FINAL REPORT

FEDERAL AID GRANT NO. T-8-P-1

INSTREAM FLOW MODELING FOR MUSSELS AND FISHES IN SOUTHEASTERN OKLAHOMA RIVERS

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

JULY 28, 2003 through JUNE 30, 2005

FINAL REPORT

STATE: Oklahoma Grant Number: T-8-P

GRANT TITLE: Instream Flow Modeling for Mussels and Fishes in Southeastern Oklahoma

GRANT PERIOD: 28 July 2003 through 30 June 2005

I. OBJECTIVES:

1. To map and model instream flow habitat for mussels, including endangered species in the Kiamichi River, Oklahoma.
2. To conduct an instream flow analysis for fishes in the Kiamichi River, Little River, Glover River, and Mountain Fork River, Oklahoma.

II. SUMMARY

We mapped and modeled instream flow habitat for mussels and fishes in the Kiamichi River and the Little River and its tributaries in southeastern Oklahoma. This report contains two sections: (1) instream flow modeling for mussels beds in the Kiamichi River, Oklahoma, and (2) determination of instream flow recommendations for four streams in southeastern Oklahoma using proportional analysis methodology. Findings and conclusions are contained within each section.

INSTREAM FLOW MODELING FOR MUSSELS AND FISHES IN SOUTHEASTERN OKLAHOMA

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Introduction

The freshwater mussel fauna of North America is the most diverse in the world (Williams et al. 1993), yet it is among the most endangered in North America. Habitat disturbances associated with the hydrologic alteration of rivers is one of the primary reasons for the collapse of many North American mussel populations (Williams and Fuller 1992; Layzer et al. 1993; Vaughn and Taylor 1999; Hughes and Parmalee 1999; Hardison and Layzer 2001). Proposed water development projects continue to threaten the ecological integrity of North American rivers; however, water management goals in the new millennium have broadened from traditional societal goals of water supply, flood control, channel maintenance, power production, and commerce to include the maintenance and enhance of natural communities and ecosystems services (Postel and Richter 2003).

The Southeast Oklahoma Water Resources Development Plan (Oklahoma Water Resources Board 2002) was developed to provide water for the future needs of Oklahoma City and north Texas by diverting water from the Little and Kiamichi rivers in southeastern Oklahoma The Kiamichi River has been identified by The Nature Conservancy as being one of eight U.S. watersheds of critical importance for conservation (The Nature Conservancy 1998). The watershed has been largely unaltered, and the river is home to 29 mussel species including three federally endangered species, *Quadrula fragosa* (winged maple leaf), *Leptodea leptodon* (scaleshell), and *Arkansia wheeleri* (Ouachita rock-pocketbook). The ecological integrity of the Kiamichi River is potentially threatened by the proposed large-scale water development project. However, a balance is needed between human water consumption and the ecological resources of the Kiamichi River.

Protection of instream flows for the stewardship of aquatic resources is based on the quantification of habitat (Annear et al. 2002). The most widely used stream habitat assessment tool is the Instream Flow Incremental Methodology (IFIM) approach (Reiser et al. 1989). The IFIM has been used to evaluate the effects of hydropeaking flows on the winged mapleleaf in the St. Croix River, Wisconsin (Johnson 1995), a mussel assemblage in Horse Lick Creek, Kentucky (Layzer and Madison 1995), and mussel assemblages in three regulated rivers in Kentucky (Hardison and Layzer 2001). It has also been used to evaluate instream flow requirements of many fish species (Stalnaker et al. 1995), including smallmouth bass (*Micropterus dolomieu*) habitat and fish habitat guilds in the Baron Fork of the Illinois River, Oklahoma in response to proposed water withdrawals (Fisher and Remshardt 2000). Limitations of using the IFIM for determining instream flow needs of mussels are summarized by Lazyer and Madison (1995) and of fishes by Fisher and Remshardt (2000).

Our objective was to model the potential impacts of water withdrawals on the musselbeds of the Kiamichi River and determine the instream flows required to protect the integrity of the musselbeds. We propose water withdrawals that would minimize the impacts to the musselbeds and suggest operational guidelines for the water withdrawal. Finally, we offer guidelines for reservoir operations that could supplement the instream flows to be withdrawn from the Kiamichi River.

Methods

Study Area

The Kiamichi River is located in southeastern Oklahoma (Figure 1). The watershed is largely unimpacted by human activities other than farming on the bottomlands and logging on the hill slopes. Two large reservoirs, Hugo Reservoir on the mainstem Kiamichi River and Sardis Reservoir on Jackfork Creek, were created for flood control, water supply, recreation, and to enhance fish and wildlife habitat. Impoundment of the Kiamichi River at Hugo began in 1974 and impoundment of Jackfork Creek began in 1983. The Kiamichi River above Hugo Reservoir is 240 mi (387 km) long and drains 1137 mi^2 (2,947 km^2). There are three U.S. Geological Survey gaging stations along this stretch of the river: a downstream station (07336200) near Antlers, Oklahoma at the State Hwy. 3 bridge; a midstream station (07335790) near Clayton, Oklahoma and below Sardis Reservoir at the U.S. Hwy. 271 bridge; and an upstream station (07335700) near Big Cedar, Oklahoma at the State Hwy. 63 bridge. Sardis Reservoir operations affect streamflow in the lower half of the Kiamichi River. Reservoir levels are kept within a specified range to accommodate potential flood events, thus releases from Sardis Reservoir often occur after major precipitation events. These releases often extend the duration of high flows or create higher flow events during periods that would otherwise have low flows.

Mussel Survey and Habitat Mapping

In conjunction with Dr. Caryn Vaughn and researchers at the University of Oklahoma (OU), we mapped musselbeds at 10 sites in the Kiamichi River (Figure 2). These musselbeds were previously surveyed by Vaughn et al. (1996). The OU research team collected and identified the mussel species and habitat at each musselbed, and we subsequently mapped the location and spatial extent of the musselbeds.

We created habitat maps for each study site using global positioning system (GPS) field measurements and geographic information systems (GIS) software Arcview 3.3 (ESRI Inc.). Each site was mapped by walking the perimeter of the musselbeds and the channel units (riffle, run, mid-channel pool, eddy pool, backwater, and side-channel) using a Trimble GeoXT GPS unit (Trimble Navigation Ltd.). We calculated the areas of each musselbed and channel unit types with ArcView.

Hydraulic measurements

At each study site, we established 3-7 cross-sectional transects to measure hydraulic features. One cross-section was established across the hydraulic control (i.e., section of channel which controls the water surface elevation of the stream in an upstream direction under sub-critical flow conditions [USGS 2001]) for each site. Other transects were established across the musselbeds and in adjacent channel units that formed the upper and lower boundaries of the site. The upper boundary cross-section was typically established across an upper hydraulic control, but often this was not feasible. Alternatively, the upper cross-section was established across the upper most musselbed boundary. Habitat boundaries were also established across the upstream and downstream boundaries of the musselbeds. Streambed elevations along each cross-section transect were surveyed to the nearest 0.01ft (0.3 cm) and referenced to a common datum (Bovee 1994). We determined stream discharge (Q) at each site by gaging the stream with a Marsh-McBirney Flow-Mate Model 2000 with a top-setting wading rod and tape, following standard stream gaging procedures (Bovee 1994). These data were collected at low flow and at least two other higher flows. At each established cross-section, we determined the water surface elevation (WSE) associated with the measured discharge using an engineering level and stadia rod. Slope was calculated as the difference in WSE of adjacent transects divided by the distance. A slope of 0.00001 was assigned when no measurable difference in WSE occurred.

At sites 1, 2, 4, 6, and 11, we installed water level recorders (Solinst Leveloggers) in the deepest location of pooled sections of the channel to measure (within 0.01 ft [0.2 cm]) water level depth. These recorders also measure water temperature. At each of these sites, we placed a steel fencepost into the streambed and attached 2 in. (5.08 cm) PVC pipe to it. A Levelogger was suspended in the pipe using braided wire from a locking PVC cap. The Leveloggers were set to measure water level and temperature every hour, which enabled us to develop a more precise hydrograph for each study site. We also placed a Solinst Barologger at site 4 to collect hourly barometric data for the Kiamichi River watershed that was used to correct the Levelogger data for changes in barometric pressure.

Hydraulic Modeling

We used the PHABSIM module (USGS 2001) of IFIM to develop hydraulic models for each site. The established cross-sections and habitat boundaries were used as input into the PHABSIM models. Water surface elevations for each cross-section transect were determined from measured stage-discharge relationships and values predicted by the WSP subroutine of PHABSIM for flows ranging from 2-940 cfs (0.057-26.6 cms). WSE's associated with at least three measured Q's were used to calibrate the models for each study site. Up to four additional data pairs were used to validate the hydraulic models. Calibration was achieved using modifications (Waddle 2004) to the methods described in USGS (2001). The WSE and Q data for the hydraulic control was fit to a curve in Excel. This curve was then used to acquire the initial WSE for each modeled discharge. Caution was taken to choose only best fit curves that did not exhibit unrealistic WSE's for extrapolated data points at the upper and lower extremes. Velocities in each cell for the simulated discharges were predicted by the VELSIM subroutine of PHABSIM from a single velocity data set.

Habitat Modeling

To model mussel emersion, we created habitat suitability criteria in PHABSIM to provide results on mussel emersion rather than suitable habitat. Because we were most interested in mussel emersion, we wanted to identify stream cells that had a depth of 0.01 to 15 ft (0.003 to 4.6 m) and a velocity range of 0.0 to 20 ft/s (0.0 to 6.1 m/s). We used only the stream cells that had an existing musselbed at that location. We used the "channel index" criterion (cells with mussels were assigned a channel index of 1.0) to identify those cells in the model. The HABTAE subroutine of PHABSIM was used to determine the weighted usable bed area of emersed musselbeds for each study site. Two of our study sites (Sites 8 and 10) had split channel morphologies with each channel having different WSE's along the cross-section. PHABSIM is not capable of modeling split channels with different WSE's. Thus, we corrected our channel profile by raising or lowering the bed elevation of one channel by a distance equal to the difference in WSE's (USGS 2001). At site 8, the left channel of cross-section 6 was lowered by 0.53 ft (0.162 m) while the right channel of cross-section 7 was lowered by 1.0 ft (0.305 m). At site 10, the right channel of cross-section 2 was lowered by 0.81 ft (0.247 m), while the right channel of cross-section 3 was lowered by 0.75 ft (0.229 m).

Finally, we created a habitat time series by incorporating our predicted levels of musselbed emersion at various discharges into the historic hydrograph. We analyzed site 10 in more detail, because it seems to be most vulnerable to impacts caused by the localized withdrawal of water from the proposed Moyers location (Figure 1). By modeling musselbed emersion over time, we were able to determine the natural variation of musselbed emersion and any impacts that hydrological changes have on the musselbeds.

Hydrologic analyses

We examined the hydrologic history of the Kiamichi River to determine how the altered hydrologic cycle might impact the mussel assemblage of the Kiamichi River. We collected data from the USGS gaging stations located along the Kiamichi River at Big Cedar and Antlers, as well as the Glover, OK gaging station (07337900) on the Glover River. All three gaging stations are located within 100 km of each other and experience similar hydrologic inputs. There are no upstream impoundments or other altering factors to the river hydrology at the Big Cedar or Glover gaging stations. The Antlers hydrographic record exists for the water years of 1973-2003, whereas the Big Cedar records cover 1966-2003 and the Glover record exists for 1962-2003.

We reconstructed the Antlers hydrograph to extend the period of record from 1962-2003. We first transformed (log [x+1]) the daily average discharge for each gaging station. The Big Cedar hydrograph was reconstructed from 1962-1966 performing a regression between the Big Cedar and Glover data and using the resulting relationship to calculate daily average discharge for the Big Cedar gaging station. Then, a multiple regression was performed between the three data sets with the Antlers data set as the independent variable. The regression produced a relationship between the three gaging stations that allowed us to calculate an estimated daily average discharge at Antlers from the Big Cedar and Glover data.

We evaluated the impacts of the Jackfork Creek impoundment (Sardis Reservoir) on the hydrology of the Kiamichi River. A double mass curve of annual runoff at Antlers and Glover was used to identify time intervals when discharge at Antlers was consistent with the discharge at Glover (Franke 1968). Major changes in slope indicate changes in the relationship between the annual runoff at the two gaging stations. After determining the reconstructed dataset did not provide unsuitable results, we used the Indicators of Hydrologic Alteration (IHA) (The Nature Conservancy and Smythe Scientific Software 2001) to characterize the Antlers dataset. First, IHA was used to explore changes in the Antlers hydrograph since the impoundment of Jackfork Creek and the creation of Sardis Reservoir. IHA analyzes the data using the Range of Variability Approach (RVA) and creates a scorecard quantifying the hydrologic changes resulting from a pre-defined impact period (Richter et al. 1997).

Results

Musselbed and Habitat Mapping

We surveyed a total of 24.93 acres (100,895 m^2) of stream habitat in the Kiamichi watershed among our 10 study sites. Musselbeds represented 7.0% of that area. They were generally found in the downstream segment of a pool, just upstream of a riffle, and the musselbeds covered an average of 5809 ft^2 (539.7 m^2) at the 10 sites. Table 1 summarizes the total musselbed areas and habitat types found at our 10 study sites.

Water Temperature

Water temperature in the Kiamichi River exceeded 30 °C at several sites during the summer of 2004. Site 1 water temperature was above 31 °C for 3 hours during the period of Levelogger record and reached a maximum of 31.2 °C on July 23, 2004. Site 4 was vandalized and there was no Levelogger data retrieved after July 13, 2004, and up until that point there were no water temperatures greater than 31 °C. Site 6 water temperature was above 31 °C 19 times during the period of record. The maximum temperature reached was 32.7 °C and the maximum continuous period greater than 31 °C was 11 hours on July 23, 2004. Site 11 water temperature rose above 31 °C 17 times during the period of Levelogger record. The maximum temperature reached was 32.55 °C and maximum time that temperatures were greater than 31 °C was 10 hours on July 23, 2004. Each of these occurrences occurred during a time when there was the additive effect of high ambient air temperatures (high temperature on July 23, 2004 was 32 °C) and very low discharges (between 14 and 100 cfs [0.40 and 2.83 cms]).

Habitat Modeling

The habitat models quantified the submerged weighted usable streambed area for each study site at decreasing discharges (Table 2). Each study site exhibited varying levels of emersion at each water level (Figure 3). Site 3 experienced the greatest emersion at low discharges. We predicted that 30% of the musselbed at site 3 would be emersed at a discharge of 2 cfs (0.057 cms). Site 10 is also important due to its proximity to the proposed withdrawal site at Moyers. The model predicted that 14.7% of the musselbed was emersed at 2 cfs (0.057 cms). Site 8 exhibited musselbed emersion at 120 cfs (3.40 cms), 0.8% of the musselbed was emersed at 40 cfs (1.13 cms), and a maximum emersion of just 7% at 2 cfs (0.057 cms). The musselbed at Site 7 was predicted to be emersed at less than 20 cfs (0.57 cms), while 6.5% of the musselbed was emersed at 2 cfs (0.057 cms). Sites 5 and 6 experienced a small amount of musselbed emersion at discharges less than 10 cfs (0.28 cms).

We analyzed site 10 in more detail, because it was the most vulnerable to potential impacts from localized water withdrawals at the proposed Moyers location. Our analyses indicated that the mean (± SD) length of emersion prior to construction of Sardis Reservoir (pre-Sardis) was not significantly different ($P = 0.78$) from the post-Sardis period (21.5 days ± 27.0 days). The magnitude of emersion events not significantly different ($P = 0.41$) between the two periods. The mean relative percent of musselbed area emersed at site 10 was 2.6% ± 6% among the pre- and post-Sardis emersion events. There was no difference in the frequency of emersion events either, an emersion event occurred every 80 days (±112 days) on average. There also was no significant difference ($P = 0.86$) in the number of emersion events annually (3.7 ± 1.8 events/year). Lastly, there was no significant difference ($P = .90$) in the mean number of days that emersion occurred annually (78.2 days/year ± 37.6 days/year).

Hydrologic Trends

We extended the records from the USGS gaging station at Antlers through the 1962 water year providing us with 42 years of data. This produced 21 years of data before the impoundment of Jackfork Creek (pre-Sardis) and 21 years after the impoundment of the creek (post-Sardis). The double mass curve indicated that there was no significant difference in the pre- and post-Sardis total annual runoff at Antlers when compared to USGS gaging station at Glover (Figure 4). IHA produced the RVA scorecard (Tables 3a and 3b [Richter et al. 1997]). The scorecard assists us in determining which hydrologic factors have changed since the impoundment of

Jackfork Creek. The "RVA categories" indicate the upper and lower boundaries (usually the median ± 17th percentile) for the middle category for each hydrologic parameter. The "hydrologic alteration factor" is a measure of how often the post-impact parameter falls within the middle RVA category compared to the pre-impact parameter. Deviations from zero indicate hydrologic differences in pre- and post- impact periods. Positive values indicate that the parameter fell within the middle RVA category more often than expected, whereas negative values indicate the parameter fell outside of the middle RVA category more than expected.

There were a few obvious patterns in the RVA. The median monthly flows for the months of November, December, January, and February fell outside of the middle category more than expected in the post-Sardis period. In fact, the flows have been higher than expected for each month (Table 3a). In June, July, and August, the median flows have fallen within the middle RVA category more often than expected post-Sardis. The majority of the minimum and maximum categories, as well as, the rise and fall rates fell within the middle category more often than expected (Table 3b). Figures 5a and 5b represent the pre- and post- impoundment hydrographs for dry, normal, and wet years.

Discussion

Musselbeds are typically found at the downstream end of a pool just upstream of a riffle. These areas are less susceptible to emersion and desiccation than musselbeds found in riffles. Musselbeds in pools are also less susceptible to high water temperatures (greater than 31 °C [88 °F]), which can cause increased physiological stress and mortality in mussels (Personal Communication, Caryn Vaughn, 12/17/2004). Our temperature data demonstrated that the water temperatures are a likely stressor to mussels during the hottest days of the summer when discharge is low. It is under these environmental conditions that the greatest short-term threats to the mussels exist.

There are other threats to the Kiamichi musselbeds, which are primarily desiccation and reproductive failure (McMahon and Bogan 2001). Both of these threats tend to increase under altered hydrologic regimes. Emersion of the musselbeds leads directly to the desiccation of both juvenile and adult mussels, although various mussel species have varying abilities to minimize desiccation. Some species are quite intolerant of being emersed. For example, *Pyganodon grandis* can survive emersed for between 2 and 32 days, whereas *Uniomersus tetralasmus* exhibits higher desiccation resistance and can tolerate emersion for up to 578 days of emersion (Byrne and Mcmahon 1994).

We do not know the emersion tolerances for many species of mussels in the Kiamichi River and cannot offer guidelines for their resistance to desiccation. We examined musselbed emersion at our 10 study sites. Sites 4-11 are found downstream of Sardis Reservoir and are the sites that may be influenced by the altered hydrologic regime of the proposed water withdrawal. At discharges less than 40 cfs (1.13 cms); emersion increases (Figure 3).

We examined site 10 in more detail by integrating results from our habitat models into the historic hydrographic record creating a habitat time series. From this comparison, we attempted to determine any differences in the patterns of mussel emersion since the creation of Sardis Reservoir. However, we found no significant differences to aid us in developing flow recommendations.

The other major threat to the Kiamichi River musselbeds is reproductive failure. Mussels have a complex life-history, which includes a period of obligate parasitism of their host fish.

The glochidial larval stages of many mussel species are obligate parasites of specific species of fish. Therefore, habitat modeling for mussels requires habitat modeling for the specific fish hosts (many of which are unknown) during specific periods of the year (i.e. glochidial release, which is also unknown for many mussel species). The complex life history of mussels present many challenges when attempting to determine the instream flow needs that support their reproductive success and survival.

One approach to minimize the chances of anthropogenic reproductive failure in mussels is to mimic the natural flow conditions that were historically present in the river. Our analysis of the hydrologic history of the Kiamichi River using the IHA produced the RVA scorecard (Tables 3a and 3b) and offers a detailed comparison of the pre- and post-Sardis periods and provides hydrologic targets which managers can aim to meet. The RVA scorecard exhibits that the post-Sardis median monthly flows for the months of November-February fall are higher than expected for each month, whereas the June-August median flows have fallen in the middle category (near the median) more often than expected (Table 3b). This pattern indicates that the impoundment of Jackfork Creek, which led to the creation of Sardis Reservoir, has changed the hydrology of the Kiamichi watershed by limiting the variability of water flows during the summer months. During the spring and fall, the hydrology of the river has changed little, but the flows are higher than normal during November-February, possibly due to the frequent releases from Sardis Reservoir. The 1, 7, 30, and 90-day minimum and maximum categories, as well as the rise and fall rates, fell within the middle category more often than expected. That each parameter falls into the median category more often than expected based upon the historical hydrograph indicates that the hydrology has become less variable than it had been previous to the impoundment of Jackfork Creek.

These changes in hydrology could have a significant long-term impact on the mussels. The fact that older mussels have the highest fecundity means that changes in their reproductive capacity may not become evident for decades after a specific event affects their ability to reproduce. The impacts of these hydrologic changes on the musselbeds cannot be determined adequately with the existing data and the next-best approach is to minimize the potential for impacts to the mussels by mimicking the historical hydrological conditions in the river.

Water Withdrawal Guidelines

Incorporating the results from this study into the known life history needs of the mussels and the hydrologic history of the Kiamichi River, we created these guidelines for the withdrawal of water from the Kiamichi River. Surveys show that there is a population of endangered mussel (*Arkansia wheeleri)* in the immediate vicinity of the proposed water withdrawal site near Moyers (Vaughn et al. 1996). This population could easily be impacted by the withdrawal activities and the locally altered hydrology greatly increases the threat to this endangered population. Therefore, it is recommended that the site for water withdrawal be placed at Hugo Reservoir and not at the Moyers site (Figure 1). This option minimizes any threat posed by localized reductions in water surface elevation caused by decreases in discharge. It also minimizes impacts to the watershed by affecting an area previously impacted by the creation of the Hugo Reservoir.

Based on our analyses, a minimum flow of 40 cfs (1.13 cms) would prevent withdrawal-related impacts to endangered mussel habitat. It is advisable to buffer this base flow and retain a minimum flow of 50 cfs (1.42 cms) in the Kiamichi River. Human induced flows below this discharge will result in mussel emersion and increased physiological stress and increased mortality within the musselbeds.

To maintain a hydrologic regime similar to the historic, unaltered regime of the Kiamichi River, it is recommended that:

1. All water withdrawals cease when the natural discharge of the Kiamichi River reach the established base flow of 50 cfs (1.42 cms) upstream of the Jackfork Creek/Kiamichi River confluence or when the discharge determined by the USGS gaging station at Clayton minus the releases from Sardis Reservoir equal 50 cfs or less. This will minimize temperature related impacts to the musselbeds of the Kiamichi River.
2. Graduated withdrawals should occur at discharges greater than 50 cfs. If 250 cfs (7.08 cms) is the maximum amount to be removed, rather than taking the next 250 cfs greater than the 50 cfs base flow, a graduated withdrawal would be preferable. For instance, OCWUT would take 50% of the available water greater than 50 cfs up to the maximum quantity to be removed, thus at a river discharge at 550 cfs (15.6 cms), OCWUT would be withdrawing their full 250 cfs allotment. At all flows greater than 550 cfs, OCWUT would continue to withdraw only 250 cfs.

Sardis Lake Operation Guidelines

The flow regime of the upper Kiamichi watershed will remain largely unaltered with the exception of the impoundment of Jackfork Creek and the proposed withdrawal. Management of the withdrawal from Kiamichi River and releases from Sardis Reservoir offers opportunities to approximate the natural, unaltered flow regime in the Kiamichi River, thus restoring the integrity of the watershed while allowing the proposed water withdrawal to move forward.

If possible, Sardis releases would equal Kiamichi withdrawals. If 250 cfs was being withdrawn, then 250 cfs would be released from Sardis Reservoir simultaneously. When this operation pattern cannot be adhered to, the following guidelines should be followed. Guidelines for releasing water from Sardis on a more sporadic schedule would be as follows:

1. Best time to begin releases is during a moderate – high precipitation event.
2. A discharge event reaching a maximum 10,000 cfs (283.17 cms) would naturally decrease to base flow conditions in about 15 days. Sardis Lake releases should be ramped down to zero over a period of approximately 15 days following the most-previous large to moderate precipitation event. For larger magnitude flood events, the duration of the release may be longer. A quick analysis of the historic hydrographs would give an estimate of the approximate recommended duration.
3. If there is a need to release more water from Sardis Reservoir than this pattern allows, a release matching the withdrawal rate would be most preferable. It is recognized that this discharge may not be sufficient in all scenarios and longer term, constant releases of smaller magnitude would be the preferable alternative.
4. The total instantaneous release from Sardis Reservoir should not exceed the instantaneous volume withdrawn (from Moyers or Hugo Reservoir) plus 50% of the total discharge (as measured at the USGS gaging station at Clayton, Oklahoma minus the concurrent Sardis release discharge). This will guarantee that the output from Sardis Reservoir provides a maximum of one-third the instream flows in the lower Kiamichi River, thus maintaining a hydrograph that mimics the unaltered flow regime.

5. In extreme cases, emergency release flows shall be prescribed for the protection of musselbeds in danger of overheating due to long-term drought conditions during the hottest parts of the year.

References

Annear, T. C., I. Chisholm, H. A. Beecher, A. Locke, P. Aarrestad, N. Burkhart, C. Coomer, C. Estes, J. Hunt, R. A. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. B. Mayes, C. B. Stalnaker, and R. Wentworth. 2002. Instream flows for riverine resource stewardship. Instream Flow Council, Wyoming.

Bovee, K. D. 1994. Data collection procedures for the Physical Habitat Simulation system. USGS, Biological Resources Division, Fort Collins, CO.

Byrne, R. A. and R. F. Mcmahon. 1994. Behavioral and Physiological-Responses to Emersion in Fresh-Water Bivalves. American Zoologist 34:194-204.

Fisher, W. L. and W. J. Remshardt. 2000. Instream flow assessment of Baron Fork Creek, Oklahoma. Final Report. Oklahoma Water Resources Board, Oklahoma City.

Franke, O. L. 1968. *Double-mass-curve* analysis of the effects of sewering on ground-water levels on Long Island, New York. U. S. Geological Survey, Report #P 0600-B, Reston, VA, United States.

Hardison, B. S. and J. B. Layzer. 2001. Relations between complex hydraulics and the localized distribution of mussels in three regulated rivers. Regulated Rivers-Research & Management 17:77-84.

Hughes, M. H. and P. W. Parmalee. 1999. Prehistoric and modern freshwater mussel (Mollusca : Bivalvia : Unionoidea) faunas of the Tennessee River: Alabama, Kentucky, and Tennessee. Regulated Rivers-Research & Management 15:25-42.

Johnson, S. L. 1995. Instream flow requirements of *Quadrula fragosa* and the aquatic community in the Lower St. Croix River Downstream of the Northern States Power hydroelectric dam at St. Croix Falls, Wisconsin. Prepared for the Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, WI.

Layzer, J. B., M. E. Gordon, and R. M. Anderson. 1993. Mussels - the Forgotten Fauna of Regulated Rivers - A Case-Study of the Caney Fork River. Regulated Rivers-Research & Management 8:63-71.

Layzer, J. B. and L. M. Madison. 1995. Microhabitat use by freshwater mussels and recommendations for determining their instream flow needs. Regulated Rivers-Research & Management 10:329-345.

McMahon, R. F. and A. E. Bogan. 2001. Mollusca: Bivalvia. Pages 331-429 *in* J. H. Thorp and A. P. Covich, editors. Academic Press, San Diego.

Oklahoma Water Resources Board. 2002. Status report to the office of the governor: Joint state/tribal water compact & water marketing proposals - Southeast Oklahoma water resources development plan.

Postel, S., and B. Richter. 2003. River for life: managing water for people and nature. Island Press, Washington, D. C.

Reiser, D. W., T. A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14:22-29.

Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? Freshwater Biology 37:231-249.

Stalnaker, C. B., B. L. Lamb, J. Henriksen, K. D. Bovee, and J. M. Bartholow. 1995. The instream flow incremental methodology: a primer for IFIM. National Biological Service, US Fish and Wildlife Service, Report #Biological Report 29, Washington, D.C.

The Nature Conservancy. 1998. Kiamichi River, Oklahoma.L. L. Master, S. R. Flack, and B. A. Stein, editors. Rivers of Life: Critical watersheds for protecting freshwater biodiversity. Nature Serve Publications, Arlington, VA.

The Nature Conservancy and Smythe Scientific Software. 2001. Indicators of Hydrologic Alteration. Smythe Scientific Software,

USGS. 2001. PHABSIM for Windows: User's Manual and Exercises, Open File Report: 01-340. Midcontinent Ecological Science Center, USGS, Fort Collins, CO.

Vaughn, C. C., C. M. Mather, M. Pyron, P. Mehlhop, and E. K. Miller. 1996. The current and historical mussel fauna of the Kiamichi River, Oklahoma. Southwestern Naturalist 41:325-328.

Vaughn, C. C. and C. M. Taylor. 1999. Impoundments and the decline of freshwater mussels: A case study of an extinction gradient. Conservation Biology 13:912-920.

Waddle, T. J. 9-15-2004. Email sent on 9/15/2004: Subject: RE: PHABSIM issues (part 2 of 2).

Williams, J. D. and Fuller, S. L. H. 9-25-1992. Effects of impoundments on freshwater mussels (Mollusca: Bivalvia: Unionidae) in the main channel of the Black Warrior and Tombigbee Rivers in western Alabama. pp.1-10.

Williams, J. D., M. L. Warren, K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation Status of Fresh-Water Mussels of the United-States and Canada. Fisheries 18:6-22.

Table 1. Area (m^2) of channel units and mussel beds found within 10 study sites in the Kiamichi River, Oklahoma.

			Pools				
Site	Riffle	Run	Mid-channel	Side-channel	Backwater	Eddy	Mussel beds
1	132.1	-	1522.9	-	-	-	446.8
2	113.7	-	1397.5	-	-	-	306.3
3	-	1239.9	-	187.5	-	-	483.9
4	407.8	376.4	2604.3	-	-	-	354.7
5	-	-	12300.3	-	-	-	619.7
6	-	683.2	20005.2	-	-	-	1019.5
7	142.4	79.4	6029.4	-	-	-	864.9
8	393.8	2044.2	39738.0	-	87.2	-	1924.3
10	242.1	213.1	6255.7	-	23.4	22.0	221.3
11	311.7	1474.1	3447.9	-	-	-	774.7
Total	1743.7	5851.5	93301.2	187.5	110.6	22.0	7015.8

Table 2. PHABSIM habitat models quantified the submerged weighted usable bed area of each study site at decreasing discharges.

Q (cfs)	Site 1 Submerged Mussel Habitat (ft2)	% Emersion	Q (cfs)	Site 2 Submerged Mussel Habitat (ft2)	% Emersion	Q (cfs)	Site 3 Submerged Mussel Habitat (ft2)	% Emersion
2	29568	0.0	2	27332	0.0	2	13045	29.7
4	29568	0.0	4	27332	0.0	4	13839	25.4
6	29568	0.0	6	27332	0.0	6	14759	20.5
8	29568	0.0	8	27332	0.0	8	15723	15.3
10	29568	0.0	10	27332	0.0	10	15821	14.7
12	29568	0.0	12	27332	0.0	12	15959	14.0
14	29568	0.0	14	27332	0.0	14	16147	13.0
16	29568	0.0	16	27332	0.0	16	16348	11.9
18	29568	0.0	18	27332	0.0	18	16577	10.7
20	29568	0.0	20	27332	0.0	20	16757	9.7
22	29568	0.0	22	27332	0.0	22	17009	8.3
24	29568	0.0	24	27332	0.0	24	17185	7.4
26	29568	0.0	26	27332	0.0	26	17346	6.5
28	29568	0.0	28	27332	0.0	28	17430	6.1
30	29568	0.0	30	27332	0.0	30	17486	5.8
32	29568	0.0	32	27332	0.0	32	17545	5.5
34	29568	0.0	34	27332	0.0	34	17600	5.2
36	29568	0.0	36	27332	0.0	36	17655	4.9
38	29568	0.0	38	27332	0.0	38	17702	4.6
40	29568	0.0	40	27332	0.0	40	17749	4.4
42	29568	0.0	42	27332	0.0	42	17786	4.2
44	29568	0.0	44	27332	0.0	44	17822	4.0
46	29568	0.0	46	27332	0.0	46	17854	3.8
48	29568	0.0	48	27332	0.0	48	17892	3.6
50	29568	0.0	50	27332	0.0	50	17918	3.4
52	29568	0.0	52	27332	0.0	52	17936	3.3
54	29568	0.0	54	27332	0.0	54	17953	3.2
56	29568	0.0	56	27332	0.0	56	18537	0.1
58	29568	0.0	58	27332	0.0	58	18556	0.0
60	29568	0.0	60	27332	0.0	60	18556	0.0
62	29568	0.0	62	27332	0.0	62	18556	0.0
64	29568	0.0	64	27332	0.0	64	18556	0.0
66	29568	0.0	66	27332	0.0	66	18556	0.0
68	29568	0.0	68	27332	0.0	68	18556	0.0
70	29568	0.0	70	27332	0.0	70	18556	0.0
72	29568	0.0	72	27332	0.0	72	18556	0.0
74	29568	0.0	74	27332	0.0	74	18556	0.0
76	29568	0.0	76	27332	0.0	76	18556	0.0
78	29568	0.0	78	27332	0.0	78	18556	0.0
80	29568	0.0	80	27332	0.0	80	18556	0.0
82	29568	0.0	82	27332	0.0	82	18556	0.0
84	29568	0.0	84	27332	0.0	84	18556	0.0
86	29568	0.0	86	27332	0.0	86	18556	0.0

Table 2. Continued.

Site 4 Q (cfs)	Submerged Mussel Habitat (ft2)	% Emersion	Site 5 Q (cfs)	Submerged Mussel Habitat (ft2)	% Emersion	Site 6 Q (cfs)	Submerged Mussel Habitat (ft2)	% Emersion
2	21633	0.0	2	3220	0.8	2	4517	1.7
10	21633	0.0	10	3245	0.0	10	4575	0.4
20	21633	0.0	20	3245	0.0	20	4594	0.0
25	21633	0.0	25	3245	0.0	25	4594	0.0
40	21633	0.0	40	3246	0.0	40	4594	0.0
50	21633	0.0	50	3246	0.0	50	4594	0.0
60	21633	0.0	60	3246	0.0	60	4594	0.0
80	21633	0.0	80	3246	0.0	80	4594	0.0
100	21633	0.0	100	3246	0.0	100	4594	0.0
120	21633	0.0	120	3246	0.0	120	4594	0.0
140	21633	0.0	140	3246	0.0	140	4594	0.0
160	21633	0.0	160	3246	0.0	160	4594	0.0
180	21633	0.0	180	3246	0.0	180	4594	0.0
200	21633	0.0	200	3246	0.0	200	4594	0.0
220	21633	0.0	220	3246	0.0	220	4594	0.0
240	21633	0.0	240	3246	0.0	240	4594	0.0
260	21633	0.0	260	3246	0.0	260	4594	0.0
280	21633	0.0	280	3246	0.0	280	4594	0.0
300	21633	0.0	300	3246	0.0	300	4594	0.0
320	21633	0.0	320	3246	0.0	320	4594	0.0
340	21633	0.0	340	3246	0.0	340	4594	0.0
360	21633	0.0	360	3246	0.0	360	4594	0.0
380	21633	0.0	380	3246	0.0	380	4594	0.0
400	21633	0.0	400	3246	0.0	400	4594	0.0
420	21633	0.0	420	3246	0.0	420	4594	0.0
440	21633	0.0	440	3246	0.0	440	4594	0.0
460	21633	0.0	460	3246	0.0	460	4594	0.0
480	21633	0.0	480	3246	0.0	480	4594	0.0
500	21633	0.0	500	3246	0.0	500	4594	0.0
520	21633	0.0	520	3246	0.0	520	4594	0.0
540	21633	0.0	540	3246	0.0	540	4594	0.0
560	21633	0.0	560	3246	0.0	560	4594	0.0
580	21633	0.0	580	3246	0.0	580	4594	0.0
600	21633	0.0	600	3246	0.0	600	4594	0.0
620	21633	0.0	620	3246	0.0	620	4594	0.0
640	21633	0.0	640	3246	0.0	640	4594	0.0
660	21633	0.0	660	3246	0.0	660	4594	0.0
680	21633	0.0	680	3246	0.0	680	4594	0.0
700	21633	0.0	700	3246	0.0	700	4594	0.0
720	21633	0.0	720	3246	0.0	720	4594	0.0
740	21633	0.0	740	3246	0.0	740	4594	0.0
760	21633	0.0	760	3246	0.0	760	4594	0.0
780	21633	0.0	780	3246	0.0	780	4594	0.0

Table 2. Continued.

Q (cfs)	Site 7 Submerged Mussel Habitat (ft2)	% Emersion	Q (cfs)	Site 8 Submerged Mussel Habitat (ft2)	% Emersion
2	24459	6.5	2	7890	7.0
10	25573	2.3	10	8214	3.2
20	26093	0.3	20	8380	1.3
25	26168	0.0	25	8420	0.8
40	26168	0.0	40	8461	0.3
50	26168	0.0	50	8472	0.2
60	26168	0.0	60	8475	0.1
80	26168	0.0	80	8479	0.1
100	26168	0.0	100	8482	0.0
120	26168	0.0	120	8485	0.0
140	26168	0.0	140	8486	0.0
160	26168	0.0	160	8486	0.0
180	26168	0.0	180	8486	0.0
200	26168	0.0	200	8486	0.0
220	26168	0.0	220	8486	0.0
240	26168	0.0	240	8486	0.0
260	26168	0.0	260	8486	0.0
280	26168	0.0	280	8486	0.0
300	26168	0.0	300	8486	0.0
320	26168	0.0	320	8486	0.0
340	26168	0.0	340	8486	0.0
360	26168	0.0	360	8486	0.0
380	26168	0.0	380	8486	0.0
400	26168	0.0	400	8486	0.0
420	26168	0.0	420	8486	0.0
440	26168	0.0	440	8486	0.0
460	26168	0.0	460	8486	0.0
480	26168	0.0	480	8486	0.0
500	26168	0.0	500	8486	0.0
520	26168	0.0	520	8486	0.0
540	26168	0.0	540	8486	0.0
560	26168	0.0	560	8486	0.0
580	26168	0.0	580	8486	0.0
600	26168	0.0	600	8486	0.0
620	26168	0.0	620	8486	0.0
640	26168	0.0	640	8486	0.0
660	26168	0.0	660	8486	0.0
680	26168	0.0	680	8486	0.0
700	26168	0.0	700	8486	0.0
720	26168	0.0	720	8486	0.0
740	26168	0.0	740	8486	0.0
760	26168	0.0	760	8486	0.0
780	26168	0.0	780	8486	0.0

Table 2. Concluded.

