.S. Geological Survey.

London Regional Office, 2000, Upper Cumberland River bacteriological survey data tables for 1998 and 1999: Water Quality Branch