	Site 10			Site 11	
Q (cfs)	Submerged Mussel Habitat (ft2)	% Emersion	Q (cfs)	Submerged Mussel Habitat (ft2)	% Emersion
2	61290	14.7	2	13492	0.0
10	68502	4.6	10	13492	0.0
20	71073	1.0	20	13492	0.0
25	71383	0.6	25	13492	0.0
40	71826	0.0	40	13492	0.0
50	71826	0.0	50	13492	0.0
60	71826	0.0	60	13492	0.0
80	71826	0.0	80	13492	0.0
100	71826	0.0	100	13492	0.0
120	71826	0.0	120	13492	0.0
140	71826	0.0	140	13492	0.0
160	71826	0.0	160	13492	0.0
180	71826	0.0	180	13492	0.0
200	71826	0.0	200	13492	0.0
220	71826	0.0	220	13492	0.0
240	71826	0.0	240	13492	0.0
260	71826	0.0	260	13492	0.0
280	71826	0.0	280	13492	0.0
300	71826	0.0	300	13492	0.0
320	71826	0.0	320	13492	0.0
340	71826	0.0	340	13492	0.0
360	71826	0.0	360	13492	0.0
380	71826	0.0	380	13492	0.0
400	71826	0.0	400	13492	0.0
420	71826	0.0	420	13492	0.0
440	71826	0.0	440	13492	0.0
460	71826	0.0	460	13492	0.0
480	71826	0.0	480	13492	0.0
500	71826	0.0	500	13492	0.0
520	71826	0.0	520	13492	0.0
540	71826	0.0	540	13492	0.0
560	71826	0.0	560	13492	0.0
580	71826	0.0	580	13492	0.0
600	71826	0.0	600	13492	0.0
620	71826	0.0	620	13492	0.0
640	71826	0.0	640	13492	0.0
660	71826	0.0	660	13492	0.0
680	71826	0.0	680	13492	0.0
700	71826	0.0	700	13492	0.0
720	71826	0.0	720	13492	0.0
740	71826	0.0	740	13492	0.0
760	71826	0.0	760	13492	0.0
780	71826	0.0	780	13492	0.0

Table 3a. Non-parametric River Variability Analysis Scorecard for the extended hydrologic records of the USGS gaging station at Antlers, OK on the Kiamichi River produced using IHA.

	Pre-impact period: 1962-1982				Post-impact period: 1983-2003						
			Range Limits				Range Limits		RVA Categories		
	Medians	Coeff. Of Variance	Low	High	Medians	Coeff. Of Variance	Low	High	Low	High	Hydrologic alteration factor*
October	87	13.9	0.0	3625	98	11.9	2.4	7764	30	813	0.00
November	336	3.3	0.0	5855	957	3.2	5.2	8614	177	750	-0.14
December	493	3.2	0.3	9151	2435	1.4	7.8	5289	357	1078	-0.29
January	643	2.0	0.0	3138	1672	1.1	154	7159	322	1112	-0.43
February	1207	1.7	23	4037	1667	1.7	154	6316	642	1567	-0.29
March	1546	2.0	153	6249	2496	0.8	853	5918	505	3019	0.86
April	1391	1.6	116	6191	2254	1.1	248	7401	770	2222	0.14
May	1715	1.5	51	6816	2489	1.2	78	12704	704	2527	-0.14
June	422	5.0	1.70	5877	1108	1.5	22	3784	93	1587	1.00
July	47	4.6	1.40	431	154	2.9	10	1704	17	159	0.43
August	33	5.4	0.1	490	20	5.4	0.0	2017	6.0	123	1.00
September	51	4.3	1.1	5914	125	3.7	0.2	2961	29	168	-0.14
1-day minimum	3.0	1.8	0.0	21	2.3	2.0	0.0	11	0.2	3.7	0.71
3-day minimum	1.0	6.6	0.0	22	2.3	2.0	0.0	12	0.2	3.8	0.50
7-day minimum	1.1	9.5	0.0	27	2.7	1.8	0.0	14	0.1	4.5	0.71
30-day minimum	3.9	4.8	0.0	145	6.5	1.2	0.0	120	1.2	9.2	0.86
90-day minimum	18	4.4	0.0	509	41	1.7	2.1	1052	10	52	0.14
1-day maximum	28094	0.9	1747	135159	24100	0.5	8190	57000	22121	35982	0.29
3-day maximum	18397	1.0	1332	73302	19233	0.6	6927	51733	13403	25469	0.71
7-day maximum	11269	1.0	717	34489	12734	0.6	4990	33029	7857	14095	0.43
30-day maximum	4070	0.9	219	9477	6467	0.6	2162	15292	3465	6446	0.14
90-day maximum	2592	0.7	154	5620	3962	0.3	1333	8509	2128	3511	-0.14
Number of zero days	0.0	0.0	0.0	131	0.0	0.0	0.0	46	0.0	11.8	
Base flow	0.0	5.7	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	1.43
Julian date of minimum	229	0.2	167	316	258	0.1	193	311	221	258	0.00
Julian date of maximum	69	0.3	30	345	150	0.5	6.0	362	81	142	0.00
Low pulse count	3.0	1.0	1.0	9.0	4.0	0.4	1.0	9.0	3.0	4.0	0.20
Low pulse duration	19	0.8	3.0	60	15	0.5	1.0	29	13	23	0.43
High pulse count	11	0.6	3.0	21	13	0.3	3.0	17	8.5	12	-0.25
High pulse duration	7.0	0.7	1.3	20	11	0.6	5.3	63	6.3	9.0	-0.57
	The low pulse threshold is 30.										
	The high pulse level is 764.2.										
Rise rate	1209	1.2	105	3112	1439	0.5	341	2579	819	2095	1.14
Fall rate	-357	-1.4	-984	-28	-480	-0.6	-1125	-125	-578	-251	0.71
Number of reversals	72	0.3	39	92	81	0.2	66	104	61	79	0.14

*Hydrologic Alteration Factor is defined as (Observed freq. - Expected freq.)/(Expected freq.). Expected = the frequency with which annual values of the IHA parameter fell within the middle RVA category in the pre-impact period. Observed = the frequency with which annual values fell within the middle RVA category in the post impact period.

Table 3b. Non-parametric River Variability Analysis Scorecard for the extended hydrologic records of the USGS gaging station at Antlers, OK on the Kiamichi River produced using IHA.

Assessment of Hydrologic Alteration

	Middle RVA Category			High RVA Category			Low RVA Category		
	Expected	Observed	Hydrologic Alteration Factor	Expected	Observed	Hydrologic Alteration Factor	Expected	Observed	Hydrologic Alteration Factor
October	7	7	0.00	7	7	0.00	7	7	0.00
November	7	6	-0.14	7	11	0.57	7	4	-0.43
December	7	5	-0.29	7	14	1.00	7	2	-0.71
January	7	4	-0.43	7	14	1.00	7	3	-0.57
February	7	5	-0.29	7	12	0.71	7	4	-0.43
March	7	13	0.86	7	8	0.14	7	0	-1.00
April	7	8	0.14	7	11	0.57	7	2	-0.71
May	7	6	-0.14	7	10	0.43	7	5	-0.29
June	7	14	1.00	7	6	-0.14	7	1	-0.86
July	7	10	0.43	7	10	0.43	7	1	-0.86
August	7	14	1.00	7	5	-0.29	7	2	-0.71
September	7	6	-0.14	7	9	0.29	7	6	-0.14
1-day minimum	7	12	0.71	7	7	0.00	7	2	-0.71
3-day minimum	8	12	0.50	6	7	0.17	7	2	-0.71
7-day minimum	7	12	0.71	7	7	0.00	7	2	-0.71
30-day minimum	7	13	0.86	7	6	-0.14	7	2	-0.71
90-day minimum	7	8	0.14	7	9	0.29	7	4	-0.43
1-day maximum	7	9	0.29	7	4	-0.43	7	8	0.14
3-day maximum	7	12	0.71	7	5	-0.29	7	4	-0.43
7-day maximum	7	10	0.43	7	7	0.00	7	4	-0.43
30-day maximum	7	8	0.14	7	11	0.57	7	2	-0.71
90-day maximum	7	6	-0.14	7	13	0.86	7	2	-0.71
Number of zero days	14	19	0.36	7	2	-0.71	0	0	0.00
Base flow	7	17	1.43	7	2	-0.71	7	2	-0.71
Date of minimum	8	8	0.00	7	9	0.29	6	4	-0.33
Date of maximum	7	7	0.00	7	11	0.57	7	3	-0.57
Low pulse count	10	12	0.20	6	5	-0.17	5	4	-0.20
Low pulse duration	7	10	0.43	7	4	-0.43	7	7	0.00
High pulse count	8	6	-0.25	6	14	1.33	7	1	-0.86
High pulse duration	7	3	-0.57	7	16	1.29	7	2	-0.71
Rise rate	7	15	1.14	7	2	-0.71	7	4	-0.43
Fall rate	7	12	0.71	7	2	-0.71	7	7	0.00
Number of reversals	7	8	0.14	7	13	0.86	7	0	-1.00

Expected = number of post-impact years expected to fall into each category

Observed = number of post-impact years that fell into each category

Hydrologic Alteration Factor = (Observed - Expected)/Expected

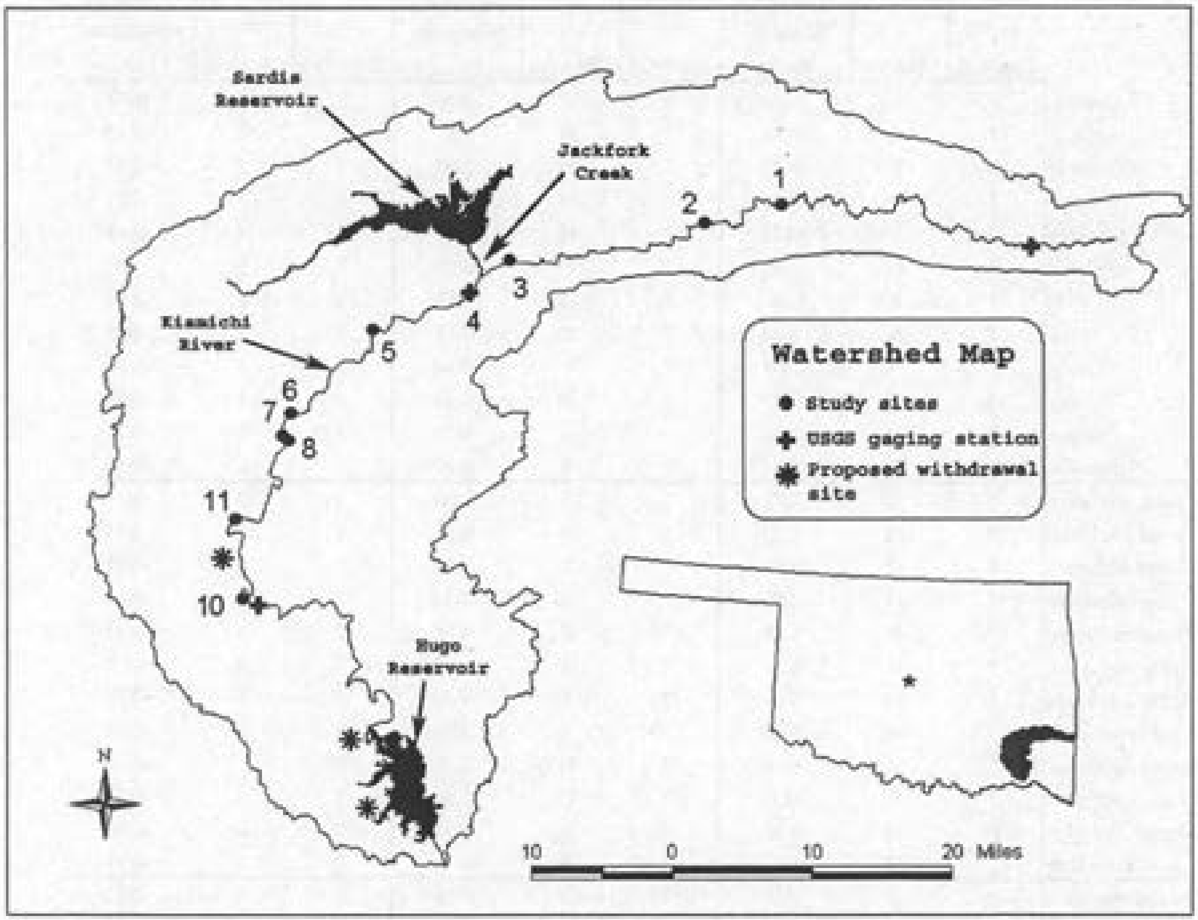
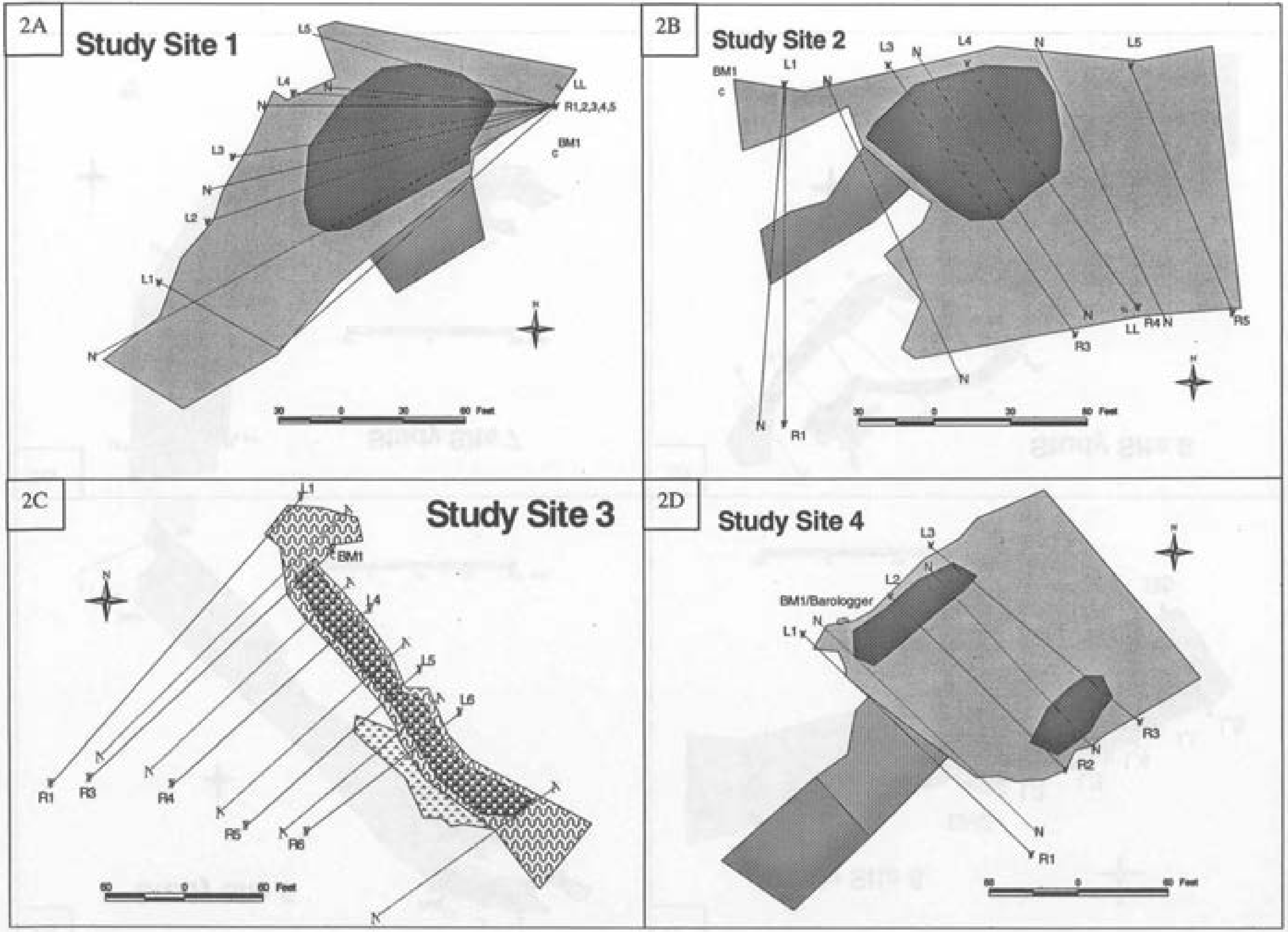


Figure 1. Map of 10 study sites with musselbeds in the Kiamichi River, southeastern Oklahoma.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L4
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L3
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L2
L1
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2B
Study Site 2
BM1
L1
L3
N
L4
N
L5
R3
LL
R4
N
R5
N
N
R1
2C
Study Site 3
L1
BM1
L4
L5
L6
R1
R3
R4
R5
R6
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R1
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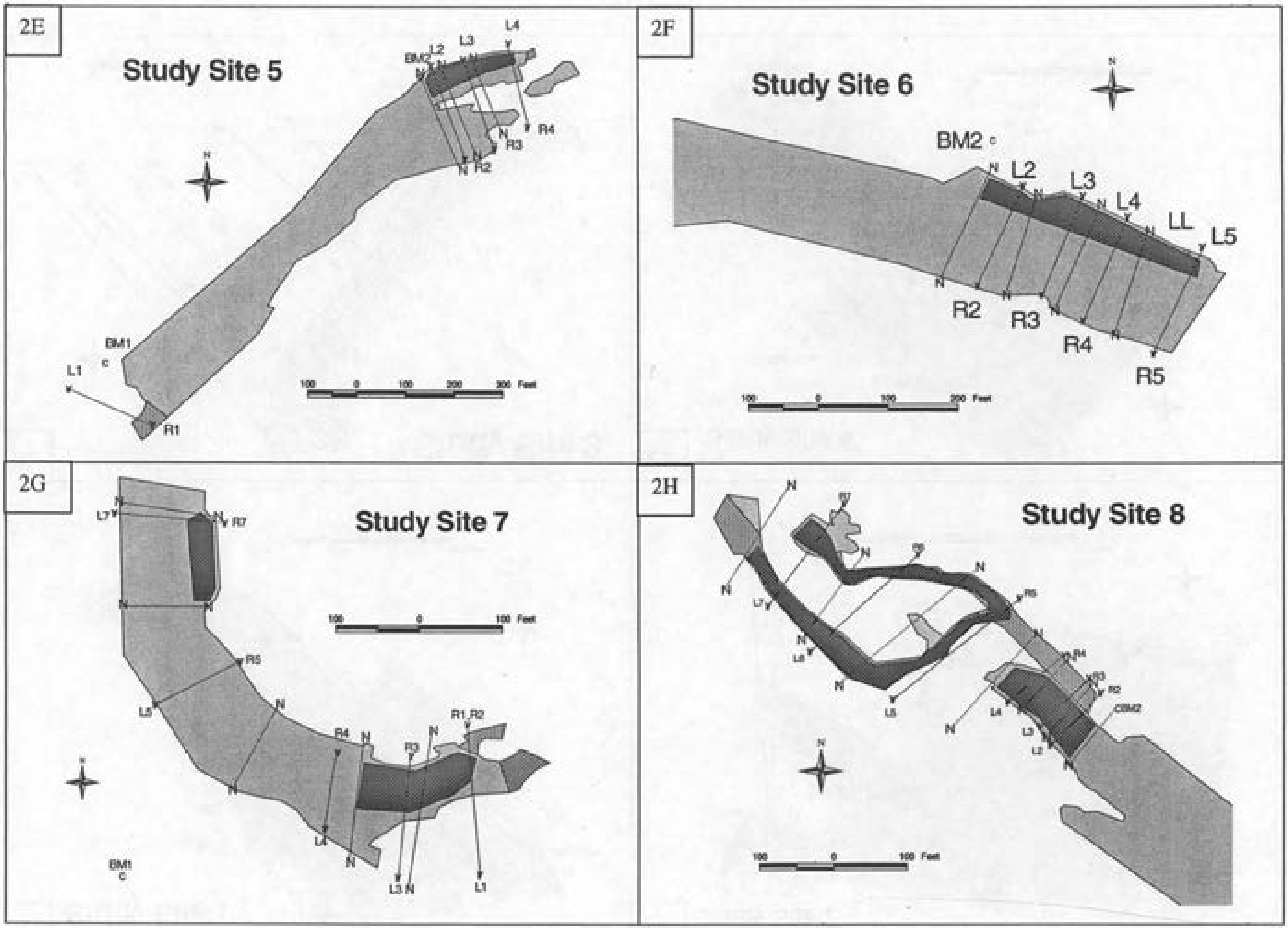
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Study Site 5
BM2
L2
L3
L4
R2
R3
R4
BM1
L1
R1
Feet
2F
Study Site 6
BM2
L2
L3
L4
LL
L5
R2
R3
R4
R5
Feet
2G
Study Site 7
L7
R7
R5
L5
R4
R3
R1,R2
L4
L3
L1
BM1
Feet
2H
Study Site 8
L7
L6
L5
L4
L3
L2
R6
R4
R3
R2
BM2
Feet

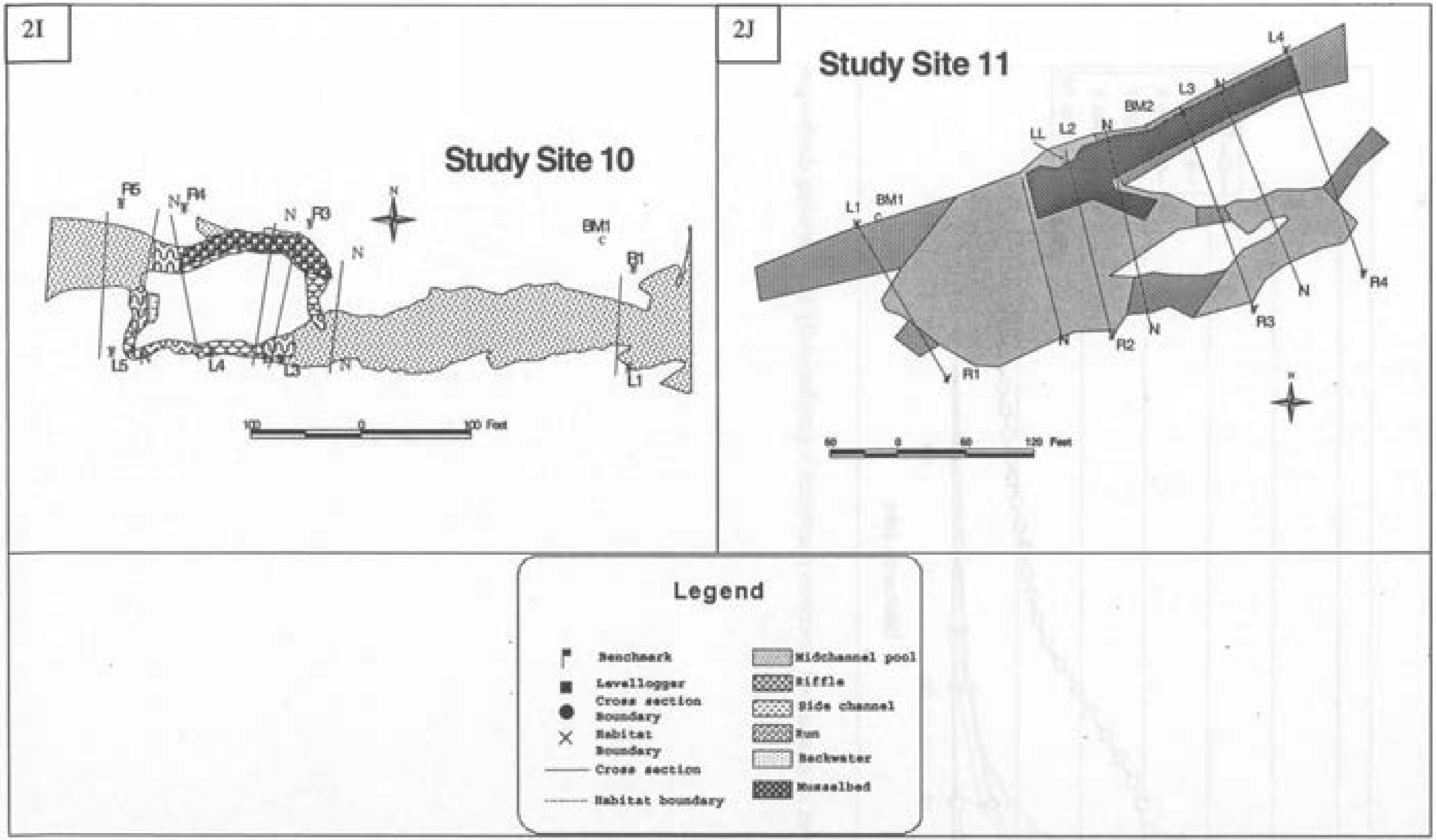

Figure 2a - j. Locations of mussel beds, channel unit types, and habitat transects cross sections at the 10 study sites in the Kiamichi River, Oklahoma.

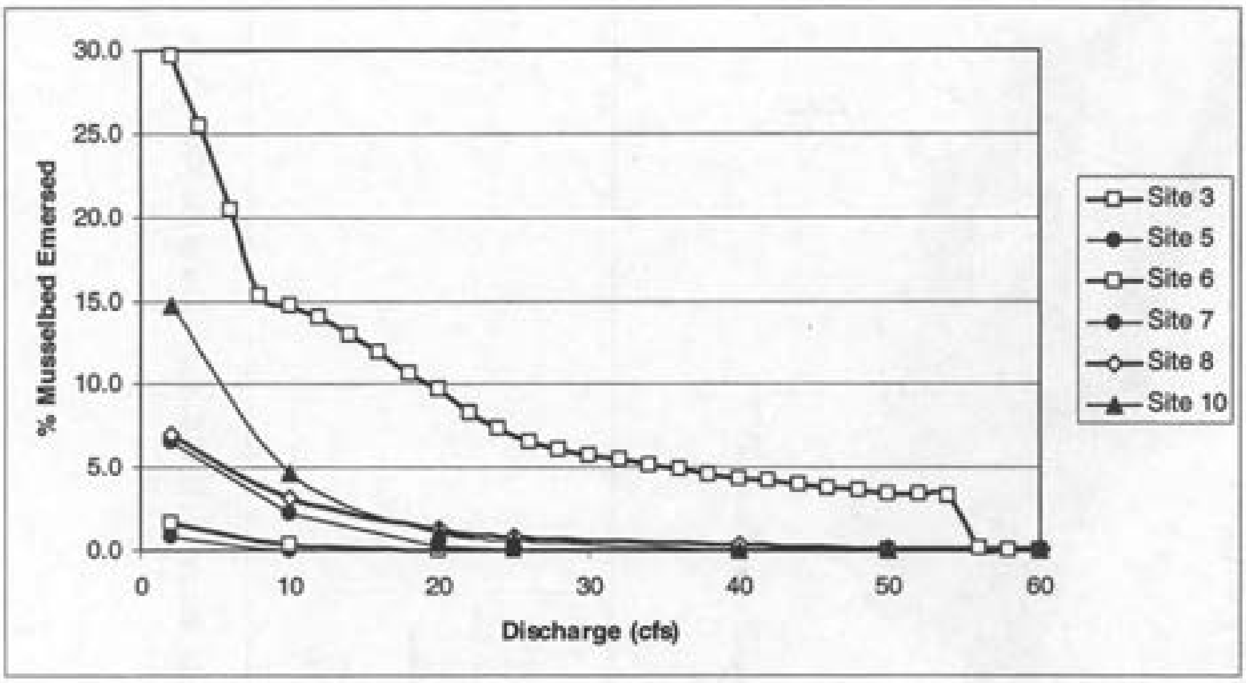

Figure 3. The percent of musselbed emersion decreases logarithmically at increasing discharges.

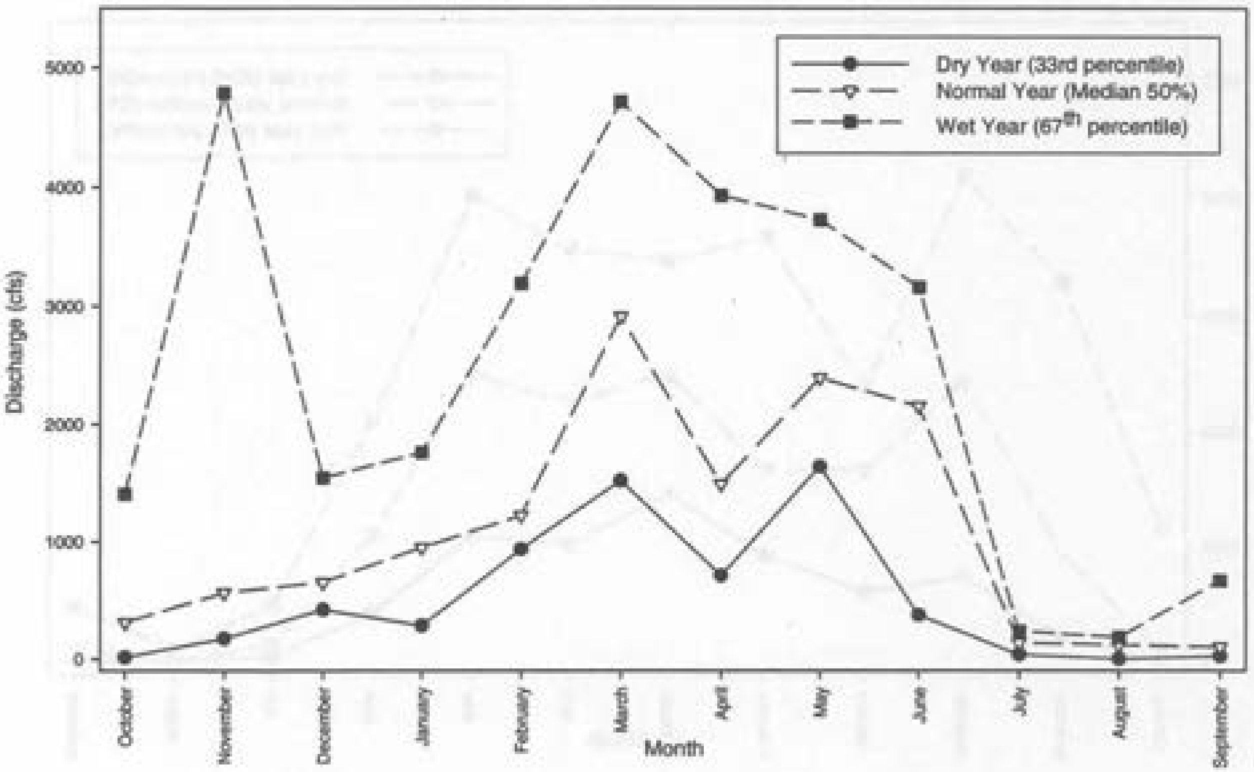

Figure 4a. Hydrographs for dry, normal, and wet years in the period prior to the construction of Sardis Reservoir (Kiamichi River gage at Antlers).

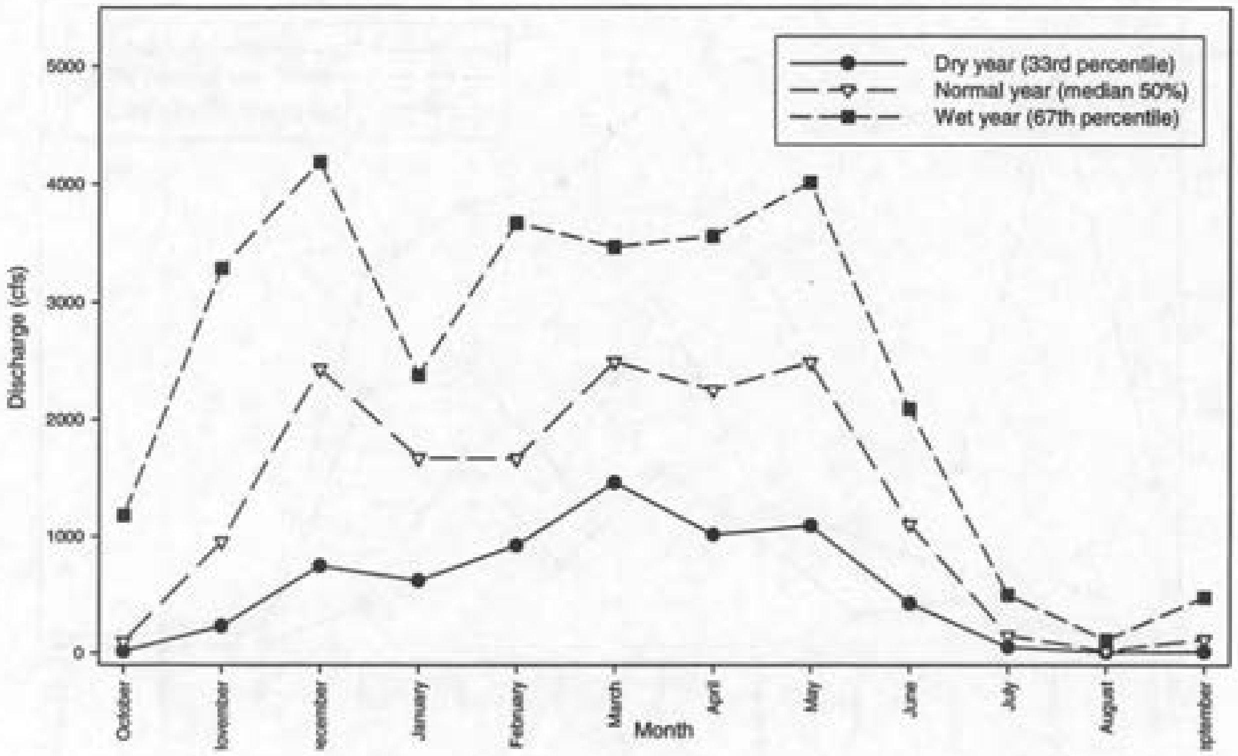

Figure 4b. Hydrographs for dry, normal, and wet years in the period following the construction of Sardis Reservoir (Kiamichi River gage at Antlers).

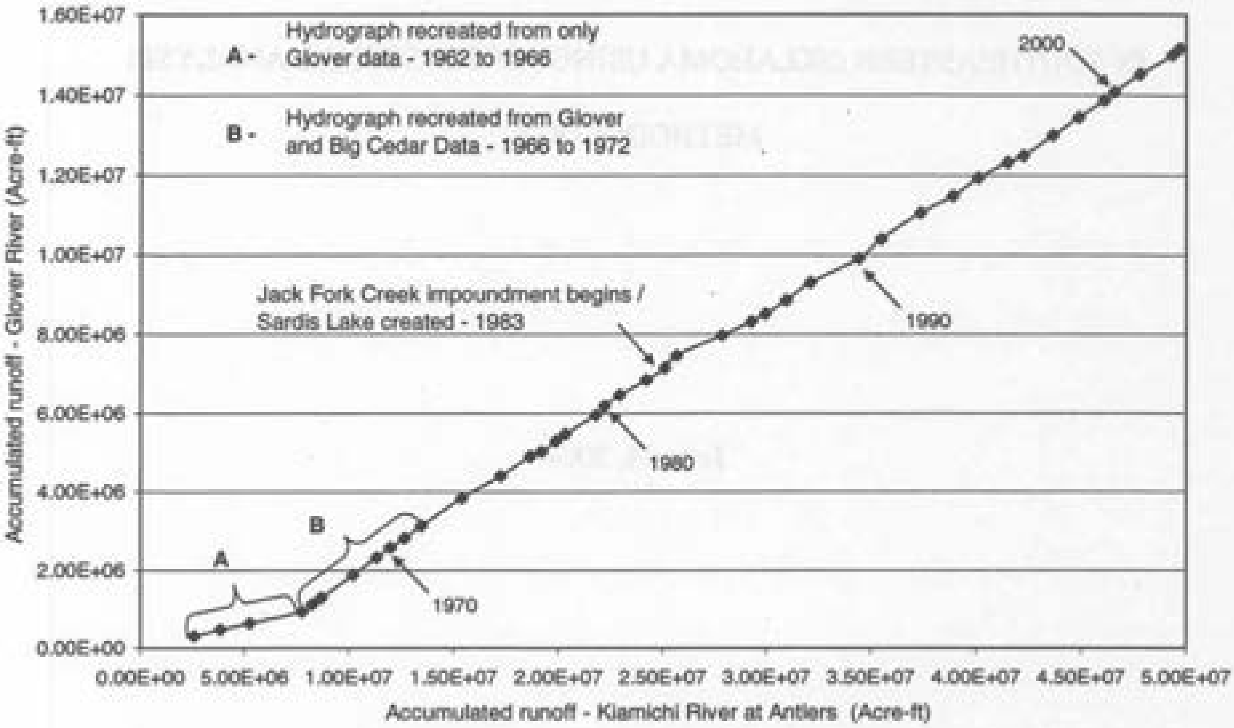

Figure 5. The double mass curve indicated that there was no significant difference in the pre- and post-Sardis total annual runoff at Antlers when compared to USGS gaging station at Glover.

DETERMINATION OF INSTREAM FLOW RECOMMENDATIONS FOR FOUR STREAMS IN SOUTHEASTERN OKLAHOMA USING PROPORTIONAL ANALYSIS METHODOLOGY

June 24, 2004

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Acknowledgements

We would like to recognize the Oklahoma Department of Wildlife and Conservation personnel who assisted with the collection of data in the field necessary to complete this investigation. Without the efforts of James Vincent and Chris Whisenhunt of the Southeastern Regional Office of ODWC, and their field technicians, this study would not have been completed. We would also like to thank Dr. William Fisher, Oklahoma State University, Stillwater, Oklahoma for his cooperation in completing necessary administrative details to make the study possible. We thank both Oklahoma State University and the Oklahoma Department of Wildlife Conservation for funding this effort.

List of Tables

List of Figures

Introduction

The State of Texas is considering the possibility of utilizing water from rivers and reservoirs in southeastern Oklahoma to augment their current and future water demands. Several rivers are being considered as potential sources of water. These include the Kiamichi River, Little River, Glover River, and Mountain Fork Creek.

It has not been determined how these water transfers would affect fish populations in the rivers from which water is being removed. The primary purpose of this study is to conduct an instream flow analysis of the rivers potentially impacted by water transfer activities. These analyses will provide resource managers and decision makers with the information necessary to evaluate the consequences of decisions they make regarding water transfers and changes to river flows. Objectives of this study include the following:

1. Examine historical flows from stream gauging records to establish mean of median flow values by month for the period of record;
2. Use gauging station calibration data to determine relations among depth, width, and velocity at each gauging station site;
3. Establish field stations to collect depth, width, and velocity measures as well as discharge values to compare to sites without gauging records to sites with gauging station records;
4. Relate historical flow values at sites with gauging station records to sites without such records;
5. Construct fish population response curves to habitat variable change as related to flows;
6. Construct a table of the relation between fish populations and discharge using the mean of median flows as supporting the 100 percent historical fish populations. The table

would depict necessary flow values to sustain various proportions of the historic fish population (i.e. 90%, 80%, etc.). Tables for each gauging station location are developed.

Study Area

These rivers are located in the Ouachita Mountains Ecoregion. Elevations range from 360 feet to 2,122 feet above sea level. Valleys are dominated with shale and alluvial till. Uplands are composed of sandstone outcroppings with shallow soils and steep rocky slopes (Bain and Waterson 1979).

The Kiamichi River is considered free-flowing for 169 miles of its length, draining over one-million acres, and passing through six counties. These counties include LeFlore, Pushmataha, Latimer, Atoka, Pittsburg, and Choctaw. The Kiamichi River is impounded at its lower end by Hugo Lake which was constructed in 1971. Flows in the river above Hugo Lake are somewhat affected by Sardis Reservoir on Jackfork Creek, a tributary to the Kiamichi River. Sardis Lake was completed in 1982.

Seventy-two percent of the Kiamichi River watershed is under private ownership. Land use practices include timber harvest, livestock production, and crop production. A number of public lands occur in the watershed including the Ouachita National Forest as well as a number of state-owned wildlife management areas.

The Kiamichi River is used extensively for recreational purposes. In addition, it has largely been spared major impacts from land use changes or water diversions. The river supports over 100 fish species and 28 mussel species (The Nature Conservancy 2003).

Glover River and Mountain Fork Creek are both tributaries to the Little River. Both the Little River and the Kiamichi River discharge into the Red River which forms the southern boundary of Oklahoma. Mountain Fork Creek is impounded by Broken Bow Lake and the Little River is impounded by Pine Creek Lake. The Glover River is free-flowing.

Mountain Fork Creek has its headwaters in Arkansas. It enters Oklahoma near the northeastern corner of McCurtain County. The Little River has its origin in LeFlore County and passes through eastern Pushmataha County before entering McCurtain County and joining the Glover River. The Glover River lies entirely within McCurtain County and drains 876 square kilometers (Orth 1980). Glover Creek is 53 km long from its mouth up to the confluence of the East and West Forks. Fork lengths are 35 and 33 km, respectively (Jones 1981).

The climate of the area could be characterized as having long, hot summers with winters being usually short and mild. Average annual temperature is 17.2 C; average July temperature is 27.8 C; and average January temperature is 6.7 C (U.S. Army Corps of Engineers 1975).

Methods

The methodology utilized to conduct this instream flow assessment is the proportional analysis method (PAM) developed by Layher and Brunson (1992). The PAM methodology was developed for use in warmwater streams and utilizes historic flow information, median flow values as recommended by Bayha (1978), and species suitability curves based on macrohabitat variables (Edwards et al. 1983; Layher 1983; Layher 1995; Layher and Maughan 1987a, 1987b, 1988). When these data are available, the methodology provides a more rapid, less costly, and more biologically defensible assessment approach than do many other instream flow techniques (Layher and Brunson 1995). Additionally, this approach defines losses/gains to fisheries in a practical manner that can be implemented due to the mesohabitat scale used to identify recommended flow values.

The PAM methodology has been used to develop instream flow legislation in Kansas and has been used successfully to determine flow values in Baron Fork Creek, Oklahoma (WRB 1998). An Instream Flow Incremental Methodology (IFIM) applied to Baron Fork Creek produced similar recommendations to PAM results (Fisher and Remshardt 2000). PAM has also been used to analyze instream flow needs in Bayou Bartholomew, Arkansas (Layher and Phillips 2000) and the Middle Fork Saline River, Arkansas (Layher and Phillips 2001).

Typically, when using PAM, historic river flows are available at sites of interest. Width, depth, and velocity relations to flow (cfs) are derived from historic stream gauge calibration data. These relations can be used to produce estimated depths and velocities at various discharge levels. Suitability index (SI) values are assigned for depth and velocity at each chosen discharge for selected species from suitability curves which were developed from over 400 sampling sites on rivers over a broad geographical area. These SI values are summed and the mean produces a Habitat Suitability Index (HSI) which is multiplied by river segment length and width to produce habitat units (HUs). HUs are plotted against discharge to determine relations between flow and biosupport capability for species of interest.

Median flow values are computed for all months of historic record. Means of medians are then calculated for each month for the entire period of record. HUs are calculated for these values. Percentages of fish habitats available at the mean of median flow by month are also calculated from 100% to 10% in increments of 10%. Relations between discharge and HUs for the species at the site are used to calculate flow (discharge) necessary to sustain the desired percentage of the historic fish population as defined by the mean of median flow value for a particular month.

This process was performed for three historic gauging stations on the Kiamichi River, one station on the Glover River, and one station on the Mountain Fork Creek. Seven fish species were selected to represent each stream for analysis: channel catfish (*Ictalurus punctatus*), spotted bass (*Micropterus punctulatus*), green sunfish (*Lepomis cyanellus*), white crappie (*Poxomis annularus*), central stoneroller (*Campostoma annomalum*), smallmouth bass (*Micropterus dolomeu*), and longear sunfish (*Lepomis megalotis*). Suitability index values for fishes used in the analysis were those developed by Layher and Maughan (1987a) for green sunfish; Layher and Maughan (1988) for central stoneroller; Edwards et al. (1983) as modified by Layher and Phillips (2001) for smallmouth bass; Layher and Maughan (1985) for channel catfish; Layher (1983) for white crappie; Layher et al. (1987) for spotted bass; and analysis of the data set used by Layher (1983) for longear sunfish. All of these relations are based on actual population estimates at streams and physicochemical variable measurements. Hence, the relations depict population response (biomass) changes to changes in variables of interest, in this case depth and velocity (Layher and Brunson 1995).

Additionally, transects to record discharge, depth, and velocity data were established as follows: 2 sites, one each at Albion and Joe Payne Road, on the Kiamichi River between the existing flow gauges at Big Cedar, Clayton, and Antlers; one site on the Little River at Honobia Store; and one site on the West Fork Glover River. These sites were established for the purpose of: 1) developing relations between discharge, width, depth, and velocity on the Little River in a reach where gauges were not present, and: 2) determining relations between flows at these sites and flows at historic stream gauges, based on drainage areas above stream gauges and drainage areas above established transect locations on the Kiamichi River and Glover River. Data from the stream gauge at Smithville on the Mountain Fork Creek was considered representative for that stream above Broken Bow Lake.

To obtain data to satisfy purpose number one above; discharge data, width, velocity, and depth measurements were taken on ten consecutive days in a glide (run) habitat near Hanobia Store. Flow events at which measurements were collected range from low flow values to higher flows; with all measurements made at flow values that might be expected to occur and represent possible mean of median flows during low flow months. Relations between flow values at this site and population responses to various flow levels were determined.

The second purpose required discharge to be measured for several consecutive days at the transect sites located between stream gauges on the Kiamichi River and above a stream gauge on the Glover River. Those data were compared to downstream stream gauge data on the same stream in the case of the Kiamichi and Glover Rivers. Discharge areas above transect sites (field stations) were compared to discharge areas above gauges to examine the possibility that flows are related to discharge area. If such a relation exists, then, a historic record of flow could be assumed to mimic that recorded at downstream gauges. Correlations between flows at gauged sites and ungauged sites (field stations) were also calculated. These relations can also be used to calculate flows at an ungauged site when flows are known at the gauged site. Consequently, if one determines a flow at a gauged site to represent a minimum flow value, the relation to the ungauged site can be used to calculate the recommended flow at that point. Relations between flow and fish habitat units can also be derived for the ungauged stream section by simply using the calculated percentage of the basin-flow relation and applying it to the flow values required to sustain levels of the fishery desired at the downstream gauge.

Due to the lack of records for discharge on the Little River, a transect site was established as described above. Drainage areas above that site were computed and flows were compared to flows at other sites on streams in the study area. Relations between drainage areas were used to calculate median flows expected at the transect site on the Little River. These values could then be used to assess impacts or changes to fish populations resulting from stream flow changes. This would assume that the stream derives flow in a very similar manner to other streams in the study area. This assumption may be substantiated because these streams are primarily rainfall driven and lack large aquifer systems.

Results

Relations for depth, width, and velocity to discharge were computed for USGS stream gauging sites on the Kiamichi River, at Big Cedar, Clayton, and Antlers; on the Mountain Fork Creek at Smithville, and the Glover River at Glover (Table 1). These relations were used to compute depth, width, and velocity at various flows of interest for each site (Tables 2-6). Relations for the Little River site at Honobia Store were derived from actual flow measurements recorded in the field ranging from approximately 12 to 40 cfs (Table 7). Calculated depths, widths, and velocities were used to assign suitability index values for seven fish species at the various flow levels.

Monthly median flows were calculated for the periods of record available at gauging station sites at Big Cedar, Clayton, and Antlers on the Kiamichi River; Smithville on Mountain Fork Creek; and Glover on the Glover River. Years of record and median flow values by month are displayed in Tables 8-12. Means of the median values by month were then calculated (Tables 8-12).

Habitat units were calculated at various flow levels for each of the seven fish species for gauging station sites and at the field station site on the Little River at Honobia. Log-log relations between cfs and habitat units available for each species were calculated (Table 13). Actual habitat units available for each species at each of the sites at various flows were then calculated from suitability index values (Tables 14-19). Regression equations were derived from HU and discharge values to produce estimated habitat units at various flows (Tables 20-25).

Relations derived between HUs and cfs were plotted for each of the seven species used in the analysis at the gauging station sites and Honobia on the Little River (Figures 1-41). These relations were used to compute smooth curves describing the relation between HUs and cfs for the seven species at the stations.

Mean median flow records were examined for each month and the resulting habitat units at those flows were considered to represent the amount of habitat (quantity * quality = HUs) available for each species over the range of recorded flows. The number of habitat units representing 90%, 80%, 70%, 60%, 50%, and 40% for each site for each species was calculated. Utilizing the regression equations depicting relations between HUs and cfs; the flow value needed to maintain each propositional level of habitat availability was calculated for each species by gauging station site (Tables 26-59).

Historical records were not available for the Little River field station at Honobia Store. Hence flow data was collected at the site for a period of ten days. These data allowed for the development of relations between flow and habitat units for each species used in the analysis.

Flow data at gauging station sites was compared to field station sites on the Kiamichi River (Table 60). Field stations were located at Albion and Joe Payne Road. A comparison of Big Cedar flows on 03/29/2004 shows that flows at Big Cedar were 22.68% of flow at Albion. If one assumed drainage area was directly proportional to flow throughout the river system, flows at any point could be calculated by computing the percentage of land area represented at a point of interest as compared to flows gauged at another point. For instance, the gauging station at Big Cedar represents 13.1% of the land area discharged at the Albion field station. The actual values for flow ranged from approximately 21% to 35%, and averaged about 24%. Using the 13.1% figure, expected discharges were calculated based on land area and displayed for comparison. These comparisons were done for sites on the West Fork Glover River and Glover River (Table 61) and the Little River (Table 62).

Relations between flows at gauged sites and field station sites were plotted (Figures 42-47). Correlations between discharge at gauged sites and ungauged sites were high for most comparisons within rivers. These relations provide methods to compute necessary flows at ungauged sites to provide necessary established minimum flows at gauging station localities.

Discussion

These data provide resource managers allocating water from rivers considered in this analysis, the information needed to make informed decisions regarding potential impacts on fishery resources. The tables depicting habitat units available at 100% of the mean-median flows for each month also provide the recommended flow values to sustain various levels of the historical fishery. For instance, Table 41 indicates that 106 cfs is the discharge needed to maintain 100% of the historical spotted bass fishery in the Kiamichi River at Antlers. To maintain 80% of the historical fishery (80% of habitat units available at 100%) would require 71 cfs, and so on. These tables are available for seven species of interest at the gauged sites on the rivers considered.

These tables are perhaps most useful in assessing summertime low flow values. The months of July, August, and September are most critical. Data used to construct suitability curves represented river segments from over 420 streams using summertime fish population and physicochemical data. Hence, these models should be expected to well represent the summertime condition. To ease the burden of regulation, minimum flow values could represent the means of recommended flows for various seasons. Rather than establishing a minimum flow for each month, the period of July, August, and September could be combined. Similar calculations could be made for other seasons.

Relations were high between habitat units and flow for most species considered. It should be noted that correlations between longear sunfish habitat units and flow, were often quite low. No relation is depicted between habitat units for this species and flow in the Glover River as no correlation was found. The longear sunfish depends on low velocity flows and relatively shallow depth. It may be that variables used in the analysis, depth and velocity, did not provide for increasing or decreasing habitat with discharge measured. In other words, the amount of longear sunfish habitat tends to stay the same with changes in flow. The useable habitat may shift from mid-stream at lower flow to river edges at higher flows, and not increase or decrease with discharge changes.

The comparison of flows at gauged and ungauged sites on the Kiamichi allows one to simply insert the appropriate cfs value for a population level desired into the relation between the gauged and ungauged site. The calculation will then yield the minimum flow desired at the ungauged site. For example, if one wanted to maintain 80% of the historical channel catfish fishery in the Kiamichi River at Clayton and upstream at Albion during July, the recommended flow to accomplish that a Clayton, from Table 33, is 46 cfs. The equation describing the relation between Clayton and Albion flows is given on Figure 43. Plugging in 46 cfs, the calculated corresponding flow needed at Albion is 43.5 cfs.

Only one gauged site existed on the Mountain Fork Creek and no field stations were established, so minimum flows should be established at that gauging station dependent on the population level desired.

Relations of habitat units to flow were calculated at the Little River field station. The gauging station on the Little River is downstream of an impoundment and results in little reliability in comparing the upstream field station at Honobia to it. The land area at the field station represented 5.94% of the area discharging to the gauging station below the reservoir. Flows measured at ten dates and compared to downstream discharge equaled from 1.26% to 2.81% of the downstream discharge. To determine flows required to maintain historical fisheries in the Little River, one could assume similar runoff patterns as other rivers in the study. Then using appropriate drainage area-discharge relations, required flow levels could be calculated. Those values could then be found on the HUs verses discharge relations for the Little River, and necessary flows to maintain various proportional levels of fish populations could be derived. Flows to maintain 100% of the historical stoneroller populations in July on the Mountain Fork Creek at Smithville are 106 cfs. That station represents a drainage area of 320 square miles. The site of the field station, for which HU relations to flow were calculated on the Little River, receives runoff from 72.93 square miles. This is 22.79% of the area represented by the Mountain Fork site. Assuming both drainages are exposed to similar storm and climatic events, it would be logical to assume similar runoff patterns if land uses and geology were similar between the two rivers. Layher and Phillips (2001) found such relations to exist on the Middle Fork Saline River in Arkansas which also flows out of the Ouachita Mountains. Assuming this relation, flows to maintain similar conditions as those discussed for the Little River field station would equal approximately 24 cfs. Having this number available would allow for proportional analysis to be performed using the HUs relations to discharge. Using both Table 25 and Figure 39, 24 cfs represents approximately 36,930 habitat units at the flow level to maintain 100% of the historical population. If one were to choose to maintain 80% of the historical population, one would need to establish flows equal to those needed for 29,544 HUs. One could use the equation on Figure 39 to calculate the needed flow or one could approximate the value from the graph, about 10 cfs.

Conclusions

This analysis provides data on fish habitat availability under various flow scenarios and should provide necessary information to water and fisheries managers with regard to water development impacts. Flows required to sustain historical fish populations for seven species of fishes are tabulated for three sites on the Kiamichi River, one site on the Mountain Fork, and one site on the Glover River. Additionally relations are provided to enable the calculation of flows needed to maintain fisheries at two additional sites on the Kiamichi River, and for an additional site on both the Little River and the Glover River.

Using the examples given, calculations could also be performed to estimate flows needed to maintain fisheries at any desired point on each of the rivers if drainage area at that point is known.

These data should provide necessary information to make well informed decisions regarding the future of fisheries on these streams. This methodology has been shown to yield results very similar to the Instream Flow Incremental Methodology (IFIM) when applied to warmwater streams (Layher and Brunson 1995; Layher and Phillips 2001).

Table 1. Log-log conversions for depth, width and velocity as a function of flow in cfs for each site.

Stream Site	Formula	R^2
Kiamichi River		
Big Cedar	$\log_{10} d = -0.5184 + 0.3261(\log_{10} cfs)$	0.6137
	$\log_{10} w = 1.0619 + 0.3901(\log_{10} cfs)$	0.7257
	$\log_{10} v = -0.4739 + 0.2468(\log_{10} cfs)$	0.3682
Clayton	$\log_{10} d = -0.8111 + 0.4827(\log_{10} cfs)$	0.9064
	$\log_{10} w = 1.1775 + 0.3134(\log_{10} cfs)$	0.8626
	$\log_{10} v = -0.4161 + 0.2276(\log_{10} cfs)$	0.5686
Antlers	$\log_{10} d = -0.9554 + 0.4992(\log_{10} cfs)$	0.9077
	$\log_{10} w = 1.1373 + 0.3253(\log_{10} cfs)$	0.8766
	$\log_{10} v = -0.1775 + 0.1706(\log_{10} cfs)$	0.4914
Mountain Fork River		
Smithville	$\log_{10} d = -0.4166 + 0.3038(\log_{10} cfs)$	0.7865
	$\log_{10} w = 0.8973 + 0.4585(\log_{10} cfs)$	0.8898
	$\log_{10} v = -0.4162 + 0.2197(\log_{10} cfs)$	0.5268
Glover River		
Glover	$\log_{10} d = -0.7986 + 0.4106(\log_{10} cfs)$	0.8976
	$\log_{10} w = 1.1673 + 0.3777(\log_{10} cfs)$	0.8535
	$\log_{10} v = -0.3345 + 0.2073(\log_{10} cfs)$	0.5274

Table 2. Depth (ft), width (ft) and velocity (ft/sec) at various flows (cfs) for Kiamichi River at Big Cedar.

cfs	Depth	Width	Velocity	cfs	Depth	Width	Velocity
2	15.11	0.38	0.40	76	62.46	1.24	0.98
4	19.80	0.48	0.47	78	63.10	1.25	0.98
6	23.20	0.54	0.52	80	63.72	1.27	0.99
8	25.95	0.60	0.56	82	64.34	1.28	1.00
10	28.31	0.64	0.59	84	64.95	1.29	1.00
12	30.40	0.68	0.62	86	65.55	1.30	1.01
14	32.29	0.72	0.64	88	66.14	1.31	1.01
16	34.01	0.75	0.67	90	66.72	1.31	1.02
18	35.61	0.78	0.69				
20	37.10	0.81	0.70				
22	38.51	0.83	0.72				
24	39.84	0.85	0.74				
26	41.10	0.88	0.75				
28	42.31	0.90	0.76				
30	43.46	0.92	0.78				
32	44.57	0.94	0.79				
34	45.64	0.96	0.80				
36	46.67	0.98	0.81				
38	47.66	0.99	0.82				
40	48.63	1.01	0.83				
42	49.56	1.03	0.84				
44	50.47	1.04	0.85				
46	51.35	1.06	0.86				
48	52.21	1.07	0.87				
50	53.05	1.09	0.88				
52	53.87	1.10	0.89				
54	54.66	1.11	0.90				
56	55.45	1.13	0.91				
58	56.21	1.14	0.91				
60	56.96	1.15	0.92				
62	57.69	1.16	0.93				
64	58.41	1.18	0.94				
66	59.12	1.19	0.94				
68	59.81	1.20	0.95				
70	60.49	1.21	0.96				
72	61.16	1.22	0.96				
74	61.81	1.23	0.97				

Table 3. Depth (ft), width (ft) and velocity (ft/sec) at various flows (cfs) for Kiamichi River at Clayton.

cfs	Depth	Width	Velocity	cfs	Depth	Width	Velocity
20	0.66	38.48	0.76	760	3.80	120.32	1.74
40	0.92	47.82	0.89	780	3.85	121.31	1.75
60	1.11	54.30	0.97	800	3.89	122.27	1.76
80	1.28	59.42	1.04	820	3.94	123.22	1.77
100	1.43	63.72	1.09	840	3.99	124.16	1.78
120	1.56	67.47	1.14	860	4.03	125.08	1.79
140	1.68	70.81	1.18	880	4.08	125.98	1.79
160	1.79	73.84	1.22	900	4.12	126.87	1.80
180	1.89	76.61	1.25	920	4.16	127.75	1.81
200	1.99	79.18	1.28	940	4.21	128.61	1.82
220	2.09	81.59	1.31	960	4.25	129.46	1.83
240	2.18	83.84	1.34	980	4.29	130.30	1.84
260	2.26	85.97	1.36	1000	4.34	131.13	1.85
280	2.35	87.99	1.38	1020	4.38	131.95	1.86
300	2.42	89.91	1.41	1040	4.42	132.75	1.86
320	2.50	91.75	1.43	1060	4.46	133.55	1.87
340	2.58	93.51	1.45	1080	4.50	134.33	1.88
360	2.65	95.20	1.46	1100	4.54	135.11	1.89
380	2.72	96.83	1.48	1120	4.58	135.87	1.90
400	2.79	98.40	1.50	1140	4.62	136.63	1.90
420	2.85	99.91	1.52	1080	3.80	120.32	1.74
440	2.92	101.38	1.53	1100	3.85	121.31	1.75
460	2.98	102.80	1.55	1120	3.89	122.27	1.76
480	3.04	104.18	1.56	1140	3.94	123.22	1.77
500	3.10	105.53	1.58	1080	3.99	124.16	1.78
520	3.16	106.83	1.59	1100	4.03	125.08	1.79
540	3.22	108.10	1.61	1120	4.08	125.98	1.79
560	3.28	109.34	1.62	1140	4.12	126.87	1.80
580	3.33	110.55	1.63	1080	4.16	127.75	1.81
600	3.39	111.73	1.65	1100	4.21	128.61	1.82
620	3.44	112.88	1.66	1120	4.25	129.46	1.83
640	3.49	114.01	1.67	1140	4.29	130.30	1.84
660	3.55	115.12	1.68				
680	3.60	116.20	1.69				
700	3.65	117.26	1.70				
720	3.70	118.30	1.71				
740	3.75	119.32	1.73				

Table 4. Depth (ft), width (ft) and velocity (ft/sec) at various flows (cfs) for Kiamichi River at Antlers.

cfs	Depth	Width	Velocity	cfs	Depth	Width	Velocity
20	0.49	36.35	1.11	780	3.08	119.70	2.07
40	0.70	45.55	1.25	800	3.12	120.69	2.08
60	0.86	51.97	1.34	820	3.16	121.66	2.09
80	0.99	57.07	1.40	840	3.19	122.62	2.10
100	1.10	61.36	1.46	860	3.23	123.56	2.10
120	1.21	65.11	1.50	880	3.27	124.49	2.11
140	1.31	68.46	1.54	900	3.31	125.41	2.12
160	1.40	71.50	1.58	920	3.34	126.30	2.13
180	1.48	74.29	1.61	940	3.38	127.19	2.14
200	1.56	76.88	1.64	960	3.41	128.07	2.14
220	1.64	79.30	1.67	980	3.45	128.93	2.15
240	1.71	81.58	1.69	1000	3.48	129.78	2.16
260	1.78	83.73	1.72	1020	3.52	130.62	2.17
280	1.85	85.77	1.74	1040	3.55	131.44	2.17
300	1.91	87.72	1.76	1060	3.59	132.26	2.18
320	1.97	89.58	1.78	1080	3.62	133.07	2.19
340	2.03	91.37	1.80	1100	3.65	133.86	2.19
360	2.09	93.08	1.81	1120	3.69	134.65	2.20
380	2.15	94.73	1.83	1140	3.72	135.43	2.21
400	2.21	96.33	1.85	1160	3.75	136.20	2.21
420	2.26	97.87	1.86	1180	3.79	136.96	2.22
440	2.31	99.36	1.88	1200	3.82	137.71	2.23
460	2.37	100.81	1.89	1220	3.85	138.45	2.23
480	2.42	102.21	1.91	1240	3.88	139.18	2.24
500	2.47	103.58	1.92	1260	3.91	139.91	2.25
520	2.51	104.91	1.93	1280	3.94	140.63	2.25
540	2.56	106.21	1.94	1300	3.97	141.34	2.26
560	2.61	107.47	1.96	1320	4.00	142.04	2.26
580	2.66	108.70	1.97	1340	4.03	142.74	2.27
600	2.70	109.91	1.98	1360	4.06	143.43	2.28
620	2.75	111.09	1.99	1380	4.09	144.11	2.28
640	2.79	112.24	2.00	1400	4.12	144.79	2.29
660	2.83	113.37	2.01	1420	4.15	145.46	2.29
680	2.87	114.48	2.02	1440	4.18	146.12	2.30
700	2.92	115.56	2.03	1460	4.21	146.78	2.30
720	2.96	116.62	2.04	1480	4.24	147.43	2.31
740	3.00	117.67	2.05	1500	4.27	148.08	2.31
760	3.04	118.69	2.06	1520	4.30	148.71	2.32

Table 4. Continued

1540	4.32	149.35	2.32
1560	4.35	149.98	2.33
1580	4.38	150.60	2.33
1600	4.41	151.22	2.34
1620	4.43	151.83	2.34
1640	4.46	152.44	2.35
1660	4.49	153.04	2.35

Table 5. Depth (ft), width (ft) and velocity (ft/sec) at various flows (cfs) for Mt. Fork River at Smithville.

cfs	Depth	Width	Velocity	cfs	Depth	Width	Velocity
10	0.77	22.69	0.64	380	2.33	120.26	1.41
20	0.95	31.18	0.74	390	2.35	121.70	1.42
30	1.08	37.55	0.81	400	2.37	123.12	1.43
40	1.18	42.84	0.86	410	2.38	124.53	1.44
50	1.26	47.45	0.91	420	2.40	125.91	1.45
60	1.33	51.59	0.94	430	2.42	127.28	1.45
70	1.39	55.37	0.98	440	2.43	128.62	1.46
80	1.45	58.87	1.00	450	2.45	129.96	1.47
90	1.50	62.13	1.03	460	2.47	131.27	1.48
100	1.55	65.21	1.05	470	2.48	132.57	1.48
110	1.60	68.12	1.08	480	2.50	133.86	1.49
120	1.64	70.89	1.10	490	2.52	135.13	1.50
130	1.68	73.54	1.12	500	2.53	136.39	1.50
140	1.72	76.09	1.14	510	2.55	137.63	1.51
150	1.76	78.53	1.15	520	2.56	138.86	1.52
160	1.79	80.89	1.17	530	2.58	140.08	1.52
170	1.82	83.17	1.19	540	2.59	141.29	1.53
180	1.86	85.38	1.20	550	2.61	142.48	1.53
190	1.89	87.52	1.21	560	2.62	143.66	1.54
200	1.92	89.60	1.23	570	2.63	144.83	1.55
210	1.94	91.63	1.24	580	2.65	145.99	1.55
220	1.97	93.61	1.25	590	2.66	147.14	1.56
230	2.00	95.53	1.27	600	2.68	148.28	1.56
240	2.03	97.42	1.28				
250	2.05	99.26	1.29				
260	2.08	101.06	1.30				
270	2.10	102.82	1.31				
280	2.12	104.55	1.32				
290	2.15	106.25	1.33				
300	2.17	107.91	1.34				
310	2.19	109.54	1.35				
320	2.21	111.15	1.36				
330	2.23	112.73	1.37				
340	2.25	114.28	1.38				
350	2.27	115.81	1.39				
360	2.29	117.32	1.40				
370	2.31	118.80	1.41				

Table 6. Depth (ft), width (ft) and velocity (ft/sec) at various flows (cfs) for Glover River at Glover.

cfs	Depth	Width	Velocity	cfs	Depth	Width	Velocity
10	0.41	35.08	0.75	230	1.48	114.64	1.43
20	0.54	45.57	0.86	240	1.51	116.49	1.44
30	0.64	53.11	0.94	250	1.53	118.30	1.45
40	0.72	59.21	0.99	260	1.56	120.07	1.47
50	0.79	64.42	1.04	270	1.58	121.79	1.48
60	0.85	69.01	1.08	280	1.61	123.48	1.49
70	0.91	73.15	1.12	290	1.63	125.13	1.50
80	0.96	76.93	1.15	300	1.65	126.74	1.51
90	1.01	80.43	1.18	310	1.68	128.32	1.52
100	1.05	83.70	1.20	320	1.70	129.87	1.53
110	1.10	86.76	1.23	330	1.72	131.38	1.54
120	1.14	89.66	1.25	340	1.74	132.87	1.55
130	1.17	92.41	1.27	350	1.76	134.34	1.56
140	1.21	95.04	1.29	360	1.78	135.77	1.57
150	1.24	97.55	1.31	370	1.80	137.19	1.58
160	1.28	99.95	1.33	380	1.82	138.57	1.59
170	1.31	102.27	1.34	390	1.84	139.94	1.59
180	1.34	104.50	1.36	400	1.86	141.29	1.60
190	1.37	106.66	1.37	410	1.88	142.61	1.61
200	1.40	108.74	1.39	420	1.90	143.91	1.62
210	1.43	110.76	1.40	430	1.92	145.20	1.63
220	1.46	112.73	1.42				

Table 7. Depth (ft), width (ft) and velocity (ft/sec) at specific flows (cfs) for Little River at Honobia Store.

cfs	Depth	Width	Velocity
0	0	0	0
12.98492	0.637	37.00	0.4346
14.3575	0.668	37.00	0.5395
16.7634	0.689	38.00	0.5373
17.9209	0.753	38.00	0.5201
19.9901	0.755	38.00	0.5865
20.2609	0.779	38.00	0.5833
21.6766	0.797	38.00	0.6400
32.8942	0.918	39.00	0.7715
33.7854	0.986	39.00	0.7827
40.1062	1.018	39.00	0.8705

Table 8. Monthly mean-median flows (cfs) for Kiamichi River at Big Cedar.

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
1965	—	—	—	—	—	—	—	—	—	4.4	4.5	24
1966	22	48.5	41	11.5	46	2.3	0.7	2.6	0.8	0	0	0.3
1967	2.3	4.65	19	129	59	20.5	17	1.3	1.15	5.5	37	98
1968	39	41	135	100.5	75	9.9	2.4	0.98	0.355	2.6	28	90
1969	57	77.5	41	70.5	59	45	4.4	1.2	0.655	7.4	24	25
1970	45	70	125	84	13	2.6	0.22	0	8.95	46	59	24
1971	62	84.5	62	22.5	36	10.6	1.5	21	1.2	24	18	109
1972	57	35	36	20	9.9	0.77	0	0	0	0	123	49
1973	112	72.5	210	116	56	85	12	2.1	11	27	56	101
1974	43	34	59	57	23	14	0.67	0.24	109	14	109.5	44
1975	47	123	100	50	73	63	2.1	12	4.4	1.5	8.25	29
1976	29	24	44	37.5	41	12	1.4	0.11	0.16	7.7	18	57
1977	73	64.5	101	51	4.8	1.3	0.03	0	0	1.3	11	16
1978	13	51.5	103	39.5	23	3.6	0	0	0	0	16	27
1979	62	56	150	112.5	140	25.5	3.4	7.8	2.05	0.52	13	54
1980	32	36	16	79.5	91	9.55	0.23	0	0	8	4	28
1981	9.9	38	65	42	93	63	43	13	6.45	22	20.5	18
1982	33	107	76	27	89	45	2.1	0.38	0	0	5.95	128
1983	26	58	39	83	162	8.55	7.6	0.26	0	0	0	33
1984	23	57	171	53	68	3.3	2.1	1.4	0.445	268	106.5	107
1985	130	139	104	63.5	32	18.5	4.6	1	0.35	1.6	75	61
1986	15	64.5	23	88.5	29	24	0	0	0	9.3	35.5	48
1987	68	73	107	38.5	11	8.55	2.4	1	2.15	0.95	63.5	148
1988	95	46	72	101.5	5.4	0	0	3.7	0.13	0	2.05	51
1989	98	153.5	127	40.5	122	41	43	2.6	0.49	0.21	1.1	2.1
1990	25	146.5	150	149	162	17	1.9	5.8	0.3	21	45.5	77
1991	159	33.5	64	145.5	51	14.5	3.6	3.4	6.9	5.2	94.5	192
1992	86	72	96	36.5	28	98.5	5.5	6.2	77	8.6	31	80
1993	105	75	106	92.5	123	18.5	1.3	0.23	2.15	26	46	66
1994	39	53	99	30	32	4.75	3.8	0.67	1.1	32	112.5	95

Table 8. Continued.

1995	136	33.5	56	110.5	59	23	2.8	0.18	0	0.38	1.3	0.82
1996	73	11	19	91	44	6.45	6.5	6.4	4.65	7.7	198	73
1997	29	103.5	93	82	14	41.5	3.1	0.38	0	29	56.5	127
1998	95	118	110	30	19	2.35	0	0	8.9	52	32	117
1999	43	95.5	100	93	68	43	17	0	0	0	0	50
2000	37	41	27	53.5	69	183.5	22	0	0	0	141	54
2001	86	185	106	60.5	17	5.35	0.98	0	7.5	14	16.5	98
2002	20	81	97	75	39	33.5	2.6	0	0	—	—	—
Mean of Medians	57.5	70.5	85.1	69.4	56.4	27.3	6.0	2.6	7.0	17.9	44.7	66.0

Table 9. Monthly mean-median flows (cfs) for Kiamichi River at Clayton.

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
1980	—	—	—	—	—	—	—	—	—	—	236	190
1981	65	279	480	209.5	583	545.5	149	98	33	1030	261.5	193
1982	137	1660	727	168	2370	549.5	62	8.2	2.25	3.9	26.5	1880
1983	195	570	305	583.5	1530	193.5	171	9.1	2.7	0	1.5	194
1984	148	260	2490	593	501	42	6.6	4.4	4.45	3480	4800	2140
1985	579	1390	1850	1065	495	182	13	6.2	4.5	6.1	783	483
1986	82	418	343	2435	1610	1084.5	22	4.1	22.5	70	172.5	192
1987	680	453	1550	220.5	79	892	40	4.3	42.5	5.5	854.5	2590
1988	1250	354	1120	846.5	37	4.55	7.8	108	30	5.2	33.5	275
1989	452	3205	1570	279	1150	1080	299	17	25	2.8	5.3	25
1990	357	3130	3030	1665	5120	1265	18	250	29.5	170	562.5	869
1991	2060	165.5	459	2070	832	89.5	8.4	37	93	13	2495	2400
1992	931	694	451	603.5	1290	2215	328	204	1490	32	147.5	2690
1993	1560	1115	1330	2390	1620	416	5.4	18	35.5	203	427	932
1994	451	1095	1100	372.5	1530	58.5	20	6.1	4.9	23	3080	940
1995	1980	241	515	1205	1910	1740	24	4.7	4.5	6.5	4.95	10
1996	633	83	69	2085	1320	96.5	36	120	80	74	2550	1100
1997	210	2300	800	620	250	165	27	7.7	2.9	178	614.5	1660
1998	4000	1055	1980	306	115	37.5	3.2	0	99.5	745	282	1580
1999	293	494	1100	2305	1810	972.5	100	3.1	1.9	0.05	0.26	110
2000	86	258	311	525	445	1060	30	1.3	0	0	911.5	927
2001	1540	2110	1630	328	69	59.5	7.1	4.2	185.5	80	39.5	977
2002	121	1975	1570	3575	347	209	45	6.5	1.1	—	—	—
Mean of Medians	809.5	1059.3	1126.4	1111.4	1137.0	589.0	64.7	41.9	99.8	291.8	831.3	1016.2

Table 10. Monthly mean-median flows(cfs) for Kiamichi River at Antlers.

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
1972	—	—	—	—	—	—	—	—	—	0	2250	472
1973	1780	1615	4610	2225	1530	1195	149	98	418	634	916	1520
1974	574	522.5	1100	1095	916	916.5	39	57	3650	208	1995	977
1975	879	2345	2220	1054.5	1430	972	125	72	81	13	75	298
1976	170	116	468	554	869	277	47	2.9	15.5	71	132.5	267
1977	759	986	1140	839	118	19	30	27	44.5	8.6	103	76
1978	42	886.5	1790	622	467	140.5	18	0	0	6.6	131	283
1979	923	708	2070	1350	1640	577.5	85	81	23.5	10	96	174
1980	208	430	151	852	1740	247.5	10	0	0	324	290.5	283
1981	104	414.5	683	320	1190	1015.5	172	135	30	1790	591	306
1982	201	2505	1140	264	3840	1170	110	13	1	4.8	48.5	2630
1983	455	1290	578	792.5	3030	219.5	204	60	2.1	5.1	17	322
1984	233	371	3710	969	730	115	27	11	9.4	4550	5330	3080
1985	965	1995	3090	1445	1840	292.5	35	9.6	8.65	16	2510	836
1986	147	770.5	582	3010	3600	1435	25	7.8	51	50	269	270
1987	701	509	2050	314.5	69	970	71	9.7	36.5	21	1320	3470
1988	1850	603	1830	1200	55	11	60	75	35.5	7.6	27	342
1989	548	3525	1790	490.5	1350	2425	381	44	96.5	8.8	5.1	7.8
1990	36	4205	4010	2980	6500	1385	103	260	54.5	184	495	1100
1991	2600	351.5	480	3515	1460	476	31	91	132	17	3175	3700
1992	1750	1230	1100	1056	2260	3150	866	246	1545	59	234.5	3680
1993	2170	1160	1740	3120	2000	1151	18	22	67.5	201	506.5	1080
1994	553	1155	1420	259	2420	243.5	98	29	17.5	77	3970	1180
1995	3180	358.5	939	2620	2650	2335	41	12	54	31	7.2	14
1996	902	117	102	3280	1990	149.5	86	255	148.5	164	5020	1560
1997	346	3110	1510	1685	449	219	46	10	3.8	196	878	2310
1998	4790	1570	2950	359	185	88.5	7.8	0	181	1500	412.5	3170
1999	468	872.5	1450	2785	2250	1105	148	9	6.95	2.2	2.8	304
2000	155	390	538	1080	819	1125	42	2.5	0	0.89	1660	1600
2001	2150	3755	1940	494.5	146	191	28	5.3	247	284	85	1310

Table 10. Continued.

2002	421	2430	1460	4570	449	322.5	81	34	3.4	—	—	—
Mean of Medians	1002.0	1343.2	1621.4	1506.7	1599.7	798.0	106.1	56.0	232.1	348.2	1085.1	1220.7

Table 11. Monthly mean-median flows (cfs) for Mt. Fork River at Smithville.

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
1991	—	—	—	—	—	—	—	—	—	28	434	1080
1992	453	423	448	143.5	144	537.5	73	49	352	75	240.5	348
1993	689	480.5	617	598	575	156.5	20	18	16	326	433.5	489
1994	349	321	525	233	270	80	136	32	34	108	656.5	650
1995	692	179.5	453	624	281	158	33	10	7.75	5.2	8.5	12
1996	283	111	163	392	186	77	95	101	62.5	102	1115	844
1997	572	842	439	312.5	69	56	21	11	7	161	392	782
1998	684	639	690	212	137	92	7.7	3.9	48	361	293.5	779
1999	341	528	454	587.5	435	329	184	11	10.5	6.4	25	256
2000	157	248	489	302	253	1220	45	4.5	3	5.7	672	386
2001	505	883.5	806	352	124	51	7.3	13	96	81	45.5	706
2002	198	635	653	654.5	279	140.5	46	7.2	11.5	—	—	—
Mean of Medians	447.5	481.0	521.5	401.0	250.3	263.4	60.7	23.7	58.9	114.5	392.4	575.6

Table 12. Monthly mean-median flows (cfs) for Glover River at Glover.

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
1961	—	—	—	—	—	—	—	—	—	49	219.5	445
1962	711	340	388	691	47	32	5.8	3.6	42	238	182.5	134
1963	123	50	414	97	46	5.8	3.3	7.1	2.6	0.5	0.3	3.1
1964	1.8	68	342	255.5	142	16	0.6	2.7	106.5	32	22	184
1965	266	431.5	202	176.5	489	99.5	11	5.1	2.7	13	14	32
1966	57	176	140	33	208	9	0.88	84	35	3.1	0.74	5.4
1967	28	49	118	483.5	290	58.5	44	1.2	55.5	13	155.5	346
1968	282	184	646	970	925	125.5	27	12	27	29	132	642
1969	322	722	332	263.5	425	141	10	1.2	1.3	0.7	42.5	74
1970	196	537	575	183	86	25	1.8	0	61	396	207	77
1971	319	366	286	73.5	166	69	56	125	14	54	133.5	524
1972	238	213	112	83	57	4.25	1.8	0	0	2.6	880	223
1973	550	466	1420	605	491	504	60	9.5	91.5	89	359.5	508
1974	370	196.5	240	292.5	117	243.5	12	27	1200	103	1160	422
1975	158	555	683	336.5	492	444.5	21	11	8.7	6.6	6.85	40
1976	29	28	203	185.5	318	61.5	14	2	17.5	25	85	215
1977	456	385.5	595	230.5	109	11	6.2	17	5.25	2.3	92.5	35
1978	168	304	506	232.5	132	46	2.7	0	0	0	121	144
1979	361	248.5	1000	666	743	119.5	51	24	4.05	2.4	44	158
1980	102	175	69	233	287	89.5	1.9	0.4	0.18	153	103	108
1981	37	193.5	188	118	799	361	51	24	18	112	78	81
1982	73	574	441	182.5	811	472	22	12	2.25	1.2	50	703
1983	154	410	232	222	564	70.5	46	9.4	0.4	1.8	65.5	325
1984	184	239	735	287.5	210	44.5	20	6.1	2.35	1270	483.5	469
1985	282	407	433	194	161	85	6.2	5.2	2.3	10	287.5	250
1986	50	249.5	87	313.5	365	421	21	10	33	154	284	285
1987	293	251.5	306	78.5	21	79	63	6.6	6.3	9.7	460	605
1988	332	255	435	299	34	6	11	62	4.65	3.4	187.5	372
1989	456	625.5	401	266	646	379	239	33	50.5	9.8	8.5	11
1990	150	526.5	951	709	978	48	12	51	1.4	97	132	370

Table 12. Continued.

1991	980	149.5	412	1110	452	57	5.6	42	151	9.6	458.5	1070
1992	479	454	499	98	251	885	188	95	547	9.5	75	504
1993	630	380.5	527	392	509	44.5	5.6	12	14	177	239.5	406
1994	277	240	473	108	730	78.5	83	24	10.5	116	575	585
1995	688	157	433	364	401	222.5	36	7.3	7	18	18	14
1996	278	34	25	204.5	159	36	40	90	157	118	1020.5	412
1997	132	819.5	484	293.5	79	46.5	9	6.4	2.55	141	471.5	798
1998	718	679	590	109.5	35	25	2.8	9.1	134	368	206.5	680
1999	156	370.5	249	315.5	525	292	48	5.1	1.95	0.65	3.2	54
2000	50	200	264	162.5	320	984.5	13	2.4	0.785	3.1	702.5	327
2001	448	670	447	232.5	229	64.5	7.1	7.5	44	28	19	437
2002	94	554.5	535	484.5	147	131	22	7.6	1.7	—	—	—
Mean of Medians	284.8	339.9	424.8	308.2	341.4	169.2	31.3	21.0	69.9	94.4	238.7	319.0

Table 13. Log-log conversions to depict relations between habitat units (HU's) and flow (cfs) at each site by species.

Stream and Species	Formula	R^2
Kiamichi River- Big Cedar		
Channel Catfish	log H.U. = 3.6799 + 0.3901 (log cfs)	1
Spotted Bass	log H.U. = 3.7937 + 0.3559 (log cfs)	0.9953
Green Sunfish	log H.U. = 4.006 + 0.3901 (log cfs)	1
White Crappie	log H.U. = 3.7726 + 0.3977 (log cfs)	0.9998
Stoneroller	log H.U. = 4.0755 + 0.3713 (log cfs)	0.9881
Smallmouth Bass	log H.U. = 3.7687 + 0.5246 (log cfs)	0.9425
Longear Sunfish	log H.U. = 4.4471 - 0.1709 (log cfs)	0.3117
Kiamichi River-Antlers		
Channel Catfish	log H.U.= 3.2268 + 0.6093 (log cfs)	0.9553
Spotted Bass	log H.U. = 3.3594 + 0.5215 (log cfs)	0.9069
Green Sunfish	log H.U. = 4.5309 + 0.0880 (log cfs)	0.2744
White Crappie	log H.U. = 3.6340 + 0.3672 (log cfs)	0.3543
Stoneroller	log H.U. = 4.5902 + 0.0552 (log cfs)	0.2756
Smallmouth Bass	log H.U. = 4.0086 + 0.3343 (log cfs)	0.9492
Longear Sunfish	log H.U. = 3.9023 + 0.1127 (log cfs)	0.4944
Kiamichi River- Clayton		
Channel Catfish	log H.U. = 3.1124 + 0.6544 (log cfs)	0.8688
Spotted Bass	log H.U. = 3.5290 + 0.4940 (log cfs)	0.9483
Green Sunfish (up-to 600 cfs)	log H.U. = 4.1421 + 0.3170 (log cfs)	0.7280
(600-1140 cfs)	log H.U. = 3.8007 + 0.3134 (log cfs)	1
White Crappie	log H.U. = 4.2881 + 0.1665 (log cfs)	0.1092
Stoneroller	log H.U. = 4.4211 + 0.1401 (log cfs)	0.8324
Smallmouth Bass	log H.U. = 4.1072 + 0.3147 (log cfs)	0.9526
Longear Sunfish	log H.U. = 3.9678 + 0.0783 (log cfs)	0.1676

Table 13. Continued.

Mountain Fork Creek-Smithville			
	Channel Catfish	log H.U. = 3.4391 + 0.5141 (log cfs)	0.9945
	Spotted Bass	log H.U. = 3.3394 + 0.5987 (log cfs)	0.9526
	Green Sunfish	log H.U. = 3.7793 + 0.5041 (log cfs)	0.9961
	White Crappie	log H.U. = 3.4124 + 0.5687 (log cfs)	0.9310
	Stoneroller	log H.U. = 4.0792 + 0.3118 (log cfs)	0.9732
	Smallmouth Bass	log H.U. = 3.8709 + 0.4468 (log cfs)	0.9710
	Longear Sunfish	log H.U. = 3.8191 + 0.1552 (log cfs)	0.5125
Glover River- Glover			
	Channel Catfish	log H.U.= 3.6928 + 0.4292 (log cfs)	0.9765
	Spotted Bass	log H.U. = 4.0100 + 0.2708 (log cfs)	0.9267
	Green Sunfish	log H.U.= 4.0358 + 0.4199 (log cfs)	0.9833
	White Crappie	log H.U. = 3.8618 + 0.3924 (log cfs)	0.9993
	Stoneroller	log H.U. = 4.4237 + 0.2109 (log cfs)	0.7611
	Smallmouth Bass	log H.U. = 3.8664 + 0.4727 (log cfs)	0.9647
Little River-Honobia Store			
	Channel Catfish	log H.U. = 4.1339 + 0.0487 (log cfs)	0.9081
	Spotted Bass	log H.U. = 4.3738 - 0.0675 (log cfs)	0.5581
	Green Sunfish	log H.U. = 4.4603 + 0.0487 (log cfs)	0.9081
	White Crappie	log H.U. = 4.2051 + 0.0706 (log cfs)	0.9453
	Stoneroller	log H.U. = 4.5659 + 0.0078 (log cfs)	0.0760
	Smallmouth Bass	log H.U. = 4.4484 - 0.0149 (log cfs)	0.1039
	Longear Sunfish	log H.U. = 5.6028 - 0.9331 (log cfs)	0.7660

Table 14. Various flows (cfs) and resulting available habitat units for select species at the Kiamichi River, Big Cedar gauging station from suitability indices assignment

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
2	6271.6	7858.4	13298.9	7858.4	15112.3	10627.4	13072.2
4	8218.9	10298.3	17427.9	10298.3	19804.5	14000.6	17130.9
6	9627.3	12063.1	20414.5	12063.1	23198.3	16460.0	23198.3
8	10770.7	13495.8	22839.1	13495.8	25953.5	18468.3	25953.5
10	11750.3	14723.2	24916.2	14723.2	28313.9	20197.1	28313.9
12	12616.4	15808.5	26752.9	15808.5	30401.1	21731.9	22344.8
14	13398.4	16788.3	28411.0	16788.3	32285.3	23122.5	23729.7
16	14114.8	15985.5	29930.2	17686.0	32821.2	22700.1	16325.6
18	14778.5	16737.1	31337.5	18517.6	34364.4	23807.6	17093.2
20	15398.6	17439.3	32652.4	19294.6	35806.3	24845.4	17810.4
22	15981.9	18099.9	33889.2	20410.6	37162.6	25824.2	18485.0
24	16533.6	18724.8	35059.3	21115.3	38445.7	26752.5	19123.2
26	17058.0	19318.7	36171.3	21785.0	39665.1	27636.8	19729.8
28	17558.4	19885.4	37232.2	22424.0	40828.5	28482.3	20308.5
30	18037.4	20427.9	38247.9	23035.7	41942.3	29293.5	20862.5
32	18497.2	20948.7	39223.1	23623.0	43011.7	30073.9	21394.4
34	18939.9	21450.0	40161.7	24188.3	44041.0	30826.6	21906.4
36	19367.0	21933.7	41067.3	24733.7	45034.0	31554.0	22400.4
38	19779.8	22401.2	41942.7	25260.9	45994.0	32258.4	10485.7
40	20179.6	22854.0	42790.4	25771.5	46923.6	32941.8	10697.6
42	20567.3	23293.1	43612.6	26266.7	47825.2	47081.8	10903.2
44	20944.0	23719.7	44411.3	26747.7	48701.0	47944.0	11102.8
46	21310.3	24134.6	45188.1	27215.6	49552.9	48782.7	11297.0
48	21667.1	24538.6	45944.6	27671.2	50382.5	49599.3	11486.2
50	22014.9	24932.5	46682.2	28115.4	51191.2	50395.5	11670.5
52	22354.3	25316.9	47401.9	28548.9	51980.5	51172.5	11850.5
54	22685.8	25692.4	48104.9	28972.3	52751.4	51931.4	12026.2
56	23010.0	26059.5	48792.2	29386.2	53505.1	52673.4	12198.1

Table 14. Continued.

58	23327.1	26418.7	49464.8	29791.3	54242.6	53399.5	12366.2
60	23637.7	26770.4	50123.3	30187.9	54964.7	54110.4	12530.8
62	23942.0	27115.0	50768.5	30576.5	55672.3	54806.9	12692.1
64	24240.4	27452.9	51401.2	30957.6	56366.1	55490.0	12850.3
66	24533.1	27784.5	52022.0	31331.4	57046.8	56160.1	13005.5
68	24820.5	28109.9	52631.3	31698.4	57715.0	56817.9	13157.8
70	25102.7	28429.6	53229.9	32058.9	58371.4	57464.1	13307.5
72	25380.1	28743.7	53818.1	32413.2	59016.4	58099.0	13454.5
74	25652.8	29052.6	54396.4	32761.5	59650.6	58723.4	13599.1
76	25921.1	29356.4	54965.2	33104.1	60274.4	59337.5	13741.3
78	26185.1	29655.4	55525.0	33441.2	60888.2	59941.8	13881.3
80	26445.0	29949.8	56076.1	33773.1	61492.6	60536.7	14019.0
82	26701.0	30239.6	56618.9	34100.0	62087.8	61122.7	14154.7
84	26953.1	30525.2	57153.7	34422.1	62674.2	61700.0	14288.4
86	27201.7	30806.7	57680.7	34739.5	63252.1	62268.9	14420.2
88	27446.7	31084.3	58200.3	35052.5	63821.9	62829.9	14550.1
90	27688.4	31358.0	58712.8	35361.1	50372.9	63383.1	12343.0

Table 15. Various flows (cfs) and resulting available habitat units for select species at the Kiamichi River, Clayton gauging station from suitability indices assignment

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
20	15969.5	18085.9	33863.0	20010.0	37133.9	25545.6	28668.1
40	19844.2	22474.2	42079.3	25343.2	46143.8	32223.7	13867.0
60	22533.1	25519.4	47781.0	28777.2	52396.2	51581.8	11945.3
80	24659.1	27927.1	52289.1	31492.3	57339.7	56448.4	13072.3
100	26445.3	29950.1	56076.7	33773.5	48111.3	60537.4	11788.9
120	28000.4	31711.2	59374.2	35759.5	50940.4	64097.2	12482.1
140	34343.0	33280.8	70810.3	38591.6	53461.8	67269.8	11329.7
160	35810.7	34703.2	73836.5	40240.9	55746.6	70144.7	11813.8
180	37157.3	36008.1	76613.0	41754.1	57842.8	72782.3	12258.1
200	38404.7	60180.6	79185.0	43155.8	56221.3	75225.7	11877.7
220	39569.2	62005.3	81585.9	44464.3	57926.0	77506.6	12237.9
240	40663.0	55335.3	83841.3	45693.5	51981.6	71265.1	12576.2
260	41696.0	56740.9	85971.1	46854.3	53302.1	73075.5	12895.7
280	42675.7	58074.2	87991.2	47955.2	54554.6	74792.5	11878.8
300	43608.5	59343.6	89914.5	49003.4	55747.0	76427.3	12138.5
320	44499.6	60556.1	91751.7	73401.3	56886.0	77988.9	12386.5
340	45353.1	61717.7	93511.6	74809.3	57977.2	79484.9	12624.1
360	46172.9	62833.2	95201.8	76161.4	56169.1	80921.5	12852.2
380	46961.9	63907.0	96828.7	77463.0	57128.9	82304.4	13071.9
400	47723.0	64942.6	98397.8	78718.3	58054.7	83638.2	13283.7
420	48458.3	65943.2	99914.0	79931.2	58949.3	84926.9	13488.4
440	49170.0	66911.7	101381.3	81105.1	59815.0	86174.1	13686.5
460	49859.7	67850.4	102803.6	82242.9	60654.1	87383.1	13878.5
480	50529.2	68761.4	104184.0	83347.2	61468.6	88556.4	14064.8
500	51179.8	69646.8	105525.4	84420.4	62260.0	89696.6	14245.9
520	51812.8	70508.2	106830.5	85464.4	63030.0	90806.0	14422.1
540	52429.3	71347.1	108101.6	86481.3	63780.0	91886.4	14593.7
560	53030.3	72164.9	109340.8	87472.6	64511.1	92939.7	14761.0

Table 15. Continued.

580	89545.4	72962.9	87887.2	110549.9	62460.7	93967.4	14924.2
600	111730.7	73742.3	46926.9	74859.6	63127.9	94971.1	15083.6
620	112884.8	74504.0	47411.6	75632.8	63779.9	95952.1	15239.5
640	114013.6	75249.0	47885.7	76389.1	64417.7	96911.6	15391.8
660	115118.5	75978.2	48349.8	77129.4	65041.9	97850.7	15541.0
680	116200.6	76692.4	48804.2	77854.4	65653.3	98770.5	15687.1
700	117261.0	77392.3	49249.6	78564.9	66252.5	99671.9	15830.2
720	118300.9	78078.6	49686.4	79261.6	66840.0	100555.8	15970.6
740	119321.1	78751.9	50114.9	79945.1	67416.4	101422.9	16108.3
760	120322.5	79412.9	50535.5	80616.1	67982.2	102274.2	16243.5
780	121306.0	80062.0	50948.5	81275.1	68537.9	103110.1	16376.3
800	122272.4	80699.8	51354.4	81922.5	69083.9	103931.5	16506.8
820	123222.3	81326.7	51753.4	82558.9	69620.6	104738.9	16635.0
840	124156.4	105532.9	52145.7	83184.8	68286.0	105532.9	16761.1
860	125075.4	106314.1	52531.7	83800.5	68791.5	106314.1	16885.2
880	125979.8	107082.8	52911.5	84406.5	69288.9	107082.8	17007.3
900	126870.2	107839.7	53285.5	31083.2	69778.6	107839.7	17127.5
920	127747.1	108585.0	53653.8	31298.0	70260.9	108585.0	17245.9
940	128611.0	109319.4	54016.6	31509.7	70736.1	109319.4	17362.5
960	129462.4	110043.1	54374.2	31718.3	71204.3	110043.1	17477.4
980	130301.8	110756.5	54726.7	31923.9	71666.0	110756.5	17590.7
1000	131129.4	111460.0	55074.3	32126.7	72121.2	111460.0	17702.5
1020	131945.7	112153.9	55417.2	32326.7	72570.1	111494.1	17812.7
1040	132751.1	112838.5	55755.5	32524.0	73013.1	112174.7	17921.4
1060	133546.0	113514.1	56089.3	32718.8	73450.3	112846.4	18028.7
1080	134330.6	114181.0	56418.9	32911.0	73881.8	113509.4	18134.6
1100	135105.3	114839.5	56744.2	33100.8	74307.9	114164.0	18239.2
1120	135870.4	115489.9	57065.6	33288.3	74728.7	114810.5	18342.5
1140	136626.2	116132.3	57383.0	33473.4	55333.6	115449.1	18444.5

Table 16. Various flows (cfs) and resulting available habitat units for select species at the Kiamichi River, Antlers gauging station from suitability indices assignment.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
20	15086.0	17085.3	31989.5	18902.9	35079.4	23906.1	20175.2
40	18901.6	21406.6	40080.5	23683.9	43951.9	30311.0	13208.3
60	21566.6	19228.0	45731.5	27542.8	45471.6	29701.5	15070.6
80	23682.3	21114.3	50217.8	30244.8	49932.5	32905.6	12554.5
100	25465.3	22704.0	53998.6	32521.9	53691.8	52157.8	13499.7
120	27021.3	24091.3	57298.1	34509.1	56972.6	55344.8	14324.5
140	28410.8	25330.1	60244.6	36283.7	59902.3	58190.8	15061.1
160	29672.1	26454.6	62919.2	37894.5	47546.9	60774.2	13227.3
180	30831.0	27487.9	65376.7	39374.6	49404.0	63147.9	13744.0
200	46513.7	28446.4	38825.4	15376.4	51126.6	65349.8	14223.2
220	47978.4	29342.1	40048.1	15860.6	52736.6	67407.6	14671.1
240	55066.4	30184.5	50987.4	17539.7	54250.6	69342.8	13052.8
260	56519.0	30980.8	52332.4	18002.4	55681.7	71172.1	13397.1
280	57898.1	31736.7	53609.3	18441.6	57040.3	72908.7	13724.0
300	59212.2	32457.1	54826.1	18860.2	58335.0	74563.5	14035.5
320	60468.5	59124.7	55989.3	19260.3	55541.4	76145.5	13437.4
340	61672.8	60302.3	57104.5	19643.9	56647.6	77662.1	13705.1
360	62830.3	61434.0	58176.2	20012.6	57710.8	79119.6	13962.3
380	63945.1	62524.1	59208.4	20367.7	58734.8	80523.5	14210.0
400	65021.0	63576.1	60204.7	20710.4	59723.0	81878.3	14449.1
420	66061.2	64593.2	61167.8	21041.7	60678.5	83188.2	14680.3
440	67068.6	65578.1	62100.5	21362.6	61603.7	84456.7	13413.7
460	68045.4	66533.3	63005.0	21673.7	62501.0	85686.8	13609.1
480	68994.0	67460.8	63883.4	21975.9	63372.3	86881.4	13798.8
500	69916.3	68362.6	64737.4	48682.5	64219.5	88042.8	13983.3
520	70814.1	69240.4	65568.6	49307.6	65044.1	89173.3	14162.8
540	71688.8	70095.7	66378.5	49916.7	65847.5	90274.8	14337.8
560	72542.0	70929.9	67168.5	50510.7	66631.1	91349.1	14508.4

Table 16. Continued.

580	73374.8	71744.2	67939.6	51090.6	64135.0	92397.9	14675.0
600	74188.5	64296.7	68693.0	51657.2	48359.9	85179.3	14837.7
620	74984.0	64986.2	69429.7	52211.1	48878.5	86092.8	14996.8
640	75762.5	65660.8	70150.4	52753.1	49385.9	86986.5	15152.5
660	76524.7	66321.4	70856.2	53283.8	49882.7	87861.6	15304.9
680	77271.4	66968.6	71547.6	53803.8	50369.5	88719.0	15454.3
700	78003.5	67603.0	72225.5	54313.6	50846.7	89559.6	15600.7
720	78721.6	68225.4	72890.4	54813.6	51314.8	90384.1	15744.3
740	79426.4	68836.2	73543.0	55304.3	51774.2	91193.3	15885.3
760	80118.4	69436.0	74183.7	55786.2	52225.3	91987.8	16023.7
780	80798.3	70025.2	74813.2	56259.5	52668.5	92768.4	16159.7
800	81466.5	70604.3	75431.9	56724.8	53104.1	93535.6	16293.3
820	82123.5	71173.7	76040.3	57182.3	53532.4	94289.9	16424.7
840	82769.8	71733.8	76638.7	57632.3	53953.6	95032.0	16554.0
860	83405.8	72285.0	77227.6	58075.1	54368.2	95762.2	16681.2
880	84031.9	72827.6	77807.3	58511.1	54776.3	96481.0	16806.4
900	125405.1	73362.0	52670.1	84021.4	52043.1	97188.9	16929.7
920	126304.9	73888.4	53048.1	84624.3	52416.5	97886.3	17051.2
940	127191.6	74407.1	53420.5	85218.4	52784.5	98573.5	17170.9
960	128065.7	74918.4	53787.6	85804.0	53147.3	99250.9	17288.9
980	128927.6	75422.6	54149.6	86381.5	53504.9	99918.9	17405.2
1000	129777.7	75919.9	54506.6	86951.0	53857.7	100577.7	17520.0
1020	130616.4	76410.6	54858.9	87513.0	54205.8	101227.7	17633.2
1040	131444.1	76894.8	55206.5	88067.5	54549.3	101869.1	17744.9
1060	132261.1	77372.7	55549.6	88614.9	54888.3	102502.3	17855.2
1080	133067.7	77844.6	55888.4	89155.4	55223.1	103127.5	17964.1
1100	133864.4	78310.7	56223.0	89689.1	55553.7	103744.9	18071.7
1120	134651.3	78771.0	56553.6	90216.4	55880.3	104354.8	18177.9
1140	135428.8	79225.9	56880.1	90737.3	56203.0	104957.3	18282.9
1160	136197.2	79675.4	57202.8	91252.1	56521.8	105552.8	18386.6
1180	136956.7	80119.7	57521.8	91761.0	56837.0	106141.4	18489.2

Table 16. Continued.

1200	137707.5	80558.9	57837.2	92264.0	57148.6	106723.3	18590.5
1220	138450.0	80993.2	58149.0	92761.5	57456.7	107298.7	18690.7
1240	139184.2	81422.8	58457.4	93253.4	57761.5	107867.8	18789.9
1260	139910.6	81847.7	58762.4	93740.1	58062.9	108430.7	18887.9
1280	140629.2	108987.6	59064.2	94221.5	56251.7	108987.6	18984.9
1300	141340.2	109538.7	59362.9	94697.9	56536.1	109538.7	19080.9
1320	142043.9	110084.1	59658.5	95169.4	56817.6	110084.1	19175.9
1340	142740.5	110623.9	59951.0	95636.1	57096.2	110623.9	19270.0
1360	143430.1	111158.3	60240.6	96098.1	57372.0	111158.3	19363.1
1380	144112.8	111687.4	60527.4	96555.6	57645.1	111687.4	19455.2
1400	144789.0	112211.4	60811.4	35473.3	57915.6	112211.4	19546.5
1420	145458.6	112730.4	61092.6	35637.4	58183.4	112730.4	19636.9
1440	146121.9	113244.5	61371.2	35799.9	58448.8	113244.5	19726.5
1460	146779.0	113753.7	61647.2	35960.9	58711.6	113753.7	19815.2
1480	147430.1	114258.3	61920.6	36120.4	58972.0	114258.3	19903.1
1500	148075.3	114758.3	62191.6	36278.4	59230.1	114758.3	19990.2
1520	148714.6	115253.8	62460.1	36435.1	59485.9	115253.8	20076.5
1540	149348.4	115745.0	62726.3	36590.4	59739.3	115745.0	20162.0
1560	149976.6	116231.8	62990.2	36744.3	59990.6	116231.8	20246.8
1580	150599.4	116714.5	63251.7	36896.8	60239.7	116714.5	20330.9
1600	151216.9	117193.1	63511.1	37048.1	60486.7	117193.1	20414.3
1620	151829.2	117667.6	63768.3	37198.1	60731.7	117667.6	20496.9
1640	152436.4	118138.2	64023.3	37346.9	60974.6	118138.2	20578.9
1660	153038.7	118605.0	64276.2	37494.5	61215.5	118605.0	20660.2

Table 17. Various flows (cfs) and resulting available habitat units for select species at the Mountain Fork Creek, Smithville gauging station from suitability indices assignment

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
10	9415.6	11797.9	19965.6	11797.9	22688.2	16296.8	16675.8
20	12938.1	14652.8	27435.0	16523.4	30085.0	21051.8	14964.5
30	15581.5	17646.5	33040.2	19899.2	36231.6	35668.4	15393.7
40	17778.4	20134.6	37698.8	22704.9	41340.1	40697.5	9424.7
50	19693.6	22303.6	41760.0	25150.9	45793.6	45081.8	10440.0
60	21410.7	24248.2	45401.0	27343.8	38952.0	49012.4	9544.5
70	22978.7	26024.1	48725.9	29346.3	41804.6	52601.9	10243.5
80	24429.5	27667.2	51802.3	31199.1	44444.1	55923.0	10890.3
90	25785.1	29202.4	54676.8	32930.3	46910.2	59026.1	11494.5
100	27061.3	30647.7	57382.9	34560.2	49231.9	61947.5	12063.5
110	28270.1	32016.7	59946.1	36103.9	51431.1	64714.6	12602.3
120	34383.2	33319.8	70893.2	38636.8	53524.4	67348.5	11342.9
130	35668.5	34565.3	73543.3	40081.1	55525.2	69866.1	11766.9
140	36901.3	35760.0	76085.1	41466.4	57444.3	72280.9	12173.6
150	38087.2	36909.3	78530.4	42799.1	59290.5	74603.9	12564.9
160	39231.1	38017.8	80888.9	44084.5	61071.1	76844.5	12942.2
170	40336.9	39089.4	83168.9	45327.0	62792.5	79010.4	13307.0
180	41408.0	40127.3	85377.3	46530.6	64459.9	81108.4	13660.4
190	42447.3	41134.5	87520.2	47698.5	66077.8	83144.2	14003.2
200	43457.4	42113.4	89602.9	48833.6	67650.2	85122.8	14336.5
210	44440.5	43066.1	91630.0	49938.3	69180.6	87048.5	14660.8
220	45398.6	71140.1	93605.4	51014.9	66459.8	88925.1	14040.8
230	46333.4	72604.9	95532.7	52065.3	67828.2	90756.1	14329.9
240	47246.4	74035.6	97415.2	53091.3	69164.8	92544.5	14612.3
250	48139.0	75434.3	99255.7	54094.4	70471.6	94292.9	14888.4
260	49012.5	76803.1	101056.7	55075.9	71750.3	96003.9	15158.5
270	49868.0	67861.6	102820.6	56037.2	63748.8	87397.5	15423.1
280	50706.5	69002.7	104549.5	56979.5	64820.7	88867.1	15682.4

Table 17. Continued.

290	51528.9	70121.9	106245.2	57903.7	65872.0	90308.5	15936.8
300	52336.2	71220.3	107909.6	58810.7	66904.0	91723.2	16186.4
310	53128.9	72299.2	109544.2	59701.6	67917.4	93112.6	16431.6
320	53908.0	73359.3	111150.5	60577.0	68913.3	94477.9	16672.6
330	54673.9	74401.7	112729.8	61437.7	69892.5	95820.3	16909.5
340	55427.4	75427.0	114283.4	62284.4	70855.7	97140.9	17142.5
350	56169.0	76436.2	115812.4	63117.8	71803.7	98440.6	17371.9
360	56899.2	77429.9	117318.0	63938.3	72737.2	99720.3	17597.7
370	57618.5	78408.7	118801.1	64746.6	73656.7	100980.9	16038.1
380	58327.4	79373.4	120262.7	65543.1	74562.8	102223.3	16235.5
390	59026.2	80324.3	121703.5	66328.4	75456.2	103448.0	16430.0
400	59715.4	81262.2	123124.5	67102.9	76337.2	104655.8	16621.8
410	60395.3	82187.4	124526.4	67866.9	77206.4	105847.4	16811.1
420	61066.3	83100.5	125909.9	68620.9	78064.1	107023.4	16997.8
430	61728.7	84001.9	127275.6	69365.2	78910.9	108184.3	17182.2
440	62382.8	84892.0	128624.3	70100.2	79747.1	109330.7	17364.3
450	63028.9	85771.3	129956.5	70826.3	80573.0	110463.0	17544.1
460	63667.3	86640.0	131272.7	105018.2	81389.1	111581.8	17721.8
470	64298.2	87498.5	132573.5	106058.8	82195.6	112687.5	17897.4
480	64921.8	88347.3	133859.5	107087.6	82992.9	113780.6	18071.0
490	65538.5	89186.4	135131.0	108104.8	83781.2	114861.3	18242.7
500	66148.4	90016.4	136388.5	109110.8	84560.9	115930.2	18412.4
510	66751.8	90837.4	137632.5	110106.0	85332.1	116987.6	18580.4
520	67348.7	91649.8	138863.3	111090.7	86095.3	118033.8	18746.5
530	67939.5	92453.7	140081.4	112065.1	86850.5	119069.2	18911.0
540	68524.2	93249.5	141287.1	113029.7	87598.0	120094.0	19073.8
550	69103.2	94037.3	142480.8	113984.6	88338.1	121108.7	19234.9
560	69676.4	94817.4	143662.8	114930.2	89070.9	122113.3	19394.5
570	70244.2	95590.0	144833.4	115866.7	85451.7	123108.4	19552.5
580	70806.6	96355.3	145992.9	116794.3	86135.8	124094.0	19709.0
590	71363.7	97113.5	147141.7	117713.3	86813.6	125070.4	19864.1
600	71915.8	97864.7	148279.9	118623.9	87485.2	126037.9	20017.8

Table 18. Various flows (cfs) and resulting available habitat units for select species at the Glover River, Glover gauging station from suitability indices assignment

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
10	14556.2	16485.3	30866.2	18239.1	33847.6	22951.68	26131.0
20	18912.4	21418.9	40103.4	23697.5	43977.1	30056.81	25292.5
30	22042.3	24963.6	46740.3	27619.3	51255.0	35232.52	29478.2
40	24572.3	27828.9	52105.2	30789.4	57138.0	39460.17	17171.0
50	26733.1	30276.0	56687.0	33496.9	62162.5	43102.18	18681.0
60	28638.9	32434.4	60728.2	36574.9	66594.0	46338.57	20012.7
70	30355.8	34378.9	64368.9	38767.6	70586.4	49273.78	21212.5
80	31926.0	36157.2	67698.6	40773.0	74237.7	51974.51	22309.8
90	33378.4	37802.0	70778.3	42627.8	77614.8	54486.37	17694.6
100	34733.5	39336.7	73651.7	44358.4	80765.8	56842.07	18412.9
110	36006.6	40778.6	76351.3	45984.3	83726.2	82424.75	19087.8
120	37209.6	42141.0	78902.3	47520.7	86523.5	85178.57	19725.6
130	38351.7	43434.4	81324.1	48979.3	89179.2	87793.02	20331.0
140	39440.3	44667.4	83632.5	50369.6	91710.7	90285.12	20908.1
150	40481.6	45846.6	85840.5	51699.4	94131.9	92668.74	21460.1
160	41480.5	36982.6	87958.7	52975.1	87458.9	84960.11	21989.7
170	42441.3	37839.2	89996.0	54202.1	89484.7	86927.96	22499.0
180	43367.5	38665.0	91960.0	55385.0	69492.5	88825.03	19332.5
190	44262.2	39462.7	93857.3	56527.7	70926.2	90657.59	19731.4
200	45128.1	40234.7	95693.3	57633.5	72313.7	92431.06	20117.3
210	45967.4	40983.0	97473.1	58705.4	73658.7	94150.18	20491.5
220	46782.3	41709.5	99200.9	59746.0	74964.3	95819.07	20854.7
230	47574.3	42415.7	100880.5	60757.6	76233.6	97441.40	21207.8
240	48345.3	43103.0	102515.2	61742.1	77468.9	99020.41	21551.5
250	49096.4	43772.7	104108.1	62701.5	78672.6	100558.98	21886.4
260	49829.2	44426.0	105661.8	63637.2	79846.7	102059.72	22213.0
270	50544.5	45063.8	107178.8	64550.8	80993.0	103524.95	22531.9
280	51243.6	45687.1	108661.1	65443.6	82113.2	104956.78	22843.5

Table 18. Continued.

290	51927.3	46296.6	110110.9	66316.8	83208.8	106357.14	23148.3
300	61468.2	46893.3	126738.5	69072.5	84281.1	107727.76	20278.2
310	62234.2	47477.6	128317.9	69933.3	85331.4	109070.23	20530.9
320	62985.0	48050.4	129865.9	70776.9	86360.8	110386.02	20778.5
330	63721.3	48612.1	131384.1	71604.3	87370.4	111676.46	21021.5
340	64443.8	49163.3	132873.9	72416.3	88361.1	112942.79	21259.8
350	65153.3	49704.6	134336.6	73213.5	89333.9	114186.15	21493.9
360	65850.2	50236.2	135773.6	73996.6	90289.5	115407.59	21723.8
370	66535.2	50758.8	137186.0	74766.4	91228.7	116608.10	21949.8
380	67208.8	51272.7	138574.8	75523.3	92152.2	117788.58	22172.0
390	67871.4	51778.2	139941.0	76267.9	93060.8	118949.89	22390.6
400	68523.5	52275.7	141285.7	77000.7	93955.0	120092.80	22605.7
410	69165.6	52765.5	142609.5	77722.2	94835.3	121218.08	22817.5
420	69798.0	53248.0	143913.4	78432.8	95702.4	122326.40	23026.1
430	70421.1	53723.3	145198.1	79133.0	96556.8	123418.41	23231.7

Table 19. Various flows (cfs) and resulting available habitat units for select species at the Little River, Honobia Store from suitability indices assignment

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.98492	15355.0	19240.0	32560.0	19240.0	37000.0	26385.8	32005.0
14.3575	15355.0	19240.0	32560.0	19240.0	37000.0	26430.4	27195.0
16.7634	15770.0	19760.0	33440.0	19760.0	38000.0	27175.5	27930.0
17.9209	15770.0	19760.0	33440.0	19760.0	38000.0	27267.9	27930.0
19.9901	15770.0	19760.0	33440.0	19760.0	38000.0	27271.8	27930.0
20.2609	15770.0	19760.0	33440.0	19760.0	38000.0	27306.4	27930.0
21.6766	15770.0	19760.0	33440.0	19760.0	38000.0	27333.4	27930.0
32.8942	16185.0	18330.0	34320.0	20670.0	37635.0	26283.0	18720.0
33.7854	16185.0	18330.0	34320.0	20670.0	37635.0	26385.1	15990.0
40.1062	16185.0	18330.0	34320.0	20670.0	37635.0	26433.2	8580.0

Table 20. Habitat Units by species derived from regression equations for select species at the Kiamichi River, Big Cedar gauging station

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
2	6271	7959	13287	7804	15391	8445	24869
4	8218	10185	17413	10281	19909	12149	22091
6	9626	11766	20397	12080	23143	15029	20612
8	10769	13035	22819	13544	25752	17477	19623
10	11749	14112	24894	14801	27977	19647	18889
12	12615	15058	26729	15914	29936	21619	18309
14	13397	15908	28386	16921	31700	23440	17833
16	14113	16682	29904	17843	33311	25141	17431
18	14777	17396	31310	18699	34800	26743	17083
20	15397	18061	32624	19499	36189	28263	16779
22	15980	18684	33859	20253	37492	29712	16507
24	16532	19272	35028	20966	38723	31100	16264
26	17056	19828	36139	21644	39891	32434	16043
28	17556	20358	37199	22291	41004	33719	15841
30	18035	20864	38214	22911	42068	34962	15655
32	18495	21349	39189	23507	43089	36166	15484
34	18938	21815	40126	24081	44069	37335	15324
36	19365	22263	41031	24634	45015	38471	15175
38	19778	22696	41906	25170	45928	39578	15035
40	20177	23114	42753	25689	46811	40658	14904
42	20565	23519	43574	26192	47666	41712	14780
44	20942	23911	44372	26681	48497	42742	14663
46	21308	24293	45148	27157	49304	43750	14552
48	21665	24663	45904	27620	50089	44738	14447
50	22012	25024	46641	28072	50854	45707	14347
52	22352	25376	47360	28514	51600	46657	14251
54	22683	25719	48063	28945	52328	47590	14159
56	23007	26054	48749	29367	53040	48506	14071

Table 20. Continued

58	23325	26382	49421	29779	53735	49408	13987
60	23635	26702	50079	30184	54416	50294	13906
62	23939	27015	50724	30580	55083	51167	13829
64	24238	27322	51356	30968	55736	52026	13754
66	24530	27623	51976	31350	56376	52873	13682
68	24818	27918	52585	31724	57005	53707	13612
70	25100	28208	53183	32092	57622	54530	13545
72	25377	28492	53771	32453	58227	55342	13480
74	25650	28771	54348	32809	58823	56143	13417
76	25918	29046	54917	33159	59408	56934	13356
78	26182	29315	55476	33503	59984	57716	13297
80	26442	29581	56027	33842	60550	58487	13239
82	26698	29842	56569	34176	61108	59250	13183
84	26950	30099	57103	34505	61657	60004	13129
86	27199	30352	57630	34830	62198	60749	13077
88	27444	30601	58149	35150	62732	61486	13025
90	27685	30847	58661	35465	63257	62215	12975

Table 21. Habitat Units by species derived from regression equations for select species at the Kiamichi River, Clayton gauging station.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
20	9200	14849	67056	31968	40121	32857	11740
40	14481	20913	66616	35879	44213	40867	12395
60	18881	25551	66360	38385	46797	46428	12795
80	22792	29453	66179	40268	48722	50828	13086
100	26375	32885	66039	41793	50269	54526	13317
120	29718	35985	65925	43081	51570	57746	13508
140	32872	38832	65828	44201	52695	60616	13672
160	35874	41480	65745	45195	53690	63217	13816
180	38748	43965	65671	46090	54584	65605	13944
200	41514	46314	65605	46905	55395	67816	14060
220	44186	48546	65546	47656	56140	69881	14165
240	46775	50679	65492	48351	56829	71821	14262
260	49290	52723	65442	49000	57470	73653	14351
280	51739	54689	65396	49608	58069	75391	14435
300	54129	56585	65353	50181	58633	77046	14513
320	56464	58418	65313	50723	59166	78627	14587
340	58749	60194	65276	51238	59671	80141	14656
360	60988	61918	65240	51728	60150	81596	14722
380	63184	63594	65207	52196	60608	82996	14784
400	65341	65226	65175	52643	61045	84347	14844
420	67461	66817	65145	53073	61463	85652	14900
440	69547	68370	65116	53485	61865	86915	14955
460	71599	69888	65088	53883	62252	88139	15007
480	73621	71373	65062	54266	62624	89328	15057
500	75615	72827	65037	54636	62983	90483	15105
520	77581	74252	65013	54994	63330	91606	15152
540	79520	75649	64989	55341	63666	92701	15197
560	81436	77020	64967	55677	63991	93768	15240

Table 21. Continued.

580	83327	78367	64945	56003	64307	94809	15282
600	85197	79691	64924	56320	64613	95826	15322
620	87044	80992	64904	56628	64910	96820	15362
640	88872	82272	64885	56928	65200	97792	15400
660	90680	83532	64866	57221	65481	98744	15437
680	92469	84773	64847	57506	65756	99676	15473
700	94239	85996	64829	57784	66023	100589	15509
720	95993	87201	64812	58056	66285	101485	15543
740	97729	88389	64795	58321	66539	102364	15576
760	99450	89562	64779	58581	66789	103227	15609
780	101155	90718	64763	58835	67032	104074	15641
800	102845	91860	64747	59083	67270	104907	15672
820	104520	92987	64732	59327	67503	105725	15702
840	106181	94101	64717	59565	67732	106530	15732
860	107829	95201	64703	59799	67955	107321	15761
880	109464	96289	64689	60028	68175	108101	15789
900	111085	97363	64675	60253	68389	108868	15817
920	112695	98426	64661	60474	68600	109624	15844
940	114292	99478	64648	60691	68807	110368	15871
960	115877	100518	64635	60904	69011	111102	15897
980	117451	101547	64622	61114	69210	111825	15923
1000	119015	102565	64610	61320	69406	112538	15948
1020	120567	103573	64598	61522	69599	113242	15973
1040	122109	104572	64586	61721	69789	113936	15997
1060	123640	105560	64574	61918	69975	114621	16021
1080	125162	106540	64563	62111	70159	115297	16044
1100	126674	107510	64552	62301	70339	115965	16067
1120	128176	108471	64541	62488	70517	116624	16090
1140	129670	109424	64530	62672	70692	117276	16112

Table 22. Habitat Units by species derived from regression equations for select species at the Kiamichi River, Antlers gauging station.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
20	9200	14849	67056	31968	40121	32857	11740
40	14481	20913	66616	35879	44213	40867	12395
60	18881	25551	66360	38385	46797	46428	12795
80	22792	29453	66179	40268	48722	50828	13086
100	26375	32885	66039	41793	50269	54526	13317
120	29718	35985	65925	43081	51570	57746	13508
140	32872	38832	65828	44201	52695	60616	13672
160	35874	41480	65745	45195	53690	63217	13816
180	38748	43965	65671	46090	54584	65605	13944
200	41514	46314	65605	46905	55395	67816	14060
220	44186	48546	65546	47656	56140	69881	14165
240	46775	50679	65492	48351	56829	71821	14262
260	49290	52723	65442	49000	57470	73653	14351
280	51739	54689	65396	49608	58069	75391	14435
300	54129	56585	65353	50181	58633	77046	14513
320	56464	58418	65313	50723	59166	78627	14587
340	58749	60194	65276	51238	59671	80141	14656
360	60988	61918	65240	51728	60150	81596	14722
380	63184	63594	65207	52196	60608	82996	14784
400	65341	65226	65175	52643	61045	84347	14844
420	67461	66817	65145	53073	61463	85652	14900
440	69547	68370	65116	53485	61865	86915	14955
460	71599	69888	65088	53883	62252	88139	15007
480	73621	71373	65062	54266	62624	89328	15057
500	75615	72827	65037	54636	62983	90483	15105
520	77581	74252	65013	54994	63330	91606	15152
540	79520	75649	64989	55341	63666	92701	15197
560	81436	77020	64967	55677	63991	93768	15240

Table 22. Continued.

580	83327	78367	64945	56003	64307	94809	15282
600	85197	79691	64924	56320	64613	95826	15322
620	87044	80992	64904	56628	64910	96820	15362
640	88872	82272	64885	56928	65200	97792	15400
660	90680	83532	64866	57221	65481	98744	15437
680	92469	84773	64847	57506	65756	99676	15473
700	94239	85996	64829	57784	66023	100589	15509
720	95993	87201	64812	58056	66285	101485	15543
740	97729	88389	64795	58321	66539	102364	15576
760	99450	89562	64779	58581	66789	103227	15609
780	101155	90718	64763	58835	67032	104074	15641
800	102845	91860	64747	59083	67270	104907	15672
820	104520	92987	64732	59327	67503	105725	15702
840	106181	94101	64717	59565	67732	106530	15732
860	107829	95201	64703	59799	67955	107321	15761
880	109464	96289	64689	60028	68175	108101	15789
900	111085	97363	64675	60253	68389	108868	15817
920	112695	98426	64661	60474	68600	109624	15844
940	114292	99478	64648	60691	68807	110368	15871
960	115877	100518	64635	60904	69011	111102	15897
980	117451	101547	64622	61114	69210	111825	15923
1000	119015	102565	64610	61320	69406	112538	15948
1020	120567	103573	64598	61522	69599	113242	15973
1040	122109	104572	64586	61721	69789	113936	15997
1060	123640	105560	64574	61918	69975	114621	16021
1080	125162	106540	64563	62111	70159	115297	16044
1100	126674	107510	64552	62301	70339	115965	16067
1120	128176	108471	64541	62488	70517	116624	16090
1140	129670	109424	64530	62672	70692	117276	16112

Table 23. Habitat Units by species derived from regression equations for select species at the Mountain Fork Creek, Smithville gauging station.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
10	8978	8672	19204	9574	24604	20783	9425
20	12822	13132	27236	14200	30539	28327	10496
30	15794	16740	33413	17883	34655	33953	11178
40	18311	19886	38628	21062	37907	38610	11688
50	20537	22729	43227	23911	40639	42658	12100
60	22555	25350	47388	26524	43016	46278	12447
70	24415	27801	51217	28954	45134	49578	12749
80	26150	30115	54783	31238	47053	52626	13015
90	27783	32315	58134	33402	48813	55470	13256
100	29329	34419	61306	35465	50443	58143	13474
110	30802	36440	64323	37440	51964	60673	13675
120	32211	38389	67207	39340	53394	63078	13861
130	33564	40273	69974	41172	54743	65375	14034
140	34868	42100	72638	42944	56023	67576	14196
150	36127	43876	75209	44663	57241	69691	14349
160	37345	45604	77696	46332	58404	71730	14494
170	38528	47290	80107	47957	59519	73700	14631
180	39677	48936	82449	49542	60589	75606	14761
190	40795	50546	84727	51089	61619	77455	14885
200	41885	52123	86946	52601	62613	79250	15004
210	42949	53668	89111	54081	63572	80997	15118
220	43989	55183	91225	55531	64501	82698	15228
230	45005	56672	93293	56953	65401	84357	15333
240	46001	58134	95316	58348	66275	85976	15435
250	46977	59573	97297	59718	67124	87559	15533
260	47933	60988	99240	61065	67950	89107	15628
270	48872	62382	101146	62390	68754	90622	15720
280	49795	63755	103018	63694	69538	92106	15809

Table 23. Continued.

290	50701	65108	104856	64978	70303	93562	15895
300	51593	66443	106664	66243	71050	94990	15979
310	52470	67761	108441	67490	71781	96392	16061
320	53333	69061	110191	68719	72495	97769	16140
330	54184	70345	111914	69932	73194	99122	16217
340	55022	71614	113611	71130	73878	100453	16292
350	55848	72867	115283	72312	74549	101763	16366
360	56662	74107	116932	73480	75206	103052	16438
370	57466	75332	118558	74634	75852	104321	16508
380	58259	76545	120162	75774	76485	105572	16576
390	59043	77745	121746	76902	77107	106804	16643
400	59816	78932	123310	78017	77718	108019	16709
410	60580	80108	124855	79121	78319	109217	16773
420	61336	81272	126380	80212	78909	110400	16836
430	62082	82425	127888	81293	79491	111566	16897
440	62820	83567	129379	82363	80062	112718	16958
450	63550	84699	130853	83422	80625	113856	17017
460	64272	85821	132311	84472	81180	114979	17075
470	64987	86933	133753	85511	81726	116090	17132
480	65694	88036	135180	86541	82264	117187	17188
490	66394	89129	136593	87562	82795	118271	17243
500	67087	90214	137991	88574	83318	119344	17297
510	67774	91290	139375	89577	83834	120404	17351
520	68454	92357	140746	90571	84343	121454	17403
530	69127	93417	142104	91558	84846	122492	17455
540	69795	94468	143450	92536	85342	123519	17505
550	70456	95511	144783	93507	85831	124536	17555
560	71112	96547	146104	94470	86315	125542	17604
570	71762	97576	147413	95426	86792	126539	17653
580	72407	98597	148711	96374	87264	127526	17700
590	73046	99611	149998	97316	87731	128504	17747
600	73680	100619	151275	98250	88192	129473	17794

Table 24. Habitat Units by species derived from regression equations for select species at the Glover River, Glover gauging station.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
10	13243	19090	28556	17956	43112	21832	21918
20	17832	23031	38203	23568	49898	30297	21651
30	21222	25704	45294	27633	54353	36697	21496
40	24011	27787	51110	30935	57753	42043	21387
50	26424	29518	56130	33766	60536	46720	21302
60	28575	31012	60596	36270	62909	50925	21234
70	30529	32333	64648	38532	64988	54774	21176
80	32330	33524	68377	40604	66844	58343	21126
90	34006	34611	71843	42525	68525	61684	21082
100	35580	35612	75093	44320	70065	64834	21043
110	37065	36543	78159	46009	71487	67821	21007
120	38476	37415	81068	47607	72811	70669	20975
130	39820	38235	83839	49126	74051	73394	20945
140	41107	39010	86489	50576	75217	76011	20918
150	42343	39745	89031	51963	76320	78530	20892
160	43532	40446	91477	53296	77366	80963	20868
170	44680	41115	93835	54579	78361	83317	20846
180	45789	41757	96115	55817	79312	85599	20825
190	46864	42373	98322	57014	80221	87815	20805
200	47907	42965	100462	58173	81094	89970	20786
210	48921	43537	102542	59298	81932	92069	20768
220	49908	44089	104564	60390	82740	94116	20751
230	50869	44623	106534	61453	83520	96114	20735
240	51807	45140	108455	62488	84273	98068	20719
250	52722	45642	110330	63497	85001	99978	20704
260	53618	46129	112162	64482	85707	101849	20690
270	54493	46603	113954	65444	86392	103683	20676
280	55350	47064	115708	66384	87057	105480	20663

Table 24. Continued.

290	56190	47514	117425	67305	87704	107245	20650
300	57014	47952	119109	68206	88333	108977	20637
310	57822	48379	120760	69089	88946	110679	20625
320	58615	48797	122381	69955	89544	112353	20614
330	59394	49205	123972	70805	90127	113999	20603
340	60160	49605	125536	71639	90696	115619	20592
350	60914	49996	127073	72459	91252	117214	20581
360	61655	50379	128585	73264	91796	118786	20571
370	62384	50754	130073	74056	92328	120334	20561
380	63102	51122	131538	74835	92849	121861	20551
390	63809	51483	132981	75602	93359	123366	20542
400	64507	51837	134402	76357	93859	124851	20533
410	65194	52185	135803	77100	94349	126317	20524
420	65872	52526	137184	77833	94829	127764	20515
430	66540	52862	138546	78555	95301	129193	20506

Table 25. Habitat Units by species derived from regression equations for select species at the Little River, Honobia Store.

Stream Flow (cfs)	Habitat Units						
	Channel Catfish	Spotted Bass	Green Sunfish	White Crappie	Stoneroller	Smallmouth Bass	Longear Sunfish
12.98492	15421	19890	32698	19218	36751	27028	36631
14.3575	15497	19756	32859	19355	36780	26987	33353
16.7634	15614	19550	33108	19568	36825	26925	28863
17.9209	15665	19462	33215	19660	36844	26898	27120
19.9901	15749	19319	33393	19812	36875	26855	24491
20.2609	15759	19302	33414	19831	36879	26849	24186
21.6766	15811	19214	33525	19926	36899	26822	22708
32.8942	16136	18681	34212	20521	37019	26656	15388
33.7854	16157	18647	34257	20560	37027	26645	15009
40.1062	16292	18432	34544	20811	37076	26577	12789

Table 26. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for channel catfish at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	23240	20916	18592	16268	13944	11620	9296
	57	**44**	**32**	**23**	**16**	**10**	**5**
February	25165	22648	20132	17615	15099	12582	10066
	70	**54**	**40**	**28**	**19**	**12**	**7**
March	27088	24379	21671	18962	16253	13544	10835
	85	**65**	**48**	**34**	**23**	**14**	**8**
April	25015	22513	20012	17510	15009	12507	10006
	69	**53**	**39**	**28**	**19**	**12**	**7**
May	23068	20762	18455	16148	13841	11534	9227
	56	**43**	**32**	**23**	**15**	**10**	**5**
June	17379	15641	13903	12166	10428	8690	6952
	27	**21**	**15**	**11**	**7**	**5**	**3**
July	9625	8663	7700	6738	5775	4813	3850
	6	**5**	**3**	**2**	**2**	**1**	**1**
August	6939	6245	5551	4857	4163	3470	2776
	3	**2**	**1**	**1**	**1**	**0**	**0**
September	10211	9190	8169	7148	6127	5106	4084
	7	**5**	**4**	**3**	**2**	**1**	**1**
October	14736	13263	11789	10315	8842	7368	5895
	18	**14**	**10**	**7**	**5**	**3**	**2**
November	21073	18966	16859	14751	12644	10537	8429
	45	**34**	**25**	**18**	**12**	**8**	**4**
December	24535	22082	19628	17175	14721	12268	9814
	66	**50**	**37**	**26**	**18**	**11**	**6**

Table 27. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for spotted bass at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	26295	23665	21036	18406	15777	13147	10518
	57	**43**	**31**	**21**	**14**	**8**	**4**
February	28274	25447	22619	19792	16965	14137	11310
	70	**52**	**38**	**26**	**17**	**10**	**5**
March	30240	27216	24192	21168	18144	15120	12096
	85	**63**	**45**	**31**	**20**	**12**	**6**
April	28120	25308	22496	19684	16872	14060	11248
	69	**52**	**37**	**25**	**17**	**10**	**5**
May	26117	23506	20894	18282	15670	13059	10447
	56	**42**	**30**	**21**	**13**	**8**	**4**
June	20171	18154	16137	14120	12103	10085	8068
	27	**20**	**15**	**10**	**6**	**4**	**2**
July	11765	10589	9412	8236	7059	5883	4706
	6	**4**	**3**	**2**	**1**	**1**	**0**
August	8729	7856	6983	6110	5237	4364	3492
	3	**2**	**1**	**1**	**1**	**0**	**0**
September	12417	11175	9934	8692	7450	6208	4967
	7	**5**	**4**	**3**	**2**	**1**	**1**
October	17353	15617	13882	12147	10412	8676	6941
	18	**13**	**10**	**7**	**4**	**3**	**1**
November	24048	21644	19239	16834	14429	12024	9619
	45	**33**	**24**	**16**	**11**	**6**	**3**
December	27628	24866	22103	19340	16577	13814	11051
	66	**49**	**35**	**24**	**16**	**9**	**5**

Table 28. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for green sunfish at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	49243	44319	39394	34470	29546	24621	19697
	57	44	32	23	16	10	5
February	53320	47988	42656	37324	31992	26660	21328
	70	54	40	28	19	12	7
March	57396	51656	45917	40177	34438	28698	22958
	85	65	48	34	23	14	8
April	53002	47702	42402	37102	31801	26501	21201
	69	53	39	28	19	12	7
May	48878	43991	39103	34215	29327	24439	19551
	56	43	32	23	15	10	5
June	36824	33142	29459	25777	22095	18412	14730
	27	21	15	11	7	5	3
July	20394	18355	16315	14276	12236	10197	8158
	6	5	3	2	2	1	1
August	14703	13233	11762	10292	8822	7351	5881
	3	2	1	1	1	0	0
September	21636	19472	17309	15145	12981	10818	8654
	7	5	4	3	2	1	1
October	31224	28102	24979	21857	18734	15612	12490
	18	14	10	7	5	3	2
November	44651	40186	35721	31256	26791	22326	17860
	45	34	25	18	12	8	4
December	51987	46788	41589	36391	31192	25993	20795
	66	50	37	26	18	11	6

Table 29. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for white crappie at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	29670	26703	23736	20769	17802	14835	11868
	57	**44**	**33**	**23**	**16**	**10**	**6**
February	32176	28959	25741	22523	19306	16088	12870
	70	**54**	**40**	**29**	**20**	**12**	**7**
March	34686	31217	27748	24280	20811	17343	13874
	85	**65**	**49**	**35**	**24**	**15**	**8**
April	31981	28783	25585	22387	19188	15990	12792
	69	**53**	**40**	**28**	**19**	**12**	**7**
May	29446	26501	23557	20612	17668	14723	11778
	56	**43**	**32**	**23**	**16**	**10**	**6**
June	22062	19856	17650	15443	13237	11031	8825
	27	**21**	**16**	**11**	**8**	**5**	**3**
July	12079	10871	9663	8455	7247	6039	4831
	6	**5**	**3**	**2**	**2**	**1**	**1**
August	8653	7787	6922	6057	5192	4326	3461
	3	**2**	**1**	**1**	**1**	**0**	**0**
September	12829	11546	10263	8980	7697	6414	5132
	7	**5**	**4**	**3**	**2**	**1**	**1**
October	18647	16782	14918	13053	11188	9323	7459
	18	**14**	**10**	**7**	**5**	**3**	**2**
November	26852	24167	21482	18796	16111	13426	10741
	45	**34**	**26**	**18**	**12**	**8**	**4**
December	31356	28220	25085	21949	18814	15678	12542
	66	**51**	**38**	**27**	**18**	**12**	**7**

Table 30. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for stoneroller at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	53551	48196	42841	37486	32130	26775	21420
	57	**43**	**32**	**22**	**15**	**9**	**5**
February	57763	51987	46210	40434	34658	28881	23105
	70	**53**	**39**	**27**	**18**	**11**	**6**
March	61958	55762	49566	43371	37175	30979	24783
	85	**64**	**47**	**33**	**22**	**13**	**7**
April	57435	51692	45948	40205	34461	28718	22974
	69	**52**	**38**	**27**	**18**	**11**	**6**
May	53174	47856	42539	37222	31904	26587	21269
	56	**42**	**31**	**22**	**14**	**9**	**5**
June	40611	36549	32488	28427	24366	20305	16244
	27	**21**	**15**	**10**	**7**	**4**	**2**
July	23141	20827	18513	16198	13884	11570	9256
	6	**5**	**3**	**2**	**2**	**1**	**1**
August	16948	15253	13559	11864	10169	8474	6779
	3	**2**	**1**	**1**	**1**	**0**	**0**
September	24480	22032	19584	17136	14688	12240	9792
	7	**5**	**4**	**3**	**2**	**1**	**1**
October	34710	31239	27768	24297	20826	17355	13884
	18	**13**	**10**	**7**	**5**	**3**	**2**
November	48787	43908	39030	34151	29272	24394	19515
	45	**34**	**25**	**17**	**11**	**7**	**4**
December	56387	50748	45110	39471	33832	28194	22555
	66	**50**	**36**	**25**	**17**	**10**	**6**

Table 31. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for smallmouth bass at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	49168	44251	39334	34418	29501	24584	19667
	57	**47**	**38**	**29**	**22**	**15**	**10**
February	54719	49248	43776	38304	32832	27360	21888
	70	**58**	**46**	**36**	**27**	**19**	**12**
March	60418	54376	48334	42292	36251	30209	24167
	85	**70**	**56**	**43**	**32**	**23**	**15**
April	54281	48853	43425	37997	32569	27141	21713
	69	**57**	**45**	**35**	**26**	**19**	**12**
May	48679	43811	38943	34076	29208	24340	19472
	56	**46**	**37**	**29**	**21**	**15**	**10**
June	33263	29936	26610	23284	19958	16631	13305
	27	**22**	**18**	**14**	**10**	**7**	**5**
July	15026	13523	12021	10518	9016	7513	6010
	6	**5**	**4**	**3**	**2**	**2**	**1**
August	9677	8710	7742	6774	5806	4839	3871
	3	**2**	**2**	**1**	**1**	**1**	**0**
September	16269	14642	13015	11388	9761	8135	6508
	7	**6**	**5**	**4**	**3**	**2**	**1**
October	26645	23980	21316	18651	15987	13322	10658
	18	**15**	**12**	**9**	**7**	**5**	**3**
November	43104	38793	34483	30173	25862	21552	17241
	45	**37**	**29**	**23**	**17**	**12**	**8**
December	52887	47598	42310	37021	31732	26444	21155
	66	**54**	**43**	**33**	**25**	**18**	**12**

Table 32. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for longear sunfish at Kiamichi River, Big Cedar.

Month	100%	90%	80%	70%	60%	50%	40%
January	14009	12608	11207	9807	8406	7005	5604
	57	**106**	**212**	**463**	**1142**	**3318**	**12243**
February	13530	12177	10824	9471	8118	6765	5412
	70	**131**	**260**	**568**	**1400**	**4068**	**15013**
March	13100	11790	10480	9170	7860	6550	5240
	85	**158**	**314**	**686**	**1691**	**4914**	**18133**
April	13565	12209	10852	9496	8139	6783	5426
	69	**129**	**256**	**559**	**1379**	**4006**	**14784**
May	14055	12650	11244	9839	8433	7028	5622
	56	**104**	**208**	**454**	**1120**	**3255**	**12012**
June	15911	14320	12729	11138	9547	7956	6365
	27	**51**	**101**	**220**	**542**	**1575**	**5813**
July	20613	18552	16490	14429	12368	10306	8245
	6	**11**	**22**	**48**	**119**	**346**	**1278**
August	23790	21411	19032	16653	14274	11895	9516
	3	**5**	**10**	**21**	**52**	**150**	**552**
September	20086	18077	16069	14060	12052	10043	8034
	7	**13**	**26**	**56**	**139**	**403**	**1487**
October	17104	15394	13683	11973	10262	8552	6842
	18	**33**	**66**	**144**	**355**	**1032**	**3808**
November	14623	13161	11699	10236	8774	7312	5849
	45	**83**	**165**	**360**	**888**	**2581**	**9526**
December	13680	12312	10944	9576	8208	6840	5472
	66	**122**	**244**	**532**	**1312**	**3812**	**14069**

Table 33. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for channel catfish at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	103646	93282	82917	72552	62188	51823	41458
	810	**689**	**576**	**469**	**371**	**281**	**200**
February	123587	111228	98869	86511	74152	61793	49435
	1059	**902**	**753**	**614**	**485**	**367**	**261**
March	128653	115787	102922	90057	77192	64326	51461
	1126	**959**	**801**	**653**	**516**	**391**	**278**
April	127529	114776	102023	89270	76517	63764	51012
	1111	**946**	**790**	**644**	**509**	**385**	**274**
May	129443	116499	103554	90610	77666	64721	51777
	1137	**968**	**808**	**659**	**521**	**394**	**280**
June	84169	75752	67335	58918	50502	42085	33668
	589	**501**	**419**	**342**	**270**	**204**	**145**
July	19828	17845	15862	13880	11897	9914	7931
	65	**55**	**46**	**37**	**30**	**22**	**16**
August	14928	13435	11943	10450	8957	7464	5971
	42	**36**	**30**	**24**	**19**	**15**	**10**
September	26338	23704	21070	18436	15803	13169	10535
	100	**85**	**71**	**58**	**46**	**35**	**25**
October	53157	47842	42526	37210	31894	26579	21263
	292	**248**	**207**	**169**	**134**	**101**	**72**
November	105462	94916	84370	73823	63277	52731	42185
	831	**708**	**591**	**482**	**381**	**288**	**205**
December	120275	108247	96220	84192	72165	60137	48110
	1016	**865**	**723**	**589**	**466**	**352**	**251**

Table 34. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for spotted bass at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	92400	83160	73920	64680	55440	46200	36960
	810	**654**	**515**	**393**	**288**	**199**	**127**
February	105526	94973	84421	73868	63315	52763	42210
	1059	**856**	**674**	**514**	**377**	**260**	**166**
March	108775	97898	87020	76143	65265	54388	43510
	1126	**910**	**717**	**547**	**400**	**277**	**176**
April	108057	97251	86446	75640	64834	54029	43223
	1111	**898**	**707**	**540**	**395**	**273**	**174**
May	109279	98351	87423	76495	65567	54640	43712
	1137	**918**	**724**	**552**	**404**	**279**	**178**
June	78964	71068	63171	55275	47378	39482	31586
	589	**476**	**375**	**286**	**209**	**145**	**92**
July	26513	23861	21210	18559	15908	13256	10605
	65	**52**	**41**	**31**	**23**	**16**	**10**
August	21399	19259	17119	14979	12840	10700	8560
	42	**34**	**27**	**20**	**15**	**10**	**7**
September	32850	29565	26280	22995	19710	16425	13140
	100	**81**	**64**	**48**	**35**	**25**	**16**
October	55816	50235	44653	39071	33490	27908	22327
	292	**236**	**186**	**142**	**104**	**72**	**46**
November	93619	84257	74895	65533	56172	46810	37448
	831	**672**	**529**	**404**	**296**	**204**	**130**
December	103384	93046	82707	72369	62030	51692	41354
	1016	**821**	**647**	**494**	**361**	**250**	**159**

Table 35. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for green sunfish at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	51540	46386	41232	36078	30924	25770	20616
	810	**578**	**397**	**259**	**159**	**89**	**44**
February	56071	50464	44857	39250	33643	28036	22429
	1059	**757**	**520**	**339**	**208**	**116**	**57**
March	57161	51444	45728	40012	34296	28580	22864
	1126	**805**	**553**	**361**	**221**	**123**	**61**
April	56921	51229	45537	39845	34153	28460	22768
	1111	**794**	**545**	**356**	**218**	**122**	**60**
May	57328	51596	45863	40130	34397	28664	22931
	1137	**812**	**558**	**364**	**223**	**125**	**61**
June	104766	94290	83813	73336	62860	52383	41907
	589	**422**	**291**	**191**	**118**	**66**	**33**
July	52008	46807	41606	36406	31205	26004	20803
	65	**46**	**32**	**21**	**13**	**7**	**4**
August	45327	40794	36262	31729	27196	22663	18131
	42	**30**	**21**	**14**	**8**	**5**	**2**
September	59676	53708	47741	41773	35806	29838	23870
	100	**72**	**49**	**32**	**20**	**11**	**6**
October	83857	75471	67085	58700	50314	41928	33543
	292	**209**	**144**	**95**	**58**	**33**	**16**
November	51970	46773	41576	36379	31182	25985	20788
	831	**594**	**408**	**266**	**163**	**91**	**45**
December	55347	49812	44277	38743	33208	27673	22139
	1016	**726**	**499**	**326**	**199**	**111**	**55**

Table 36. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for white crappie at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	59200	53280	47360	41440	35520	29600	23680
	810	**430**	**212**	**95**	**38**	**13**	**3**
February	61911	55720	49529	43337	37146	30955	24764
	1059	**563**	**277**	**124**	**49**	**16**	**4**
March	62547	56292	50037	43783	37528	31273	25019
	1126	**598**	**295**	**132**	**52**	**18**	**5**
April	62407	56167	49926	43685	37444	31204	24963
	1111	**590**	**291**	**130**	**52**	**17**	**5**
May	62644	56380	50115	43851	37587	31322	25058
	1137	**604**	**298**	**133**	**53**	**18**	**5**
June	56146	50532	44917	39302	33688	28073	22459
	589	**313**	**154**	**69**	**27**	**9**	**2**
July	38866	34979	31093	27206	23320	19433	15546
	65	**34**	**17**	**8**	**3**	**1**	**0**
August	36158	32542	28927	25311	21695	18079	14463
	42	**22**	**11**	**5**	**2**	**1**	**0**
September	41777	37600	33422	29244	25066	20889	16711
	100	**53**	**26**	**12**	**5**	**2**	**0**
October	49950	44955	39960	34965	29970	24975	19980
	292	**155**	**76**	**34**	**14**	**5**	**1**
November	59462	53516	47570	41624	35677	29731	23785
	831	**442**	**218**	**98**	**39**	**13**	**3**
December	61484	55336	49187	43039	36891	30742	24594
	1016	**540**	**266**	**119**	**47**	**16**	**4**

Table 37. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for stoneroller at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	67382	60644	53906	47167	40429	33691	26953
	810	**382**	**934**	**610**	**373**	**209**	**102**
February	69969	62972	55975	48978	41981	34984	27988
	1059	**499**	**1054**	**688**	**421**	**235**	**115**
March	70573	63516	56459	49401	42344	35287	28229
	1126	**531**	**1083**	**707**	**432**	**242**	**119**
April	70441	63397	56353	49309	42264	35220	28176
	1111	**524**	**1076**	**703**	**430**	**240**	**118**
May	70666	63599	56533	49466	42400	35333	28266
	1137	**536**	**1087**	**710**	**434**	**243**	**119**
June	64445	58001	51556	45112	38667	32223	25778
	589	**278**	**810**	**529**	**324**	**181**	**89**
July	47290	42561	37832	33103	28374	23645	18916
	65	**30**	**302**	**197**	**121**	**67**	**33**
August	44502	40052	35602	31151	26701	22251	17801
	42	**20**	**249**	**162**	**99**	**55**	**27**
September	50254	45228	40203	35178	30152	25127	20101
	100	**47**	**366**	**239**	**146**	**82**	**40**
October	58406	52566	46725	40885	35044	29203	23363
	292	**138**	**592**	**387**	**236**	**132**	**65**
November	67633	60870	54106	47343	40580	33817	27053
	831	**392**	**945**	**617**	**378**	**211**	**104**
December	69563	62607	55651	48694	41738	34782	27825
	1016	**479**	**1034**	**675**	**413**	**231**	**113**

Table 38. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for smallmouth bass at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	105299	94769	84239	73709	63179	52649	42120
	810	**579**	**398**	**261**	**160**	**89**	**44**
February	114597	103137	91678	80218	68758	57298	45839
	1059	**758**	**521**	**341**	**209**	**117**	**58**
March	116832	105149	93466	81783	70099	58416	46733
	1126	**806**	**554**	**363**	**222**	**124**	**61**
April	116341	104706	93072	81438	69804	58170	46536
	1111	**795**	**547**	**358**	**219**	**123**	**60**
May	117177	105459	93742	82024	70306	58588	46871
	1137	**813**	**559**	**366**	**224**	**126**	**62**
June	95269	85742	76215	66688	57161	47634	38108
	589	**421**	**290**	**190**	**116**	**65**	**32**
July	47534	42781	38027	33274	28520	23767	19014
	65	**46**	**32**	**21**	**13**	**7**	**4**
August	41469	37322	33175	29028	24882	20735	16588
	42	**30**	**21**	**13**	**8**	**5**	**2**
September	54488	49039	43590	38142	32693	27244	21795
	100	**71**	**49**	**32**	**20**	**11**	**5**
October	76378	68740	61102	53465	45827	38189	30551
	292	**209**	**144**	**94**	**58**	**32**	**16**
November	106182	95564	84946	74327	63709	53091	42473
	831	**595**	**409**	**268**	**164**	**92**	**45**
December	113110	101799	90488	79177	67866	56555	45244
	1016	**727**	**500**	**327**	**200**	**112**	**55**

Table 39. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for longear sunfish at Kiamichi River, Clayton.

Month	100%	90%	80%	70%	60%	50%	40%
January	15686	14118	12549	10980	9412	7843	6274
	810	**211**	**47**	**9**	**1**	**0**	**0**
February	16020	14418	12816	11214	9612	8010	6408
	1059	**276**	**61**	**11**	**2**	**0**	**0**
March	16097	14487	12878	11268	9658	8049	6439
	1126	**293**	**65**	**12**	**2**	**0**	**0**
April	16080	14472	12864	11256	9648	8040	6432
	1111	**289**	**64**	**12**	**2**	**0**	**0**
May	16109	14498	12887	11276	9665	8054	6444
	1137	**296**	**66**	**12**	**2**	**0**	**0**
June	15300	13770	12240	10710	9180	7650	6120
	589	**153**	**34**	**6**	**1**	**0**	**0**
July	12870	11583	10296	9009	7722	6435	5148
	65	**17**	**4**	**1**	**0**	**0**	**0**
August	12440	11196	9952	8708	7464	6220	4976
	42	**11**	**2**	**0**	**0**	**0**	**0**
September	13315	11983	10652	9320	7989	6657	5326
	100	**26**	**6**	**1**	**0**	**0**	**0**
October	14482	13033	11585	10137	8689	7241	5793
	292	**76**	**17**	**3**	**0**	**0**	**0**
November	15719	14147	12575	11003	9431	7859	6287
	831	**216**	**48**	**9**	**1**	**0**	**0**
December	15968	14371	12774	11178	9581	7984	6387
	1016	**265**	**59**	**11**	**1**	**0**	**0**

Table 40. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for channel catfish at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	113561	102205	91984	82786	74507	67057	60351
	1002	**843**	**709**	**596**	**502**	**422**	**355**
February	135762	122186	109968	98971	89074	80166	72150
	1343	**1130**	**950**	**800**	**673**	**566**	**476**
March	152258	137032	123329	110996	99897	89907	80916
	1621	**1364**	**1147**	**965**	**812**	**683**	**575**
April	145602	131042	117938	106144	95530	85977	77379
	1507	**1267**	**1066**	**897**	**754**	**635**	**534**
May	151017	135915	122324	110091	99082	89174	80257
	1600	**1346**	**1132**	**952**	**801**	**674**	**567**
June	98852	88967	80070	72063	64857	58371	52534
	798	**671**	**565**	**475**	**400**	**336**	**283**
July	28916	26024	23422	21080	18972	17074	15367
	106	**89**	**75**	**63**	**53**	**45**	**38**
August	19579	17621	15859	14273	12846	11561	10405
	56	**47**	**40**	**33**	**28**	**24**	**20**
September	46586	41927	37735	33961	30565	27509	24758
	232	**195**	**164**	**138**	**116**	**98**	**82**
October	59635	53671	48304	43474	39126	35214	31692
	348	**293**	**246**	**207**	**174**	**147**	**123**
November	119210	107289	96560	86904	78214	70392	63353
	1085	**913**	**768**	**646**	**543**	**457**	**384**
December	128079	115271	103744	93369	84032	75629	68066
	1221	**1027**	**864**	**727**	**611**	**514**	**433**

Table 41. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for spotted bass at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	84014	75613	68051	61246	55122	49610	44649
	1002	**819**	**669**	**547**	**447**	**365**	**298**
February	97888	88099	79289	71360	64224	57802	52022
	1343	**1097**	**897**	**733**	**599**	**489**	**400**
March	107982	97184	87466	78719	70847	63763	57386
	1621	**1325**	**1082**	**884**	**723**	**590**	**482**
April	103929	93536	84183	75765	68188	61369	55232
	1507	**1231**	**1006**	**822**	**672**	**549**	**448**
May	107229	96506	86855	78170	70353	63317	56986
	1600	**1307**	**1068**	**873**	**713**	**583**	**476**
June	74609	67148	60433	54390	48951	44056	39650
	798	**652**	**533**	**435**	**356**	**291**	**237**
July	26054	23448	21103	18993	17094	15384	13846
	106	**87**	**71**	**58**	**47**	**39**	**32**
August	18660	16794	15115	13603	12243	11019	9917
	56	**46**	**37**	**31**	**25**	**20**	**17**
September	39187	35268	31741	28567	25711	23140	20826
	232	**190**	**155**	**127**	**103**	**85**	**69**
October	48410	43569	39212	35291	31762	28585	25727
	348	**284**	**232**	**190**	**155**	**127**	**104**
November	87579	78821	70939	63845	57460	51714	46543
	1085	**887**	**724**	**592**	**484**	**395**	**323**
December	93126	83814	75432	67889	61100	54990	49491
	1221	**997**	**815**	**666**	**544**	**445**	**363**

Table 42. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for green sunfish at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	62370	56133	50520	45468	40921	36829	33146
	1002	**303**	**91**	**28**	**8**	**3**	**1**
February	64000	57600	51840	46656	41990	37791	34012
	1343	**406**	**123**	**37**	**11**	**3**	**1**
March	65068	58561	52705	47435	42691	38422	34580
	1621	**490**	**148**	**45**	**13**	**4**	**1**
April	64650	58185	52366	47130	42417	38175	34357
	1507	**455**	**137**	**42**	**13**	**4**	**1**
May	64991	58492	52643	47379	42641	38377	34539
	1600	**483**	**146**	**44**	**13**	**4**	**1**
June	61133	55020	49518	44566	40109	36098	32489
	798	**241**	**73**	**22**	**7**	**2**	**1**
July	51189	46070	41463	37316	33585	30226	27204
	106	**32**	**10**	**3**	**1**	**0**	**0**
August	48385	43547	39192	35273	31746	28571	25714
	56	**17**	**5**	**2**	**0**	**0**	**0**
September	54839	49355	44419	39977	35980	32382	29143
	232	**70**	**21**	**6**	**2**	**1**	**0**
October	56830	51147	46032	41429	37286	33557	30202
	348	**105**	**32**	**10**	**3**	**1**	**0**
November	62809	56528	50875	45788	41209	37088	33379
	1085	**328**	**99**	**30**	**9**	**3**	**1**
December	63463	57117	51405	46265	41638	37474	33727
	1221	**369**	**111**	**34**	**10**	**3**	**1**

Table 43. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for white crappie at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	54440	48996	44096	39687	35718	32146	28932
	1002	**752**	**564**	**424**	**318**	**239**	**179**
February	60625	54563	49107	44196	39776	35799	32219
	1343	**1008**	**757**	**568**	**426**	**320**	**240**
March	64963	58467	52620	47358	42622	38360	34524
	1621	**1217**	**913**	**686**	**515**	**386**	**290**
April	63237	56913	51222	46100	41490	37341	33607
	1507	**1131**	**849**	**637**	**478**	**359**	**269**
May	64644	58179	52361	47125	42413	38171	34354
	1600	**1201**	**901**	**676**	**508**	**381**	**286**
June	50074	45067	40560	36504	32854	29568	26611
	798	**599**	**450**	**337**	**253**	**190**	**143**
July	23872	21485	19336	17402	15662	14096	12686
	106	**80**	**60**	**45**	**34**	**25**	**19**
August	18872	16985	15286	13758	12382	11144	10029
	56	**42**	**32**	**24**	**18**	**13**	**10**
September	31820	28638	25775	23197	20877	18790	16911
	232	**174**	**131**	**98**	**74**	**55**	**42**
October	36926	33234	29910	26919	24227	21805	19624
	348	**261**	**196**	**147**	**110**	**83**	**62**
November	56056	50451	45406	40865	36779	33101	29791
	1085	**814**	**611**	**459**	**344**	**258**	**194**
December	58534	52680	47412	42671	38404	34564	31107
	1221	**916**	**688**	**516**	**387**	**291**	**218**

Table 44. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for stoneroller at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	56996	51297	46167	41550	37395	33656	30290
	1002	**149**	**22**	**3**	**0**	**0**	**0**
February	57926	52133	46920	42228	38005	34205	30784
	1343	**199**	**30**	**4**	**1**	**0**	**0**
March	58531	52678	47410	42669	38402	34562	31106
	1621	**240**	**36**	**5**	**1**	**0**	**0**
April	58294	52465	47218	42497	38247	34422	30980
	1507	**223**	**33**	**5**	**1**	**0**	**0**
May	58488	52639	47375	42637	38374	34536	31083
	1600	**237**	**35**	**5**	**1**	**0**	**0**
June	56285	50656	45591	41032	36928	33236	29912
	798	**118**	**18**	**3**	**0**	**0**	**0**
July	50353	45318	40786	36707	33037	29733	26760
	106	**16**	**2**	**0**	**0**	**0**	**0**
August	48605	43745	39370	35433	31890	28701	25831
	56	**8**	**1**	**0**	**0**	**0**	**0**
September	52576	47319	42587	38328	34495	31046	27941
	232	**34**	**5**	**1**	**0**	**0**	**0**
October	53766	48389	43550	39195	35276	31748	28573
	348	**52**	**8**	**1**	**0**	**0**	**0**
November	57248	51523	46371	41734	37560	33804	30424
	1085	**161**	**24**	**4**	**1**	**0**	**0**
December	57621	51859	46673	42006	37805	34025	30622
	1221	**181**	**27**	**4**	**1**	**0**	**0**

Table 45. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for smallmouth bass at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	102752	92477	83229	74906	67416	60674	54607
	1002	**731**	**533**	**389**	**284**	**207**	**151**
February	113329	101996	91796	82616	74355	66919	60227
	1343	**980**	**715**	**522**	**381**	**278**	**203**
March	120688	108619	97757	87981	79183	71265	64138
	1621	**1183**	**863**	**630**	**460**	**335**	**245**
April	117764	105988	95389	85850	77265	69538	62585
	1507	**1099**	**802**	**585**	**427**	**312**	**227**
May	120147	108132	97319	87587	78828	70946	63851
	1600	**1167**	**852**	**621**	**453**	**331**	**241**
June	95222	85700	77130	69417	62475	56228	50605
	798	**582**	**425**	**310**	**226**	**165**	**120**
July	48510	43659	39293	35364	31828	28645	25780
	106	**77**	**57**	**41**	**30**	**22**	**16**
August	39167	35250	31725	28552	25697	23127	20815
	56	**41**	**30**	**22**	**16**	**12**	**8**
September	63019	56717	51045	45941	41347	37212	33491
	232	**169**	**124**	**90**	**66**	**48**	**35**
October	72163	64947	58452	52607	47346	42611	38350
	348	**254**	**185**	**135**	**99**	**72**	**53**
November	105526	94973	85476	76928	69235	62312	56081
	1085	**792**	**578**	**422**	**308**	**224**	**164**
December	109763	98787	88908	80017	72016	64814	58333
	1221	**891**	**650**	**474**	**346**	**252**	**184**

Table 46. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for longear sunfish at Kiamichi River, Antlers.

Month	100%	90%	80%	70%	60%	50%	40%
January	17398	15658	14092	12683	11415	10273	9246
	1002	**393**	**154**	**61**	**24**	**9**	**4**
February	17982	16184	14566	13109	11798	10618	9556
	1343	**527**	**207**	**81**	**32**	**13**	**5**
March	18368	16531	14878	13390	12051	10846	9761
	1621	**637**	**250**	**98**	**39**	**15**	**6**
April	18216	16395	14755	13280	11952	10757	9681
	1507	**592**	**232**	**91**	**36**	**14**	**6**
May	18340	16506	14855	13370	12033	10830	9747
	1600	**628**	**247**	**97**	**38**	**15**	**6**
June	16957	15261	13735	12362	11126	10013	9012
	798	**313**	**123**	**48**	**19**	**7**	**3**
July	13509	12158	10942	9848	8863	7977	7179
	106	**42**	**16**	**6**	**3**	**1**	**0**
August	12569	11312	10181	9162	8246	7422	6679
	56	**22**	**9**	**3**	**1**	**1**	**0**
September	14754	13279	11951	10756	9680	8712	7841
	232	**91**	**36**	**14**	**6**	**2**	**1**
October	15444	13900	12510	11259	10133	9119	8208
	348	**137**	**54**	**21**	**8**	**3**	**1**
November	17555	15799	14219	12797	11518	10366	9329
	1085	**426**	**167**	**66**	**26**	**10**	**4**
December	17789	16010	14409	12968	11672	10504	9454
	1221	**479**	**188**	**74**	**29**	**11**	**4**

Table 47. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for channel catfish at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	95906	86315	77684	69916	62924	56632	50968
	1002	**816**	**665**	**542**	**441**	**360**	**293**
February	111501	100351	90316	81284	73156	65840	59256
	1343	**1094**	**892**	**726**	**592**	**482**	**393**
March	122829	110546	99491	89542	80588	72529	65276
	1621	**1321**	**1076**	**877**	**714**	**582**	**474**
April	118283	106454	95809	86228	77605	69845	62860
	1507	**1227**	**1000**	**815**	**664**	**541**	**441**
May	121983	109785	98807	88926	80033	72030	64827
	1600	**1303**	**1062**	**865**	**705**	**574**	**468**
June	85313	76782	69103	62193	55974	50376	45339
	798	**650**	**530**	**431**	**352**	**286**	**233**
July	30240	27216	24494	22045	19840	17856	16071
	106	**86**	**70**	**57**	**47**	**38**	**31**
August	21761	19585	17627	15864	14278	12850	11565
	56	**46**	**37**	**30**	**25**	**20**	**16**
September	45220	40698	36629	32966	29669	26702	24032
	232	**189**	**154**	**126**	**102**	**83**	**68**
October	55696	50126	45114	40602	36542	32888	29599
	348	**284**	**231**	**188**	**153**	**125**	**102**
November	99916	89925	80932	72839	65555	58999	53100
	1085	**884**	**720**	**587**	**478**	**389**	**317**
December	106153	95537	85984	77385	69647	62682	56414
	1221	**995**	**810**	**660**	**538**	**438**	**357**

Table 48. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for spotted bass at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	136779	123101	110791	99712	89741	80767	72690
	1002	**840**	**705**	**591**	**496**	**416**	**349**
February	163013	146711	132040	118836	106953	96257	86632
	1343	**1126**	**945**	**792**	**664**	**557**	**467**
March	182455	164210	147789	133010	119709	107738	96964
	1621	**1360**	**1140**	**956**	**802**	**673**	**564**
April	174615	157154	141438	127294	114565	103108	92798
	1507	**1264**	**1060**	**889**	**745**	**625**	**524**
May	180994	162894	146605	131944	118750	106875	96187
	1600	**1342**	**1125**	**944**	**791**	**664**	**557**
June	119350	107415	96674	87006	78306	70475	63428
	798	**669**	**561**	**471**	**395**	**331**	**278**
July	35667	32100	28890	26001	23401	21061	18955
	106	**89**	**75**	**63**	**52**	**44**	**37**
August	24314	21882	19694	17725	15952	14357	12921
	56	**47**	**39**	**33**	**28**	**23**	**19**
September	56987	51289	46160	41544	37389	33650	30285
	232	**195**	**163**	**137**	**115**	**96**	**81**
October	72637	65373	58836	52952	47657	42891	38602
	348	**292**	**245**	**205**	**172**	**144**	**121**
November	143462	129116	116204	104584	94125	84713	76242
	1085	**910**	**763**	**640**	**537**	**450**	**377**
December	153942	138548	124693	112224	101002	90901	81811
	1221	**1024**	**859**	**720**	**604**	**506**	**425**

Table 49. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for green sunfish at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	195901	176311	158680	142812	128531	115678	104110
	1002	**813**	**660**	**535**	**434**	**352**	**286**
February	227090	204381	183943	165549	148994	134095	120685
	1343	**1090**	**884**	**718**	**582**	**472**	**383**
March	249690	224721	202249	182024	163822	147439	132695
	1621	**1316**	**1067**	**866**	**703**	**570**	**463**
April	240625	216563	194906	175416	157874	142087	127878
	1507	**1223**	**992**	**805**	**653**	**530**	**430**
May	248005	223204	200884	180796	162716	146444	131800
	1600	**1298**	**1053**	**855**	**693**	**563**	**456**
June	174661	157195	141475	127328	114595	103135	92822
	798	**647**	**525**	**426**	**346**	**281**	**228**
July	63171	56854	51169	46052	41447	37302	33572
	106	**86**	**70**	**57**	**46**	**37**	**30**
August	45751	41176	37059	33353	30018	27016	24314
	56	**45**	**37**	**30**	**24**	**20**	**16**
September	93730	84357	75921	68329	61496	55347	49812
	232	**188**	**153**	**124**	**101**	**82**	**66**
October	114976	103478	93130	83817	75436	67892	61103
	348	**282**	**229**	**186**	**151**	**122**	**99**
November	203930	183537	165183	148665	133798	120419	108377
	1085	**880**	**714**	**580**	**470**	**382**	**310**
December	216404	194763	175287	157758	141982	127784	115006
	1221	**990**	**804**	**652**	**529**	**429**	**348**

Table 50. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for white crappie at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	131521	118368	106532	95878	86291	77662	69895
	1002	**833**	**692**	**575**	**478**	**397**	**330**
February	155373	139836	125852	113267	101940	91746	82572
	1343	**1116**	**927**	**770**	**640**	**532**	**442**
March	172926	155633	140070	126063	113457	102111	91900
	1621	**1347**	**1119**	**930**	**773**	**642**	**533**
April	165860	149274	134346	120912	108821	97939	88145
	1507	**1252**	**1040**	**864**	**718**	**597**	**496**
May	171610	154449	139004	125103	112593	101334	91200
	1600	**1329**	**1104**	**918**	**762**	**634**	**526**
June	115548	103994	93594	84235	75811	68230	61407
	798	**663**	**551**	**458**	**380**	**316**	**263**
July	36685	33016	29715	26743	24069	21662	19496
	106	**88**	**73**	**61**	**51**	**42**	**35**
August	25493	22944	20649	18584	16726	15053	13548
	56	**46**	**39**	**32**	**27**	**22**	**18**
September	57254	51529	46376	41738	37564	33808	30427
	232	**193**	**160**	**133**	**111**	**92**	**76**
October	72095	64885	58397	52557	47301	42571	38314
	348	**289**	**240**	**200**	**166**	**138**	**115**
November	137617	123855	111470	100323	90291	81262	73135
	1085	**902**	**749**	**622**	**517**	**430**	**357**
December	147150	132435	119191	107272	96545	86891	78201
	1221	**1014**	**843**	**700**	**582**	**483**	**402**

Table 51. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for stoneroller at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	103483	93135	83822	75439	67895	61106	54995
	1002	**715**	**510**	**364**	**259**	**185**	**132**
February	113385	102047	91842	82658	74392	66953	60257
	1343	**958**	**683**	**487**	**348**	**248**	**177**
March	120238	108214	97393	87653	78888	70999	63899
	1621	**1156**	**825**	**588**	**420**	**299**	**213**
April	117519	105767	95190	85671	77104	69394	62454
	1507	**1075**	**767**	**547**	**390**	**278**	**198**
May	119735	107762	96986	87287	78558	70702	63632
	1600	**1141**	**814**	**580**	**414**	**295**	**211**
June	96392	86753	78078	70270	63243	56919	51227
	798	**569**	**406**	**290**	**207**	**147**	**105**
July	51387	46248	41623	37461	33715	30343	27309
	106	**76**	**54**	**39**	**27**	**20**	**14**
August	42091	37882	34094	30684	27616	24854	22369
	56	**40**	**28**	**20**	**14**	**10**	**7**
September	65591	59032	53129	47816	43034	38731	34858
	232	**166**	**118**	**84**	**60**	**43**	**31**
October	74426	66983	60285	54256	48831	43948	39553
	348	**248**	**177**	**126**	**90**	**64**	**46**
November	106086	95478	85930	77337	69603	62643	56379
	1085	**774**	**552**	**394**	**281**	**200**	**143**
December	110054	99049	89144	80230	72207	64986	58487
	1221	**871**	**621**	**443**	**316**	**225**	**161**

Table 52. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for smallmouth bass at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	162812	146531	131878	118690	106821	96139	86525
	1002	**792**	**625**	**494**	**390**	**308**	**243**
February	185590	167031	150328	135295	121766	109589	98630
	1343	**1061**	**838**	**662**	**523**	**413**	**326**
March	201871	181684	163516	147164	132448	119203	107283
	1621	**1281**	**1012**	**799**	**631**	**499**	**394**
April	195362	175826	158243	142419	128177	115359	103823
	1507	**1190**	**940**	**743**	**587**	**463**	**366**
May	200664	180597	162537	146284	131655	118490	106641
	1600	**1264**	**998**	**789**	**623**	**492**	**389**
June	147066	132359	119123	107211	96490	86841	78157
	798	**630**	**498**	**393**	**311**	**245**	**194**
July	59709	53738	48364	43528	39175	35257	31732
	106	**84**	**66**	**52**	**41**	**33**	**26**
August	44859	40373	36336	32702	29432	26489	23840
	56	**44**	**35**	**28**	**22**	**17**	**14**
September	84707	76236	68613	61751	55576	50019	45017
	232	**183**	**145**	**114**	**90**	**71**	**56**
October	101523	91370	82233	74010	66609	59948	53953
	348	**275**	**217**	**172**	**136**	**107**	**85**
November	168713	151842	136658	122992	110693	99623	89661
	1085	**857**	**677**	**535**	**422**	**334**	**264**
December	177828	160046	144041	129637	116673	105006	94505
	1221	**964**	**762**	**602**	**475**	**375**	**297**

Table 53. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for longear sunfish at Mountain Fork Creek, Smithville.

Month	100%	90%	80%	70%	60%	50%	40%
January	19268	17341	15607	14046	12642	11378	10240
	1002	**508**	**258**	**131**	**66**	**34**	**17**
February	20165	18148	16333	14700	13230	11907	10716
	1343	**681**	**346**	**175**	**89**	**45**	**23**
March	20762	18686	16817	15136	13622	12260	11034
	1621	**822**	**417**	**212**	**107**	**54**	**28**
April	20527	18474	16627	14964	13468	12121	10909
	1507	**764**	**388**	**197**	**100**	**51**	**26**
May	20719	18647	16782	15104	13594	12234	11011
	1600	**811**	**412**	**209**	**106**	**54**	**27**
June	18599	16739	15065	13559	12203	10983	9884
	798	**405**	**205**	**104**	**53**	**27**	**14**
July	13599	12239	11015	9914	8922	8030	7227
	106	**54**	**27**	**14**	**7**	**4**	**2**
August	12313	11082	9974	8976	8079	7271	6544
	56	**28**	**14**	**7**	**4**	**2**	**1**
September	15356	13820	12438	11194	10075	9067	8161
	232	**118**	**60**	**30**	**15**	**8**	**4**
October	16352	14717	13245	11921	10729	9656	8690
	348	**177**	**90**	**45**	**23**	**12**	**6**
November	19508	17557	15801	14221	12799	11519	10367
	1085	**550**	**279**	**142**	**72**	**36**	**18**
December	19867	17881	16093	14483	13035	11732	10558
	1221	**619**	**314**	**159**	**81**	**41**	**21**

Table 54. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for channel catfish at Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	55760	50184	44608	39032	33456	27880	22304
	285	**223**	**169**	**124**	**87**	**57**	**34**
February	60151	54136	48121	42106	36091	30076	24060
	340	**266**	**202**	**148**	**103**	**68**	**40**
March	66196	59576	52957	46337	39717	33098	26478
	425	**332**	**253**	**185**	**129**	**84**	**50**
April	57676	51909	46141	40373	34606	28838	23070
	308	**241**	**183**	**134**	**94**	**61**	**36**
May	60264	54238	48211	42185	36158	30132	24106
	341	**267**	**203**	**149**	**104**	**68**	**40**
June	44592	40132	35673	31214	26755	22296	17837
	169	**132**	**101**	**74**	**51**	**34**	**20**
July	21604	19444	17283	15123	12963	10802	8642
	31	**24**	**19**	**14**	**10**	**6**	**4**
August	18205	16384	14564	12743	10923	9102	7282
	21	**16**	**12**	**9**	**6**	**4**	**2**
September	30517	27466	24414	21362	18310	15259	12207
	70	**55**	**42**	**30**	**21**	**14**	**8**
October	34709	31238	27767	24296	20825	17354	13883
	94	**74**	**56**	**41**	**29**	**19**	**11**
November	51687	46518	41350	36181	31012	25844	20675
	239	**187**	**142**	**104**	**73**	**47**	**28**
December	58534	52680	46827	40974	35120	29267	23413
	319	**250**	**190**	**139**	**97**	**63**	**38**

Table 55. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for spotted bass Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	47283	42555	37827	33098	28370	23642	18913
	285	**193**	**125**	**76**	**43**	**22**	**10**
February	49600	44640	39680	34720	29760	24800	19840
	340	**230**	**149**	**91**	**52**	**26**	**12**
March	52689	47420	42151	36882	31613	26345	21076
	425	**288**	**186**	**114**	**64**	**33**	**14**
April	48302	43472	38642	33812	28981	24151	19321
	308	**209**	**135**	**83**	**47**	**24**	**10**
May	49659	44693	39727	34761	29795	24829	19864
	341	**231**	**150**	**91**	**52**	**26**	**12**
June	41064	36958	32852	28745	24639	20532	16426
	169	**115**	**74**	**45**	**26**	**13**	**6**
July	25996	23396	20796	18197	15597	12998	10398
	31	**21**	**14**	**8**	**5**	**2**	**1**
August	23334	21001	18667	16334	14000	11667	9334
	21	**14**	**9**	**6**	**3**	**2**	**1**
September	32326	29093	25860	22628	19395	16163	12930
	70	**47**	**31**	**19**	**11**	**5**	**2**
October	35060	31554	28048	24542	21036	17530	14024
	94	**64**	**41**	**25**	**14**	**7**	**3**
November	45074	40567	36059	31552	27044	22537	18030
	239	**162**	**105**	**64**	**36**	**18**	**8**
December	48754	43879	39003	34128	29253	24377	19502
	319	**216**	**140**	**85**	**48**	**25**	**11**

Table 56. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for green sunfish at Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	116545	104890	93236	81581	69927	58272	46618
	285	**222**	**167**	**122**	**84**	**55**	**32**
February	125517	112965	100414	87862	75310	62759	50207
	340	**264**	**200**	**145**	**101**	**65**	**38**
March	137844	124059	110275	96491	82706	68922	55138
	425	**331**	**250**	**182**	**126**	**82**	**48**
April	120462	108416	96370	84324	72277	60231	48185
	308	**240**	**181**	**132**	**91**	**59**	**35**
May	125747	113173	100598	88023	75448	62874	50299
	341	**266**	**201**	**146**	**101**	**66**	**39**
June	93654	84289	74923	65558	56193	46827	37462
	169	**132**	**99**	**72**	**50**	**32**	**19**
July	46093	41484	36874	32265	27656	23046	18437
	31	**24**	**18**	**13**	**9**	**6**	**4**
August	38985	35086	31188	27289	23391	19492	15594
	21	**16**	**12**	**9**	**6**	**4**	**2**
September	64624	58161	51699	45237	38774	32312	25850
	70	**54**	**41**	**30**	**21**	**13**	**8**
October	73294	65965	58635	51306	43977	36647	29318
	94	**73**	**55**	**40**	**28**	**18**	**11**
November	108210	97389	86568	75747	64926	54105	43284
	239	**186**	**140**	**102**	**71**	**46**	**27**
December	122214	109993	97771	85550	73328	61107	48886
	319	**248**	**187**	**136**	**94**	**61**	**36**

Table 57. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for white crappie at Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	66833	60150	53466	46783	40100	33416	26733
	285	**218**	**161**	**115**	**77**	**49**	**28**
February	71629	64466	57304	50141	42978	35815	28652
	340	**260**	**192**	**137**	**92**	**58**	**33**
March	78183	70365	62546	54728	46910	39091	31273
	425	**325**	**241**	**171**	**116**	**73**	**41**
April	68930	62037	55144	48251	41358	34465	27572
	308	**236**	**175**	**124**	**84**	**53**	**30**
May	71752	64577	57402	50227	43051	35876	28701
	341	**261**	**193**	**138**	**93**	**58**	**33**
June	54481	49033	43585	38137	32689	27241	21792
	169	**129**	**96**	**68**	**46**	**29**	**16**
July	28088	25279	22470	19661	16853	14044	11235
	31	**24**	**18**	**13**	**9**	**5**	**3**
August	24018	21616	19215	16813	14411	12009	9607
	21	**16**	**12**	**8**	**6**	**4**	**2**
September	38518	34666	30814	26963	23111	19259	15407
	70	**53**	**40**	**28**	**19**	**12**	**7**
October	43327	38994	34662	30329	25996	21664	17331
	94	**72**	**53**	**38**	**26**	**16**	**9**
November	62356	56120	49885	43649	37413	31178	24942
	239	**182**	**135**	**96**	**65**	**41**	**23**
December	69866	62880	55893	48906	41920	34933	27947
	319	**244**	**181**	**129**	**87**	**55**	**31**

Table 58. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for stoneroller at Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	87373	78636	69899	61161	52424	43687	34949
	285	**173**	**99**	**52**	**25**	**11**	**4**
February	90689	81620	72551	63483	54414	45345	36276
	340	**206**	**118**	**63**	**30**	**13**	**4**
March	95058	85553	76047	66541	57035	47529	38023
	425	**258**	**147**	**78**	**38**	**16**	**6**
April	88836	79953	71069	62185	53302	44418	35534
	308	**187**	**107**	**57**	**27**	**12**	**4**
May	90773	81696	72618	63541	54464	45386	36309
	341	**207**	**118**	**63**	**30**	**13**	**4**
June	78285	70457	62628	54800	46971	39143	31314
	169	**103**	**59**	**31**	**15**	**6**	**2**
July	54832	49349	43866	38383	32899	27416	21933
	31	**19**	**11**	**6**	**3**	**1**	**0**
August	50408	45368	40327	35286	30245	25204	20163
	21	**13**	**7**	**4**	**2**	**1**	**0**
September	64975	58478	51980	45483	38985	32488	25990
	70	**42**	**24**	**13**	**6**	**3**	**1**
October	69217	62295	55373	48452	41530	34608	27687
	94	**57**	**33**	**17**	**8**	**4**	**1**
November	84177	75759	67341	58924	50506	42088	33671
	239	**145**	**83**	**44**	**21**	**9**	**3**
December	89483	80534	71586	62638	53690	44741	35793
	319	**194**	**111**	**59**	**28**	**12**	**4**

Table 59. Habitat units available at 100% of mean-median flows by month and flows in cfs required to maintain various portions of historic available habitat units for smallmouth bass at Glover River, Glover.

Month	100%	90%	80%	70%	60%	50%	40%
January	106340	95706	85072	74438	63804	53170	42536
	285	**228**	**178**	**134**	**97**	**66**	**41**
February	115600	104040	92480	80920	69360	57800	46240
	340	**272**	**212**	**160**	**115**	**78**	**49**
March	128457	115611	102765	89920	77074	64228	51383
	425	**340**	**265**	**200**	**144**	**98**	**61**
April	110372	99335	88298	77261	66223	55186	44149
	308	**247**	**192**	**145**	**105**	**71**	**44**
May	115839	104255	92671	81087	69503	57919	46335
	341	**273**	**213**	**161**	**116**	**79**	**49**
June	83136	74823	66509	58195	49882	41568	33254
	169	**135**	**106**	**80**	**57**	**39**	**24**
July	37427	33684	29941	26199	22456	18713	14971
	31	**25**	**20**	**15**	**11**	**7**	**5**
August	30995	27896	24796	21697	18597	15498	12398
	21	**17**	**13**	**10**	**7**	**5**	**3**
September	54751	49276	43801	38326	32851	27376	21900
	70	**56**	**44**	**33**	**24**	**16**	**10**
October	63088	56779	50470	44161	37853	31544	25235
	94	**76**	**59**	**44**	**32**	**22**	**14**
November	97818	88036	78254	68473	58691	48909	39127
	239	**191**	**149**	**112**	**81**	**55**	**34**
December	112181	100963	89745	78527	67308	56090	44872
	319	**255**	**199**	**150**	**108**	**74**	**46**

Table 60. Discharge relationship between gauged data collection sites and field station sites on the Kiamichi River.

Site & Drainage Area	Date	Discharge	% of Down-stream Discharge	Discharge Calculated from Drainage Area
Big Cedar	3/29/2004	38	22.68%	22.02
40.1 mi^2	3/30/2004	33	24.25%	17.88
Gauging Station	3/31/2004	30	24.22%	16.28
	4/1/2004	28	24.69%	14.90
	4/2/2004	26	24.21%	14.11
	4/5/2004	18	23.09%	10.24
	4/6/2004	16	23.89%	8.80
	4/7/2004	22	35.01%	8.26
	4/8/2004	25	20.75%	15.83
Albion	3/29/2004	168	102.81%	69.57
305.27 mi^2	3/30/2004	136	77.76%	74.69
Field Station	3/31/2004	124	84.85%	62.31
	4/1/2004	113	92.21%	52.50
	4/2/2004	107	96.73%	47.37
	4/5/2004	78	88.58%	37.56
	4/6/2004	67	83.73%	34.14
	4/7/2004	63	14.72%	182.24
	4/8/2004	120	5.68%	904.82
Clayton	3/29/2004	163	82.85%	176.82
708 mi^2	3/30/2004	175	78.82%	199.53
Gauging Station	3/31/2004	146	77.27%	169.81
	4/1/2004	123	66.97%	165.06
	4/2/2004	111	59.16%	168.63
	4/5/2004	88	70.61%	112.00
	4/6/2004	80	63.10%	113.94
	4/7/2004	427	371.49%	103.30
	4/8/2004	2120	-	-
Joe Payne Rd.	3/29/2004	197	81.30%	167.54
787.81 mi^2	3/30/2004	222	79.01%	194.54
Field Station	3/31/2004	189	62.98%	207.69
	4/1/2004	184	68.79%	184.84
	4/2/2004	188	80.53%	161.31
	4/5/2004	125	69.23%	124.61
	4/6/2004	127	77.30%	113.54
	4/7/2004	115	71.39%	111.46
	4/8/2004	-	-	-
Antlers	3/29/2004	242		
1138 mi^2	3/30/2004	281		
Gauging Station	3/31/2004	300		
	4/1/2004	267		
	4/2/2004	233		
	4/5/2004	180		

Table 60. Continued.

4/6/2004	164
4/7/2004	161
4/8/2004	2390

Table 61. Discharge relationship between a gauged data collection site and a field station site on the Glover River.

Site	Date	Discharge	% D.S. Discharge	% D.S. Drainage
W. Fork Glover	3/10/2004	140	36.87%	292.98
242.86 mi^2	3/11/2004	118	39.02%	233.613
Field Station	3/12/2004	89	36.36%	189.666
	3/15/2004	67	23.77%	218.193
	3/16/2004	69	28.55%	185.811
	3/17/2004	54	26.82%	156.513
	3/18/2004	62	35.01%	136.467
	3/19/2004	57	36.30%	121.818
	3/22/2004	63	41.47%	116.421
	3/23/2004	45	30.89%	112.566
Glover	3/10/2004	380		
315 mi^2	3/11/2004	303		
Gauging Station	3/12/2004	246		
	3/15/2004	283		
	3/16/2004	241		
	3/17/2004	203		
	3/18/2004	177		
	3/19/2004	158		
	3/22/2004	151		
	3/23/2004	146		

Table 62. Discharge relationship between a gauged data collection sites and a field station site on the Little River.

Site	Date	Discharge	% D.S. Discharge	% D.S. Drainage
Little River (Honobia Store)	3/10/2004	40	1.26%	189.21
72.93 mi^2	3/11/2004	34	1.56%	129.115
Field Station	3/12/2004	33	2.81%	69.615
	3/15/2004	22	1.90%	67.83
	3/16/2004	20	1.95%	61.88
	3/17/2004	20	2.16%	55.097
	3/18/2004	18	2.10%	50.7535
	3/19/2004	17	2.09%	47.838
	3/22/2004	14	1.92%	44.506
	3/23/2004	13	1.84%	42.007
Little River	3/10/2004	3180		
1226 mi^2	3/11/2004	2170		
Gauging Station	3/12/2004	1170		
	3/15/2004	1140		
	3/16/2004	1040		
	3/17/2004	926		
	3/18/2004	853		
	3/19/2004	804		
	3/22/2004	748		
	3/23/2004	706		

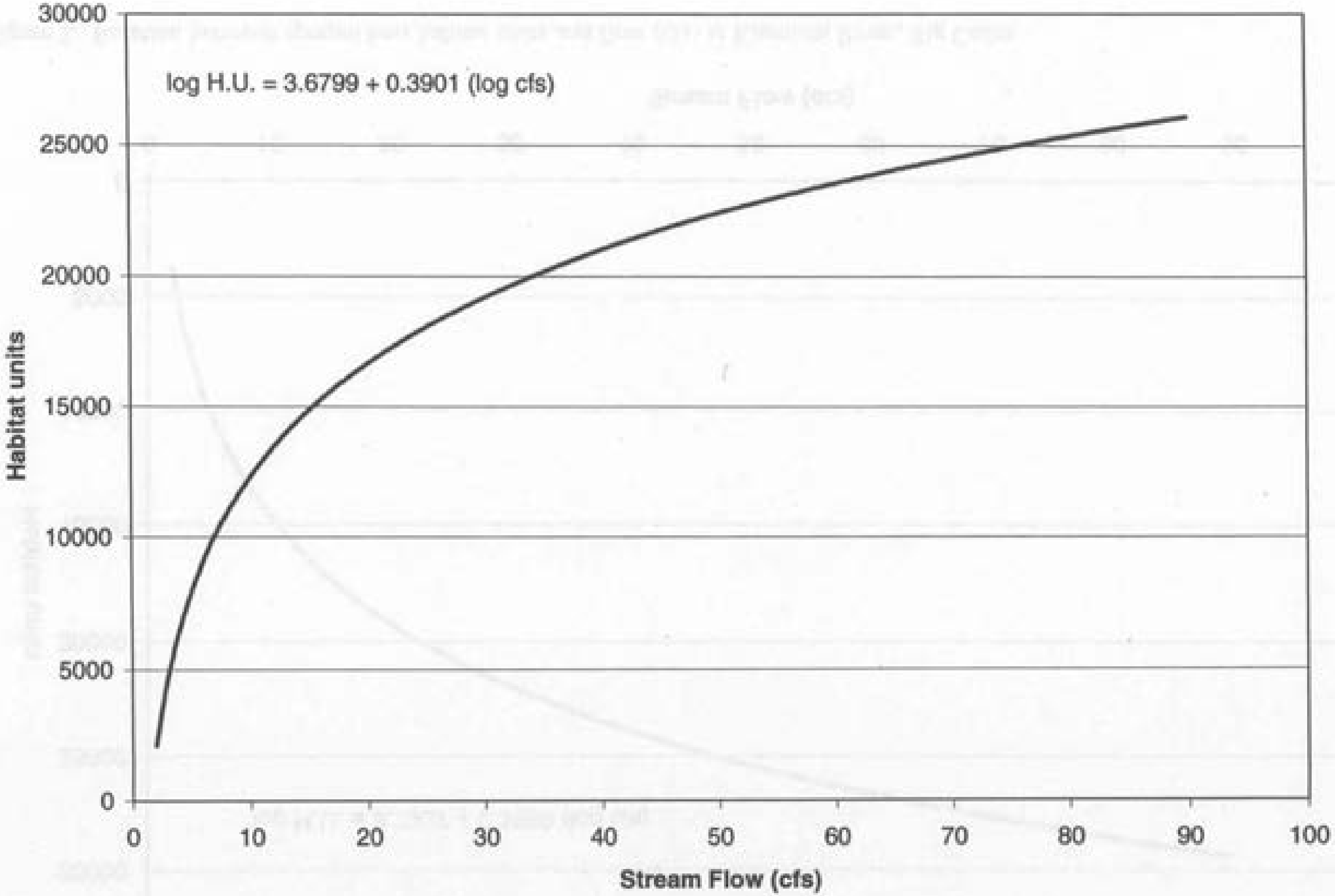

Figure 1. Relation between channel catfish habitat units and flow (cfs) at Kiamichi River, Big Cedar.

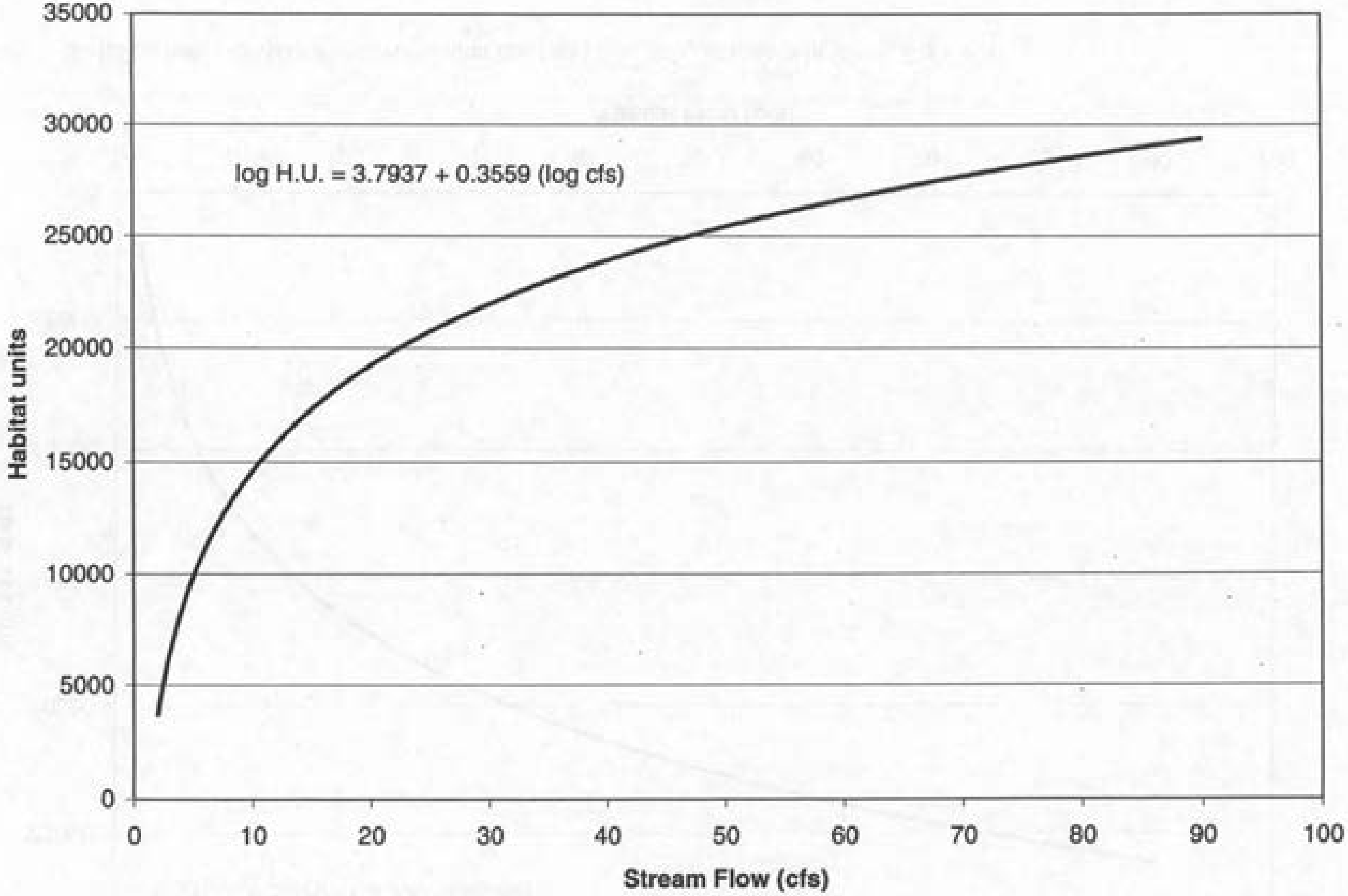

Figure 2. Relation between spotted bass habitat units and flow (cfs) at Kiamichi River, Big Cedar.

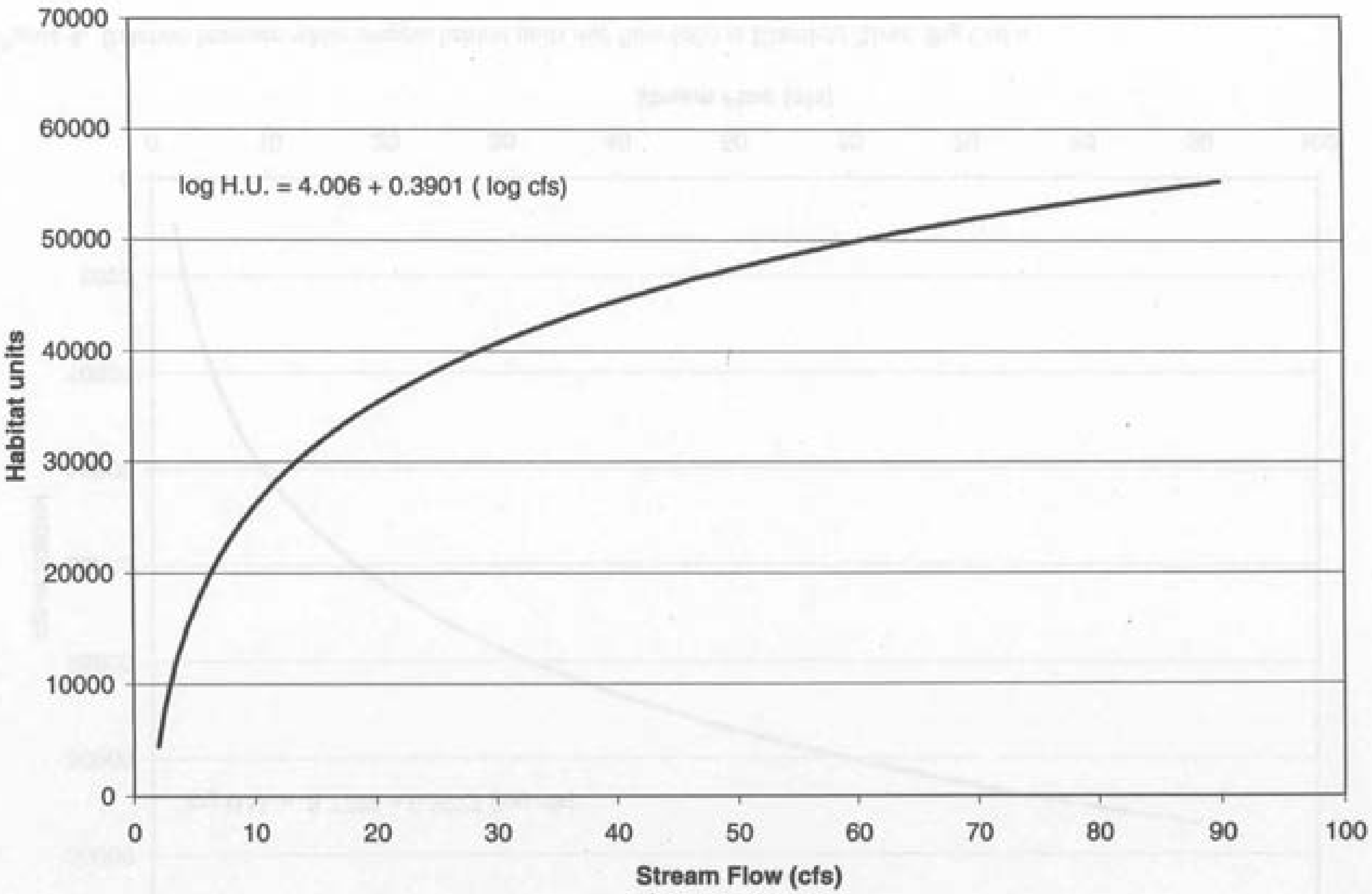

Figure 3. Relation between green sunfish habitat units and flow (cfs) at Kiamichi River, Big Cedar.

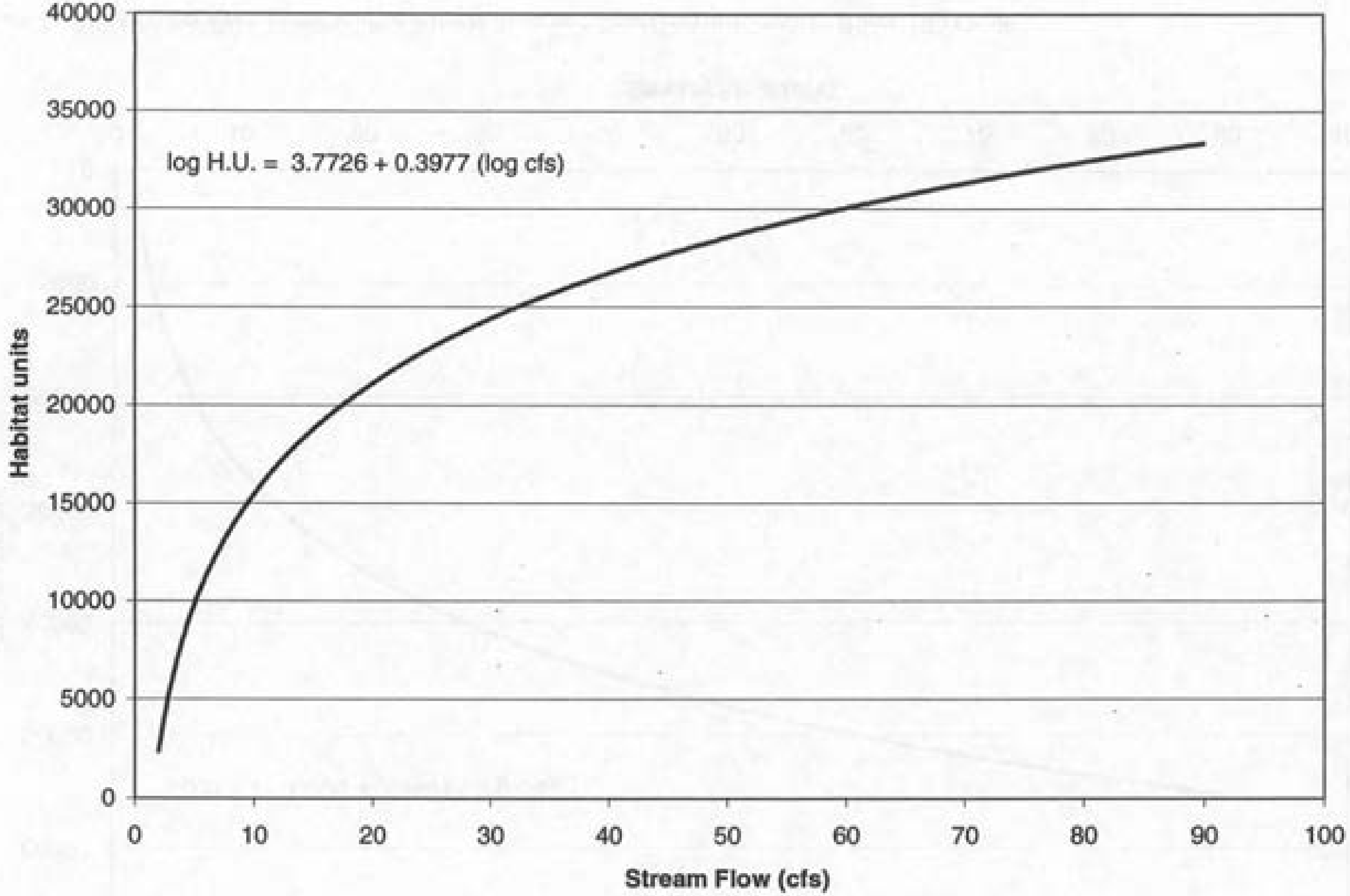

Figure 4. Relation between white crappie habitat units and flow (cfs) at Kiamichi River, Big Cedar.

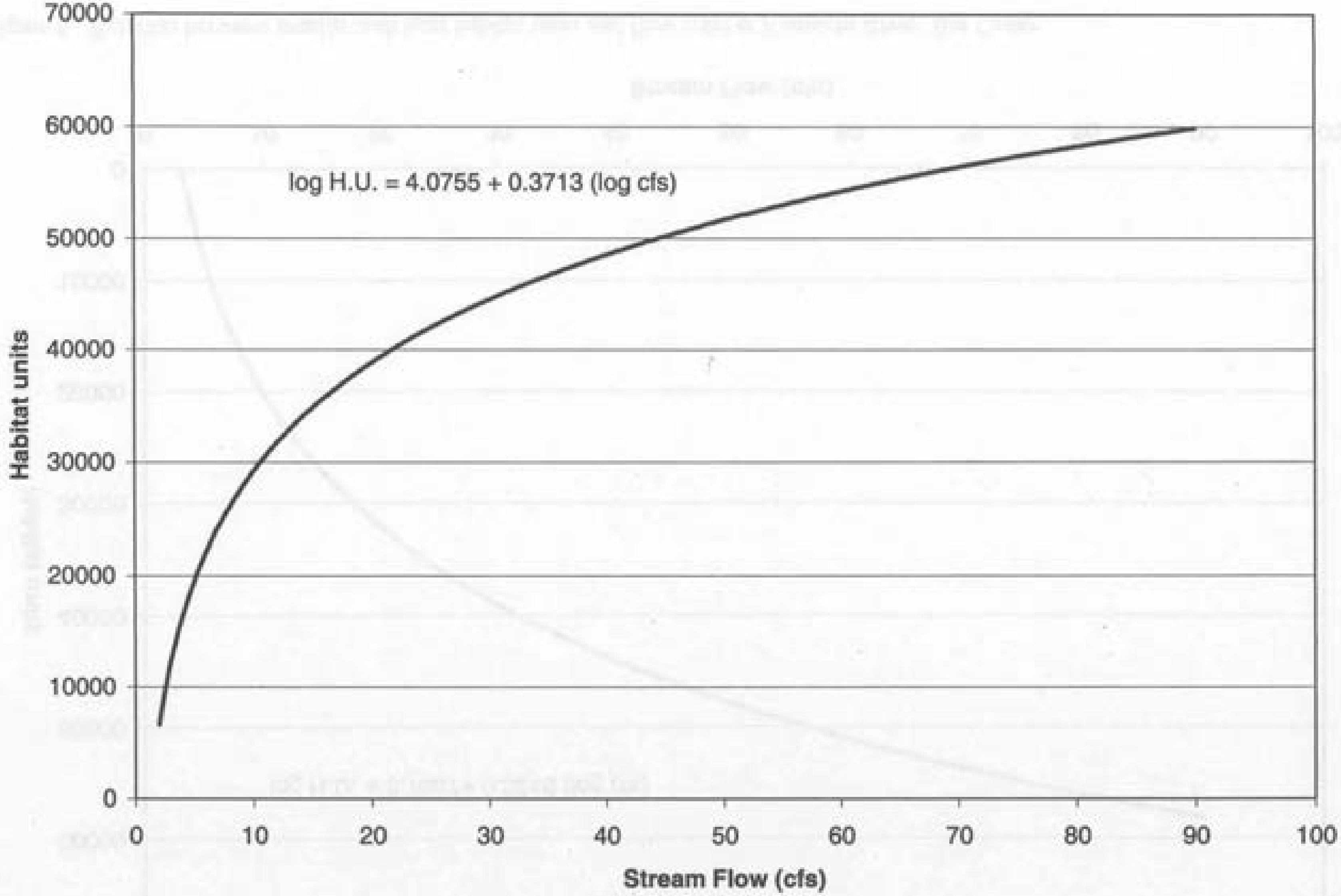

Figure 5. Relation between stoneroller habitat units and flow (cfs) at Kiamichi River, Big Cedar.

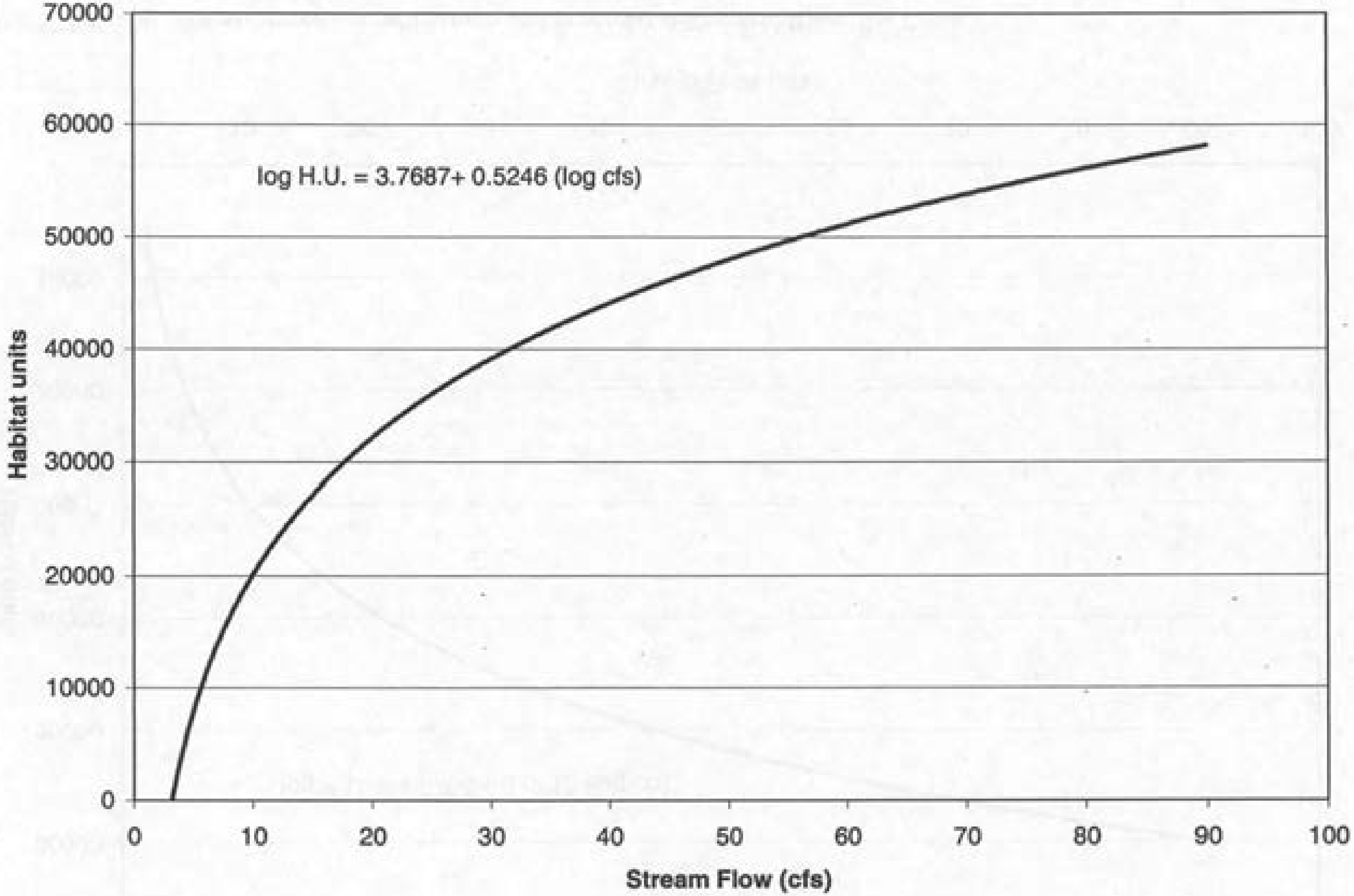

Figure 6. Relation between smallmouth bass habitat units and flow (cfs) at Kiamichi River, Big Cedar.

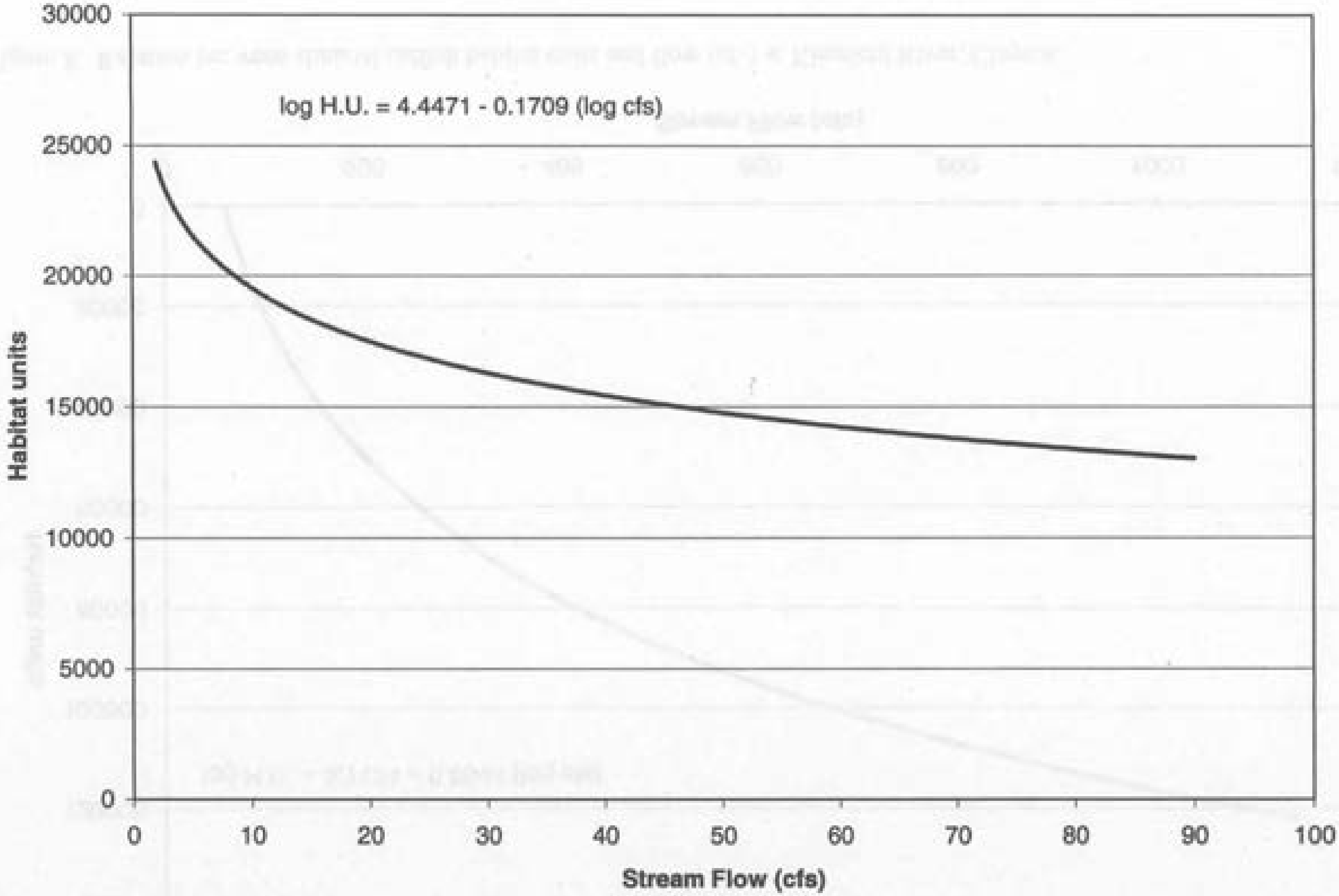

Figure 7. Relation between longear sunfish habitat units and flow (cfs) at Kiamichi River, Big Cedar.

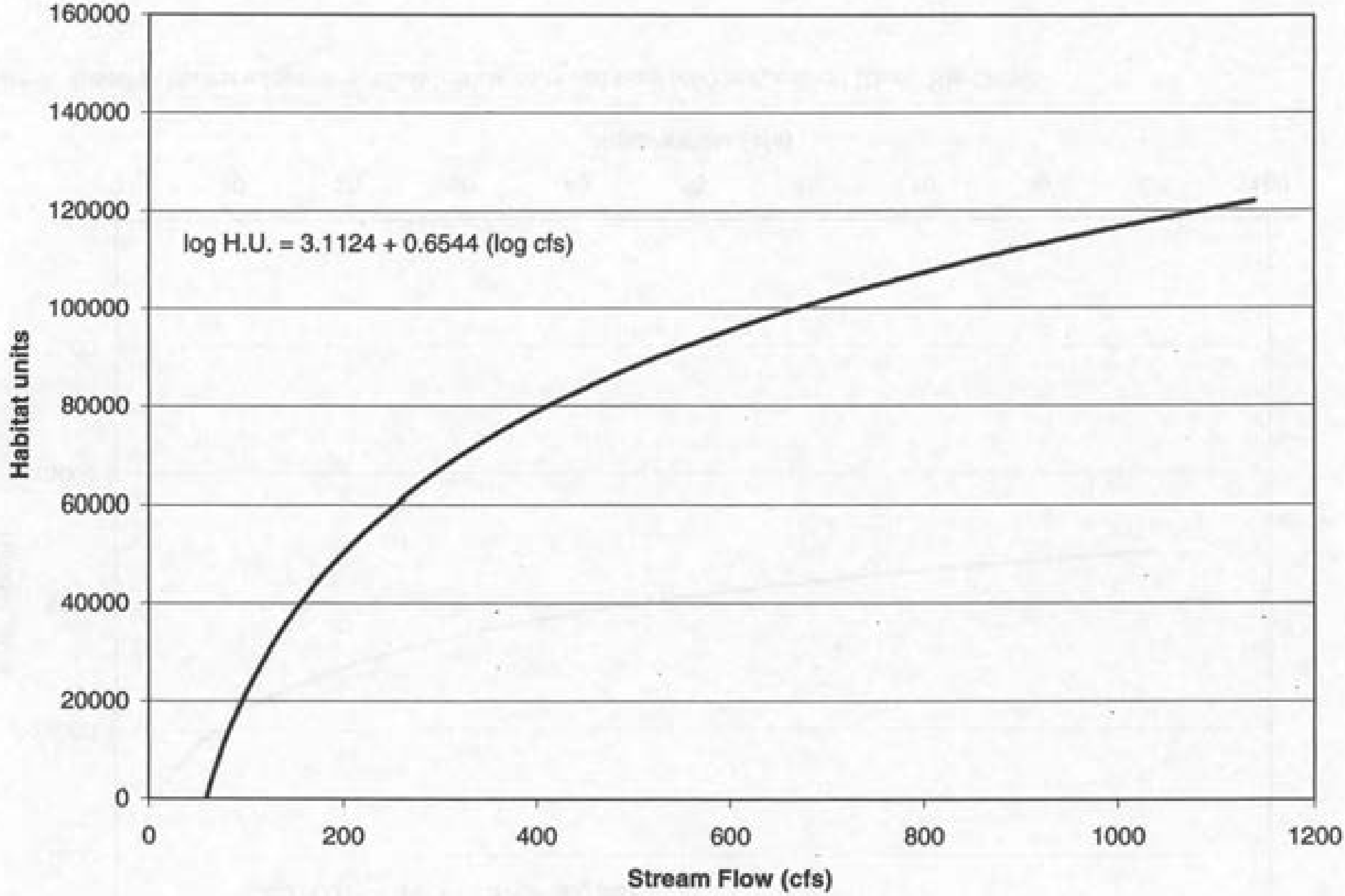

Figure 8. Relation between channel catfish habitat units and flow (cfs) at Kiamichi River, Clayton.

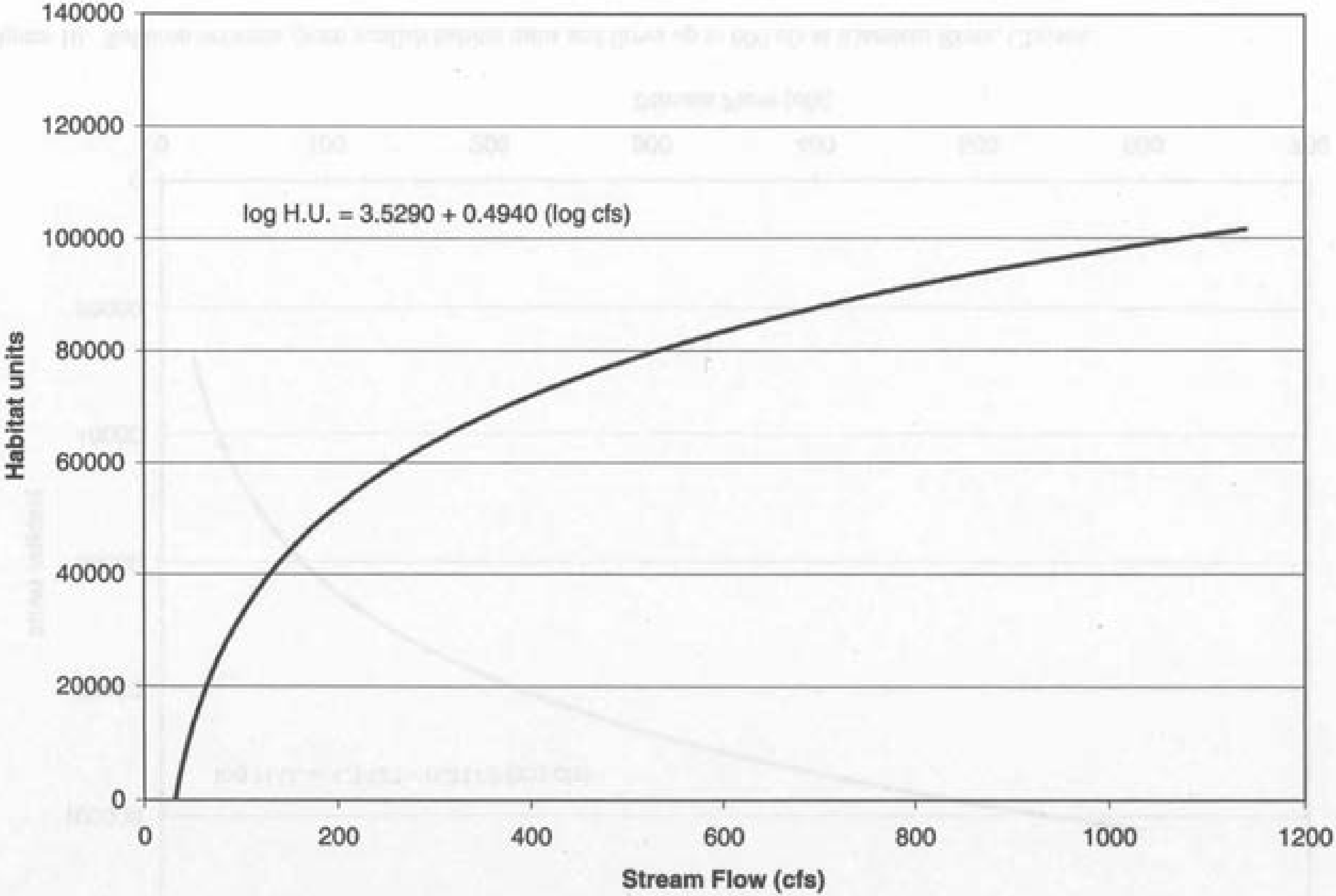

Figure 9. Relation between spotted bass habitat units and flow (cfs) at Kiamichi River, Clayton.

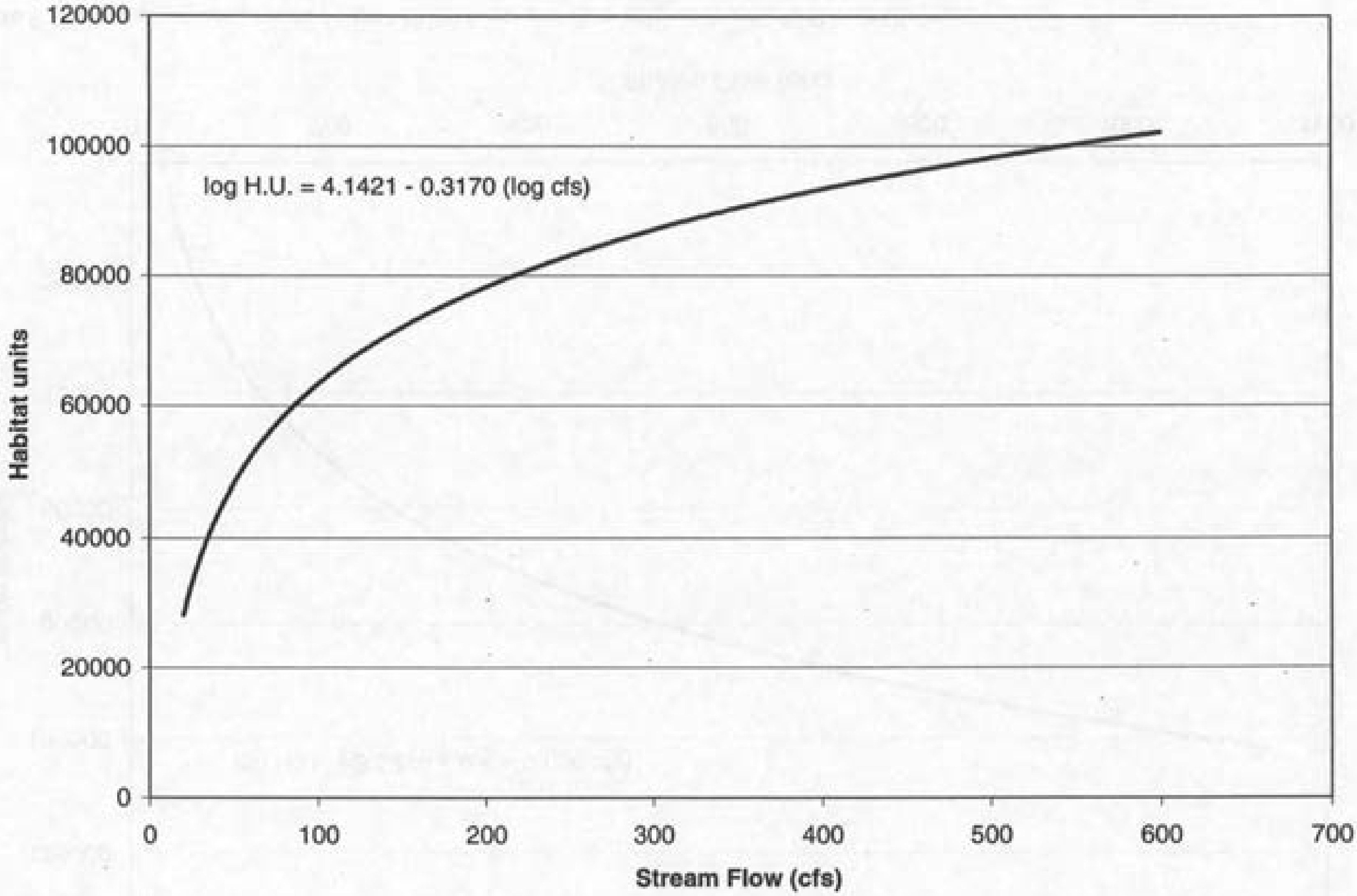

Figure 10. Relation between green sunfish habitat units and flows up to 600 cfs at Kiamichi River, Clayton.

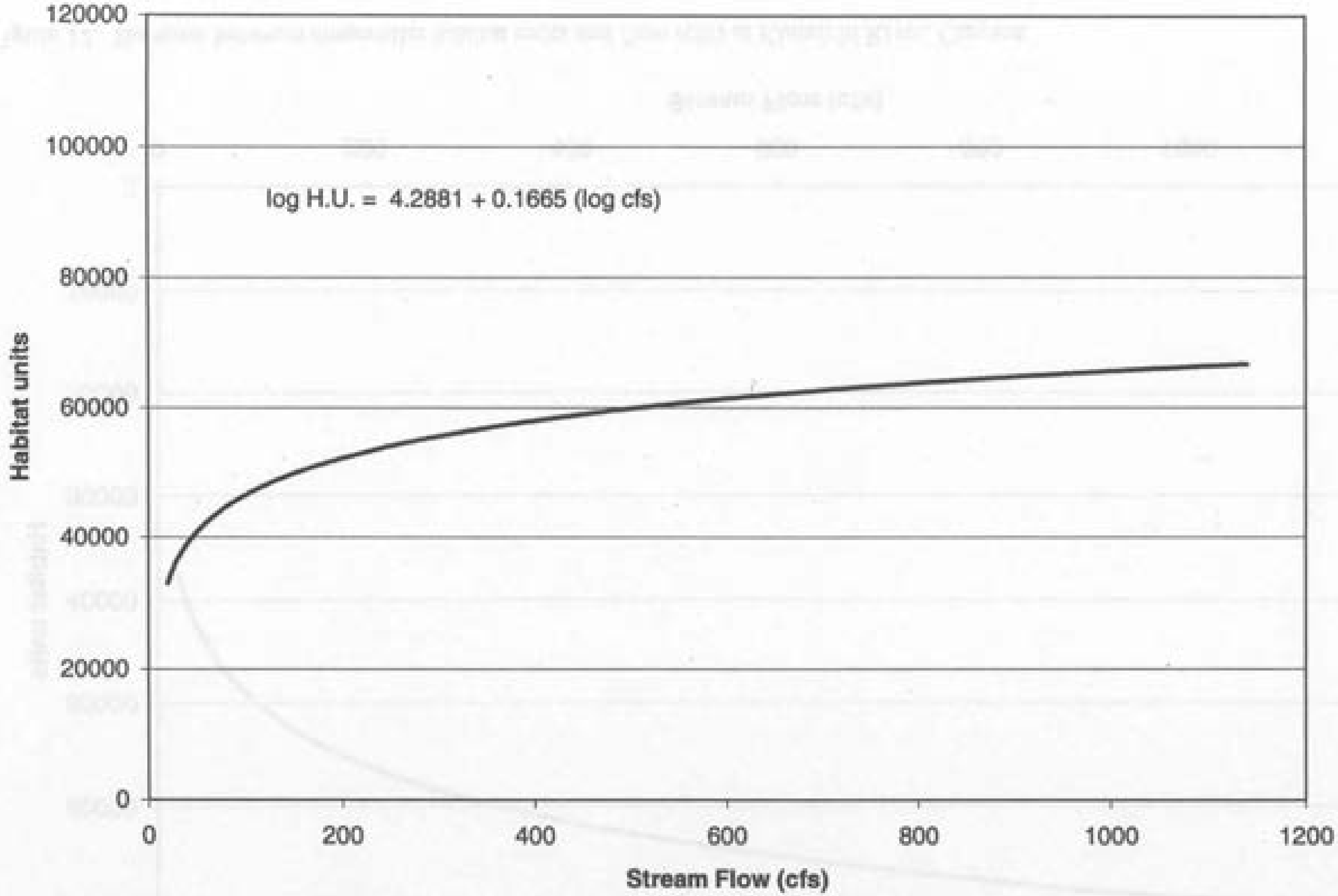

Figure 11. Relation between white crappie habitat units and flow (cfs) at Kiamichi River, Clayton.

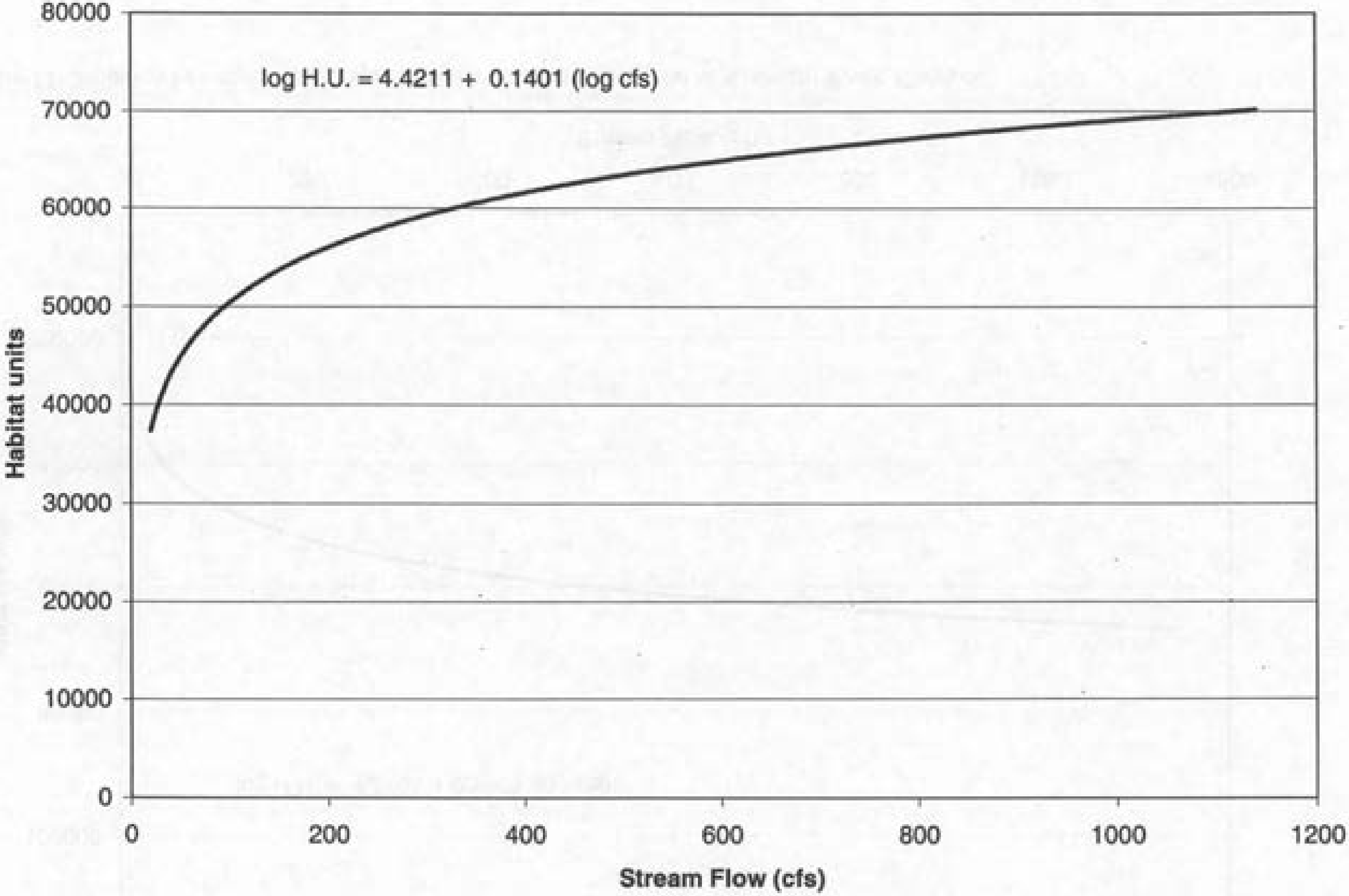

Figure 12. Relation between stoneroller habitat units and flow (cfs) at Kiamichi River, Clayton.

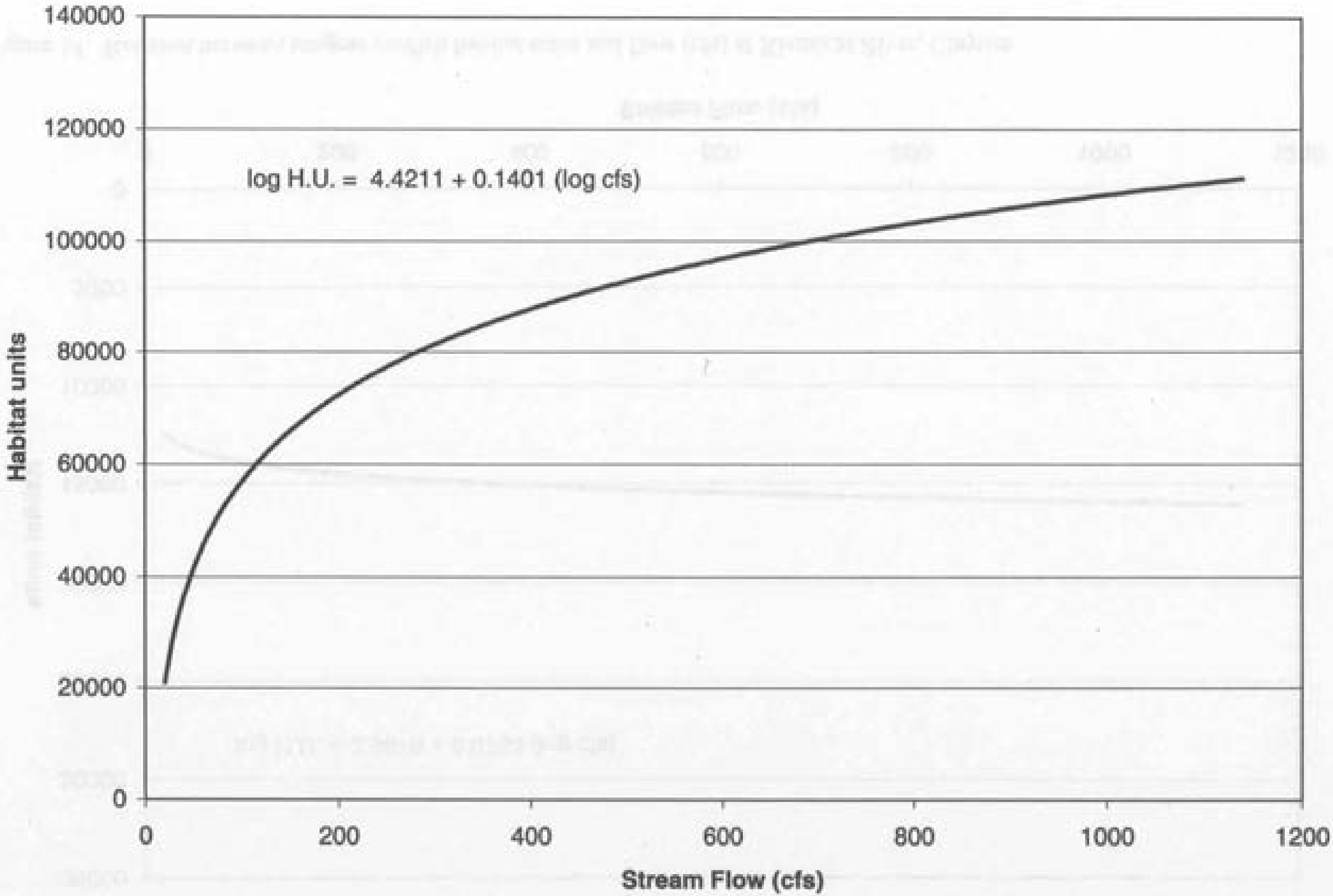

Figure 13. Relation between smallmouth bass habitat units and flow (cfs) at Kiamichi River, Clayton.

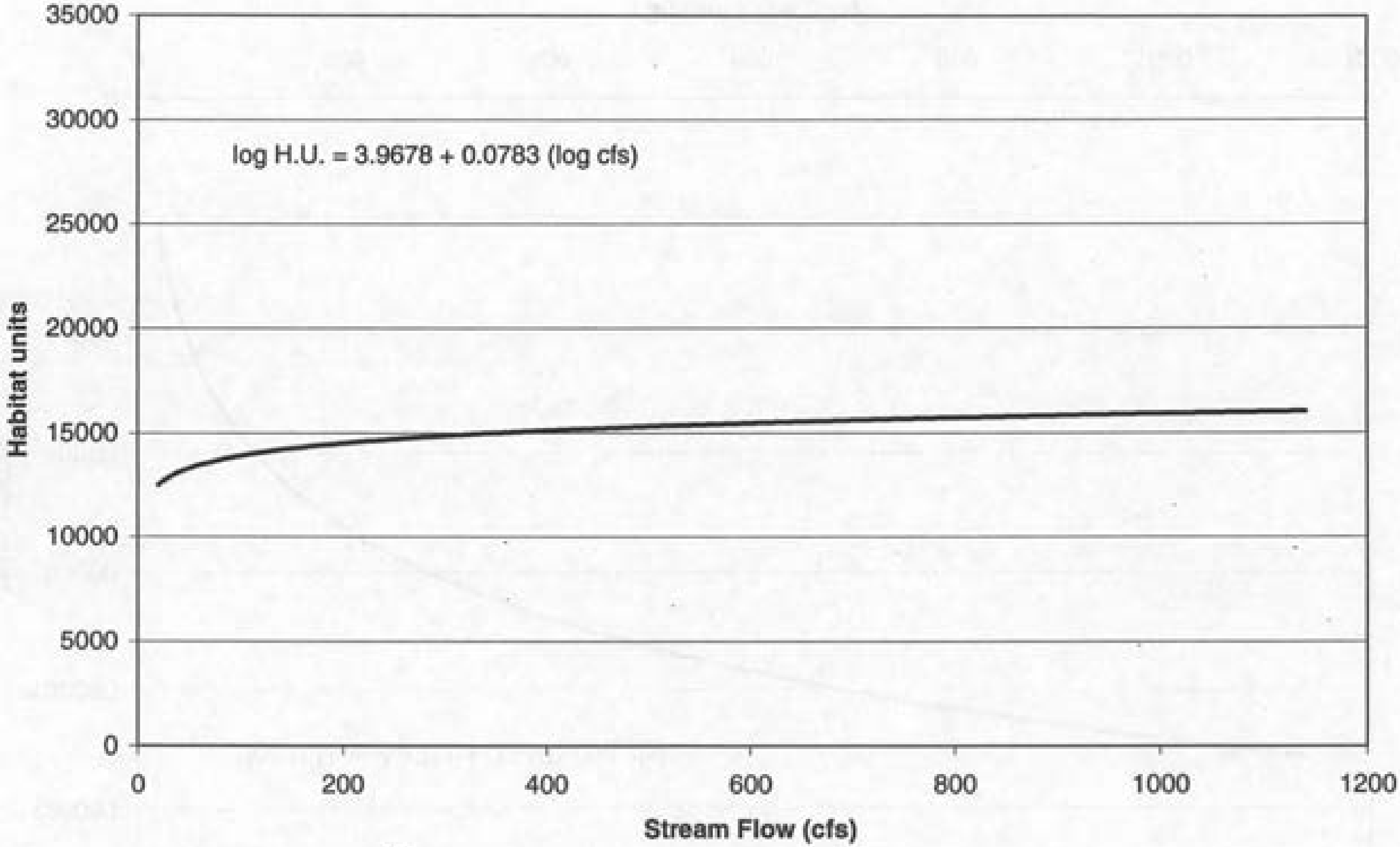

Figure 14. Relation between longear sunfish habitat units and flow (cfs) at Kiamichi River, Clayton.

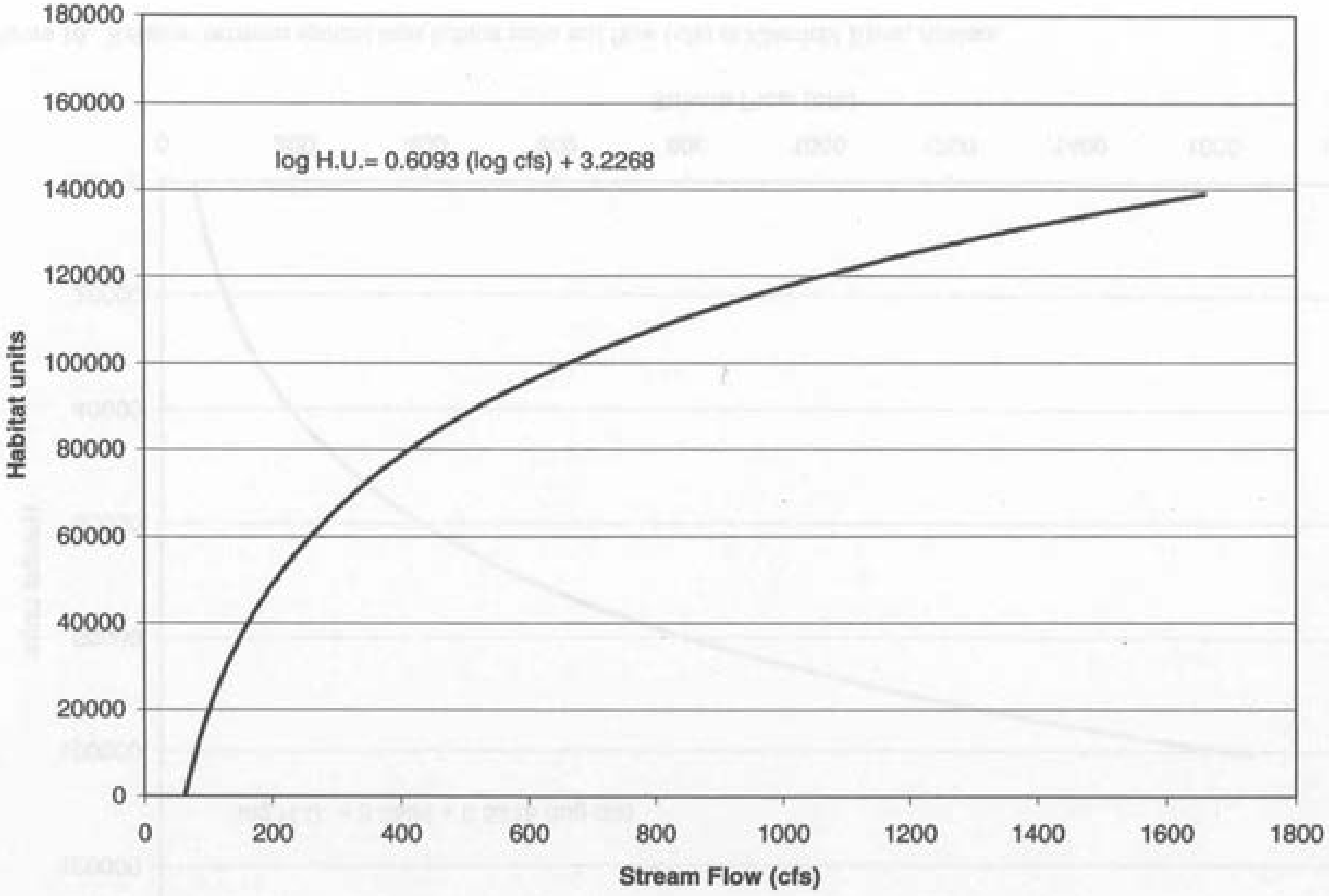

Figure 15. Relation between channel catfish habitat units and flow (cfs) at Kiamichi River, Antlers.

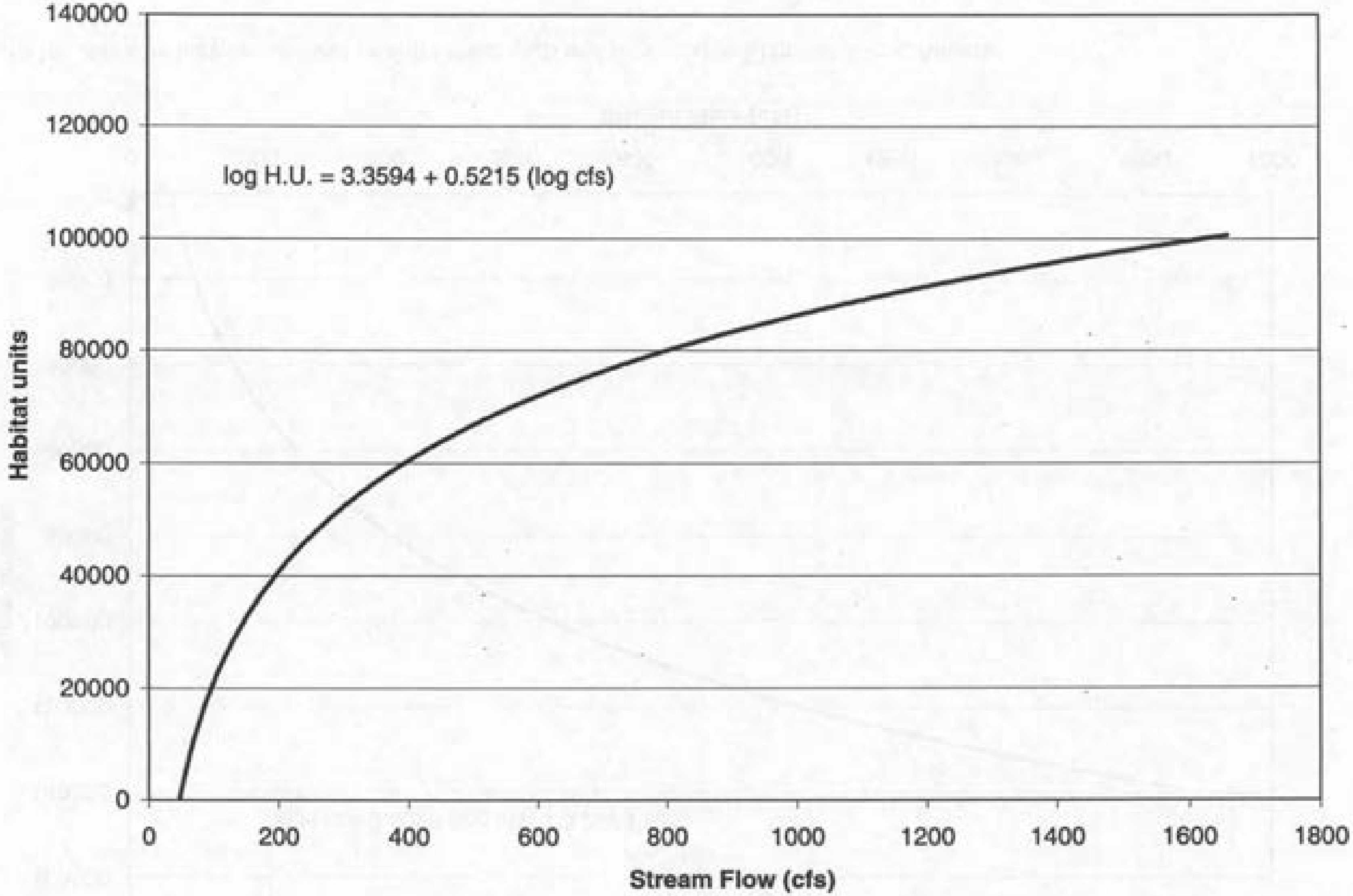

Figure 16. Relation between spotted bass habitat units and flow (cfs) at Kiamichi River, Antlers.

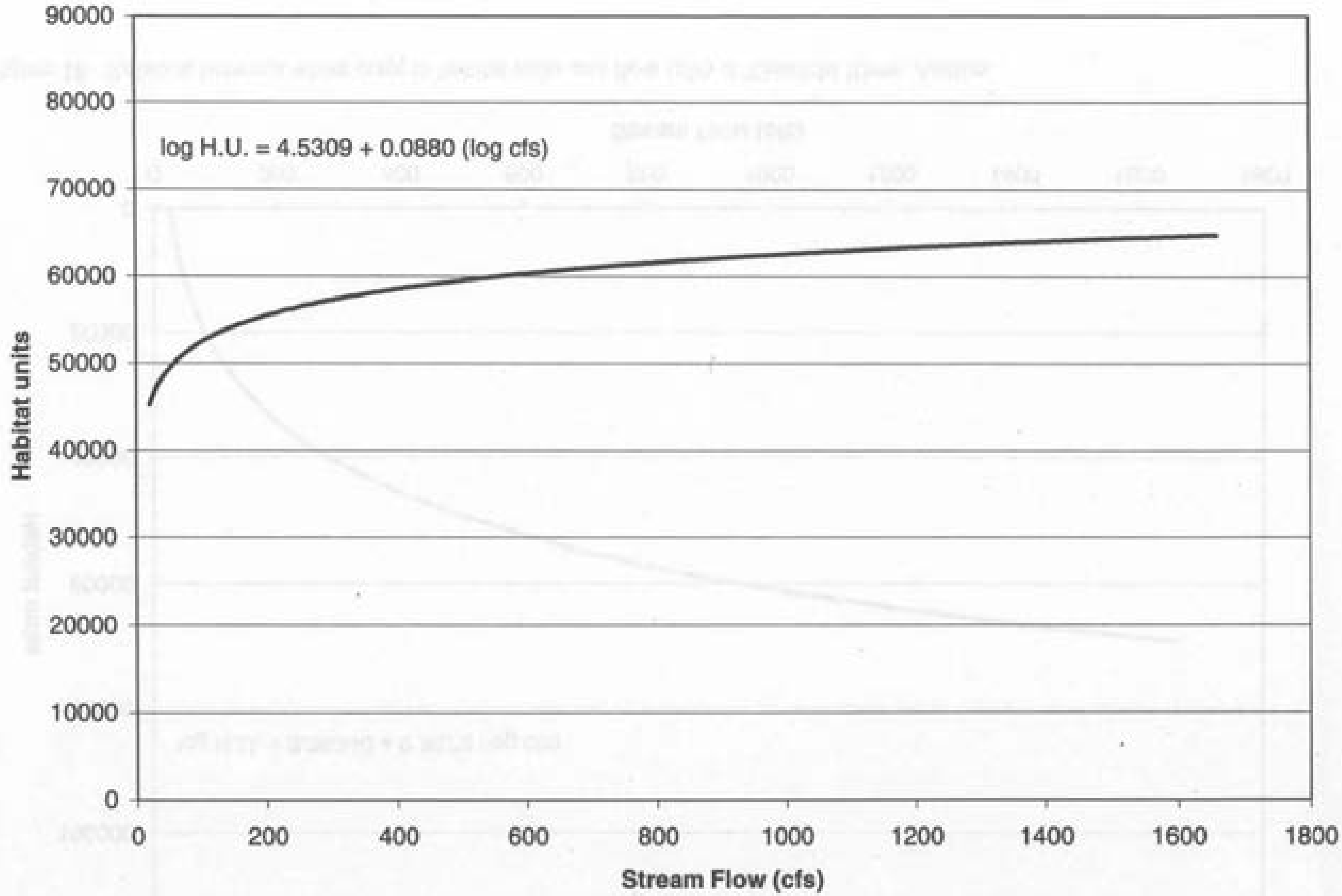

Figure 17. Relation between green sunfish habitat units and flow (cfs) at Kiamichi River, Antlers.

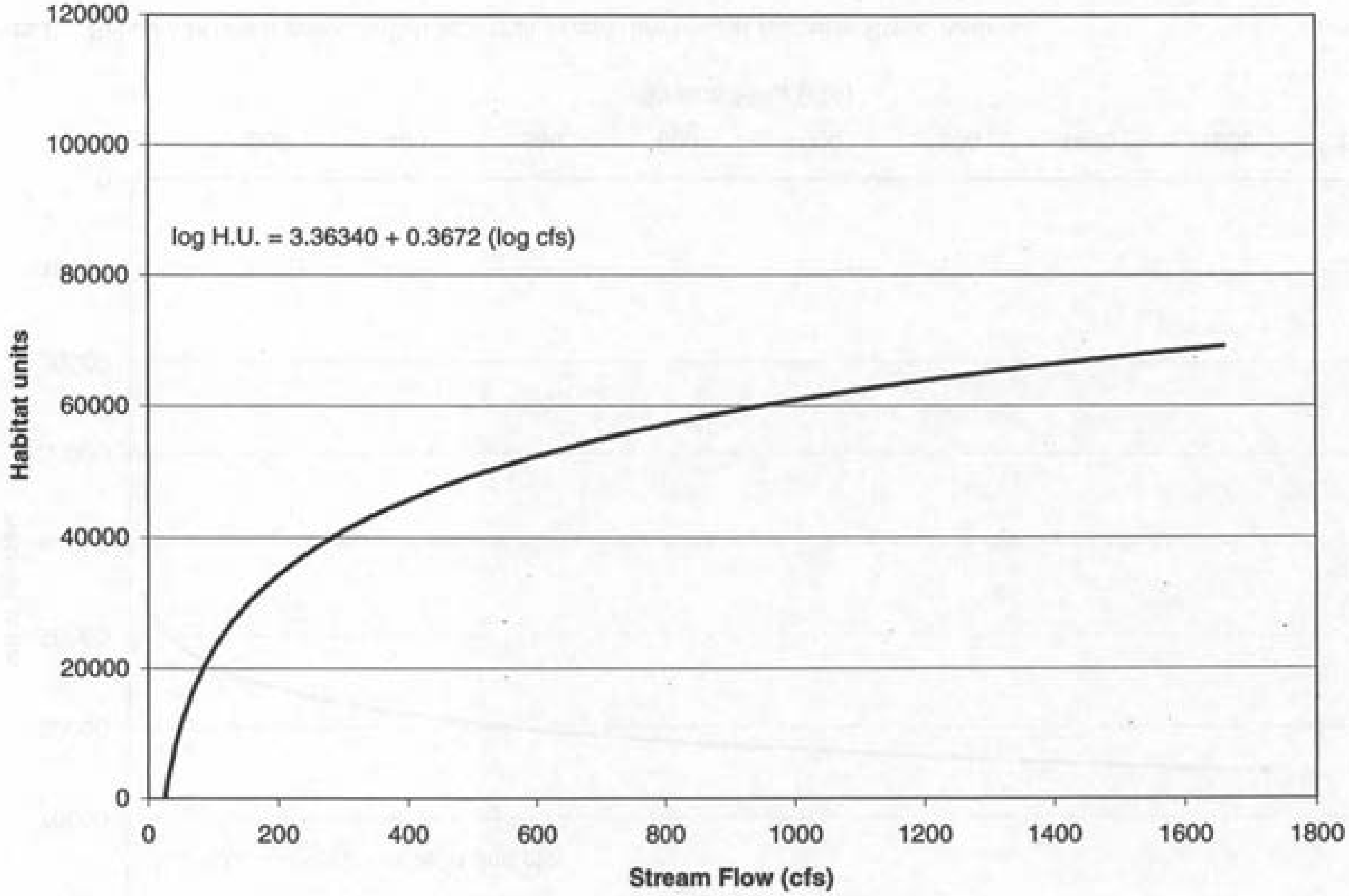

Figure 18. Relation between white crappie habitat units and flow (cfs) at Kiamichi River, Antlers.

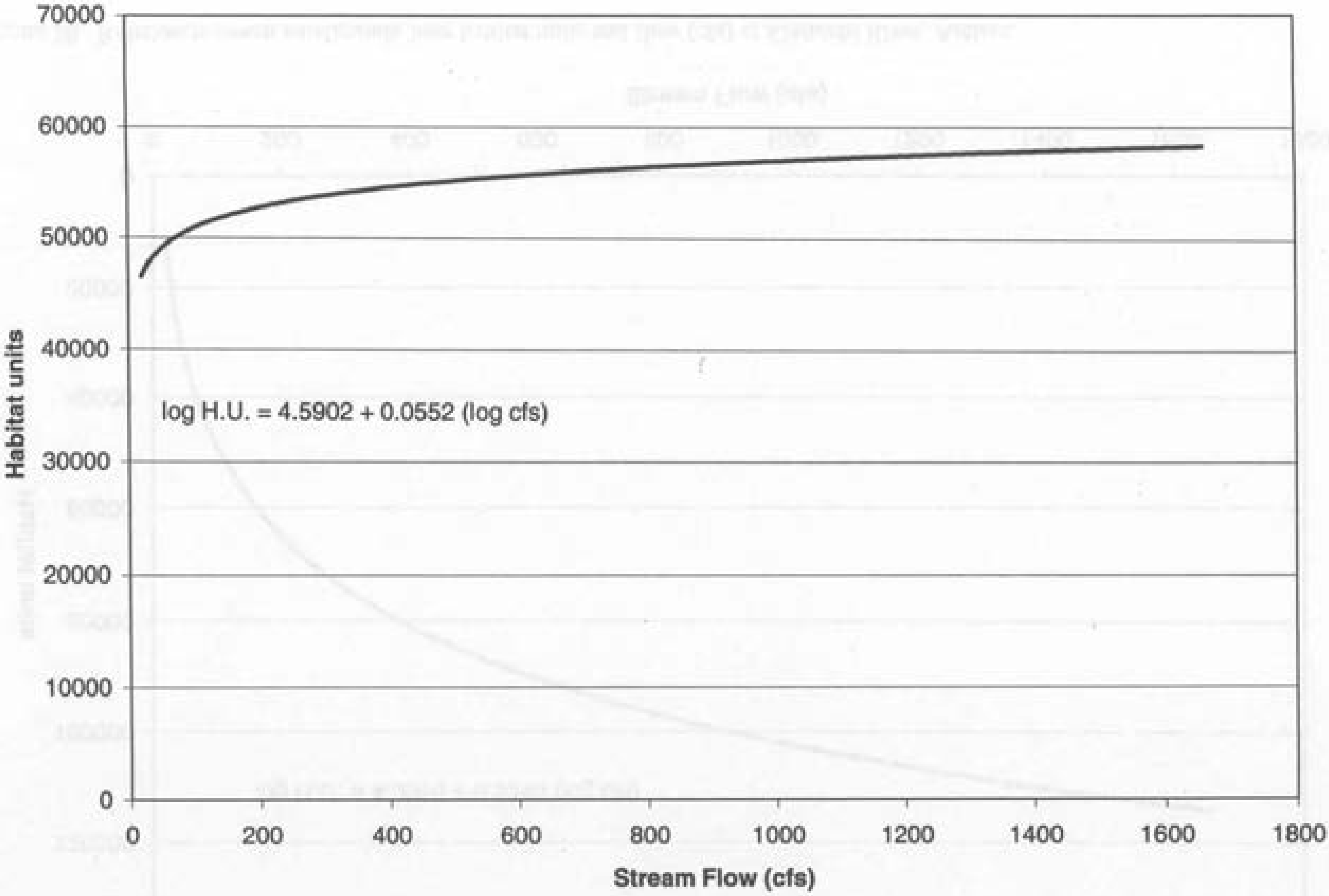

Figure 19. Relation between stoneroller habitat units and flow (cfs) at Kiamichi River, Antlers.

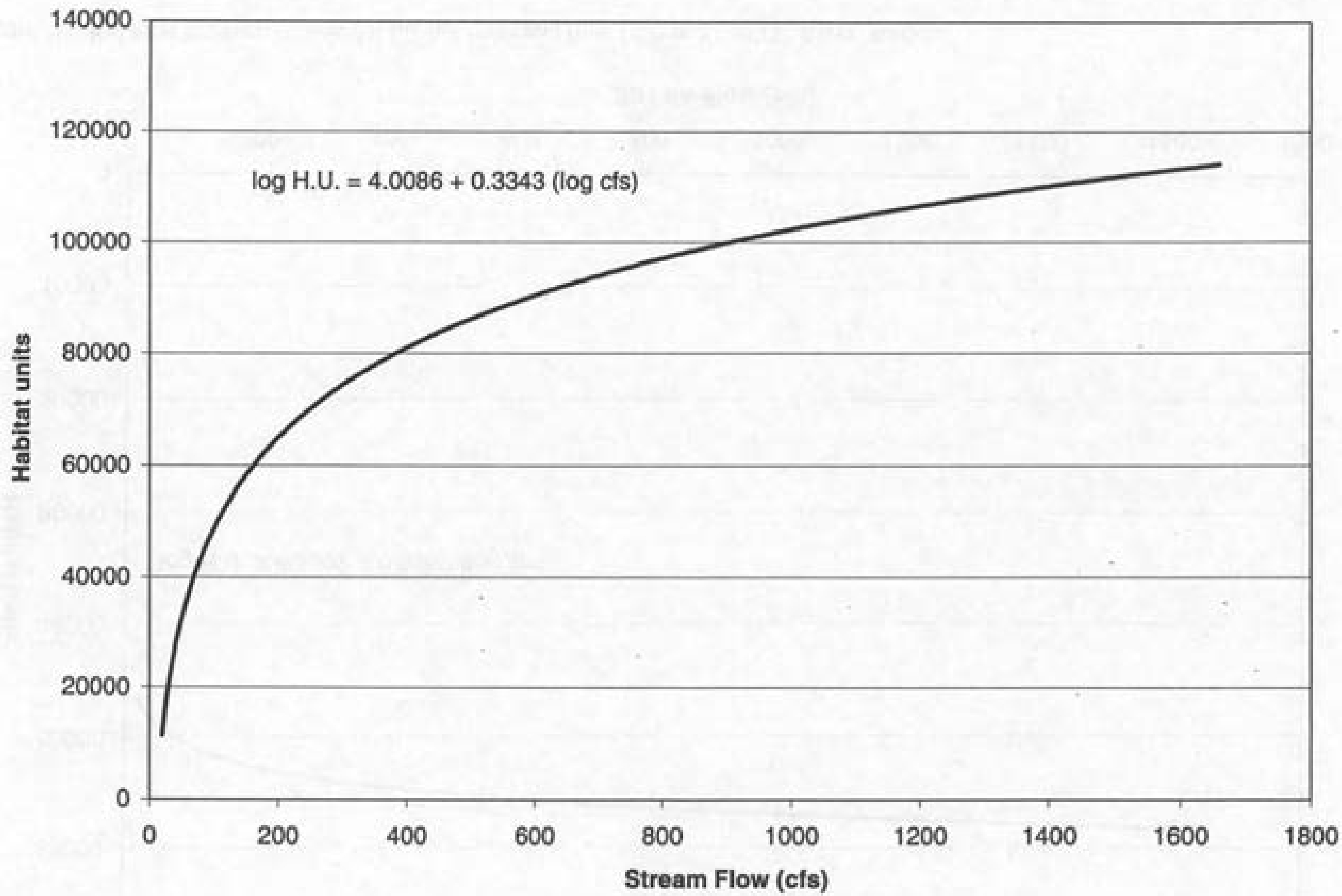

Figure 20. Relation between smallmouth bass habitat units and flow (cfs) at Kiamichi River, Antlers.

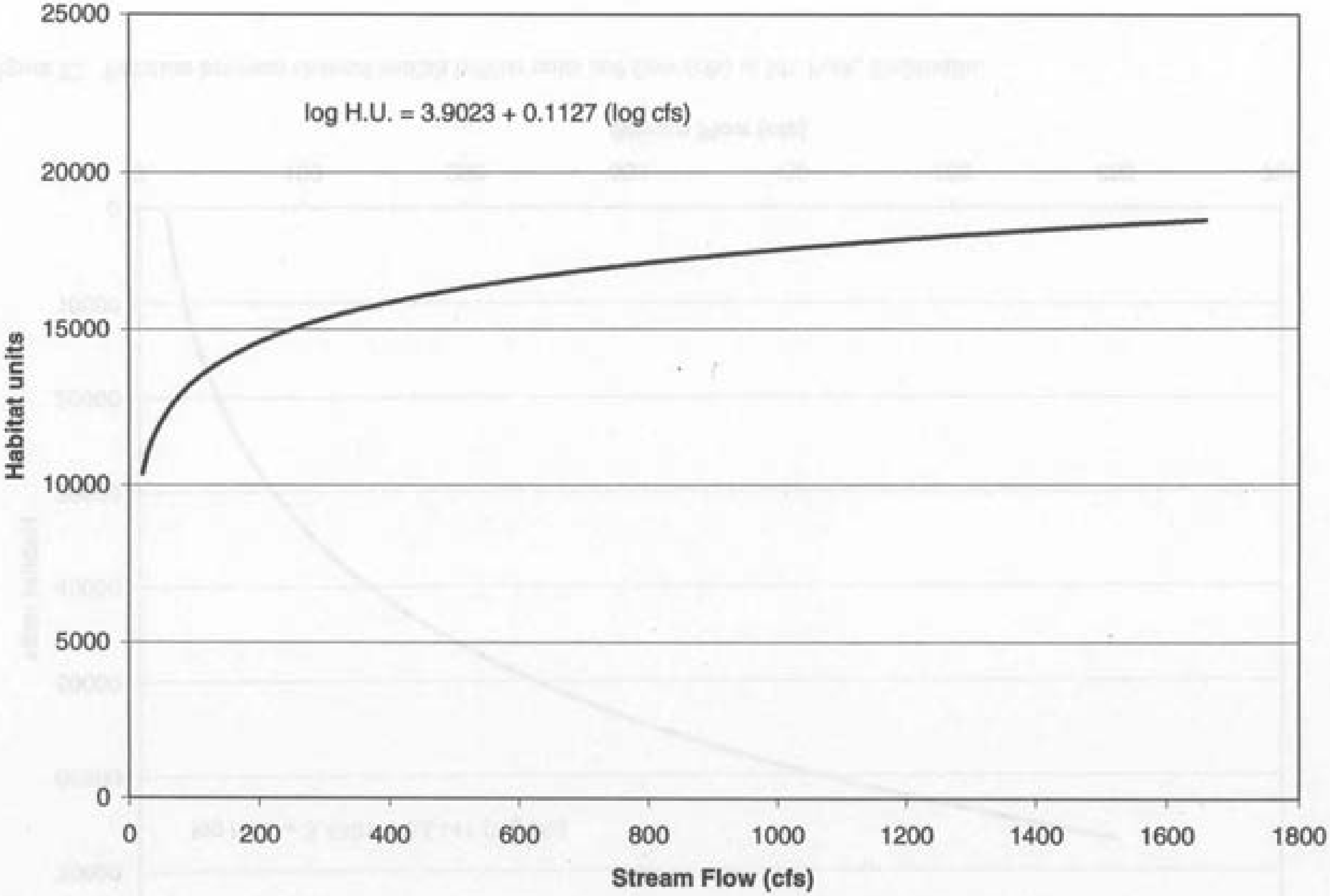

Figure 21. Relation between longear sunfish habitat units and flow (cfs) at Kiamichi River, Antlers.

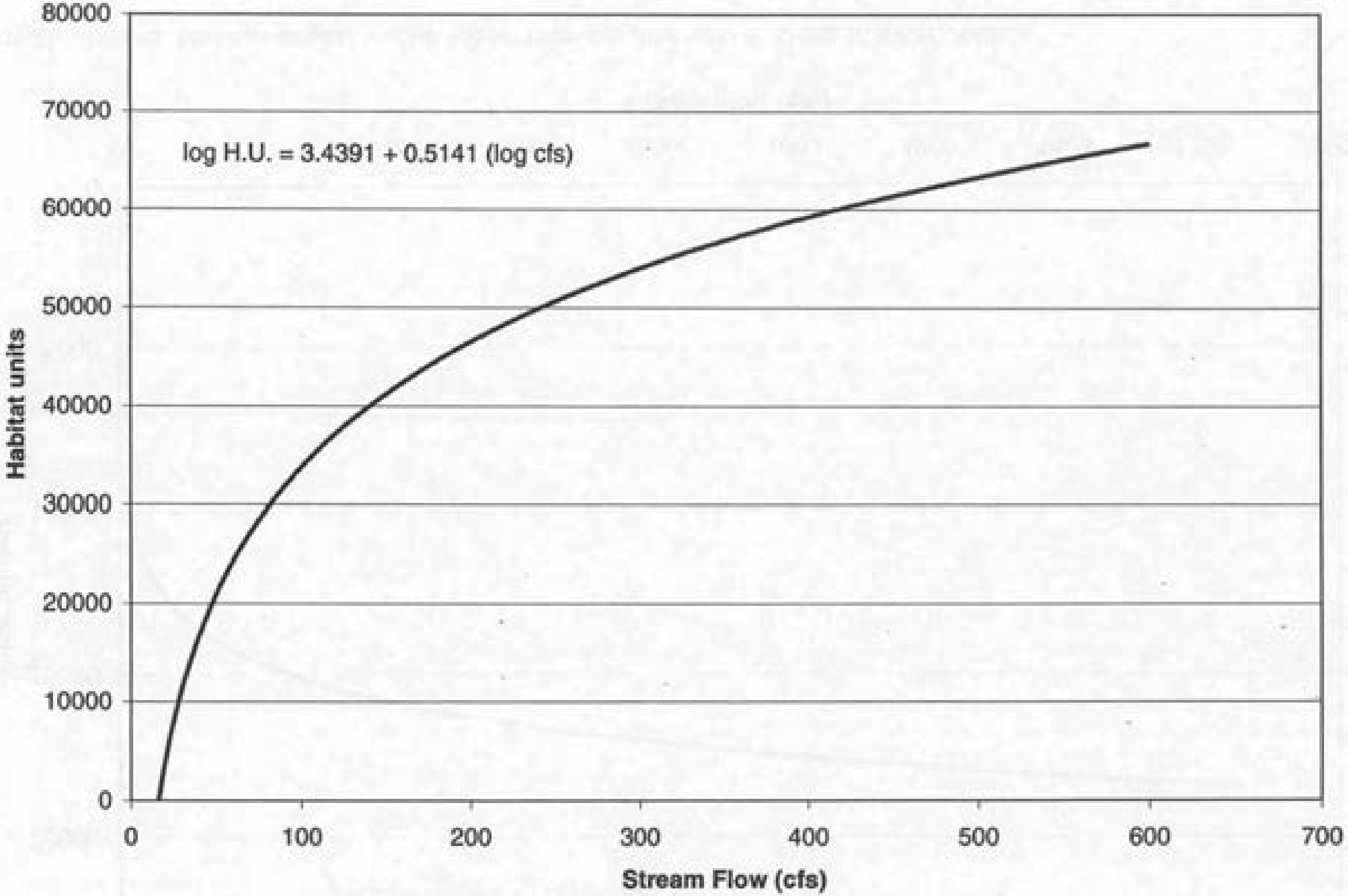

Figure 22. Relation between channel catfish habitat units and flow (cfs) at Mt. Fork, Smithville.

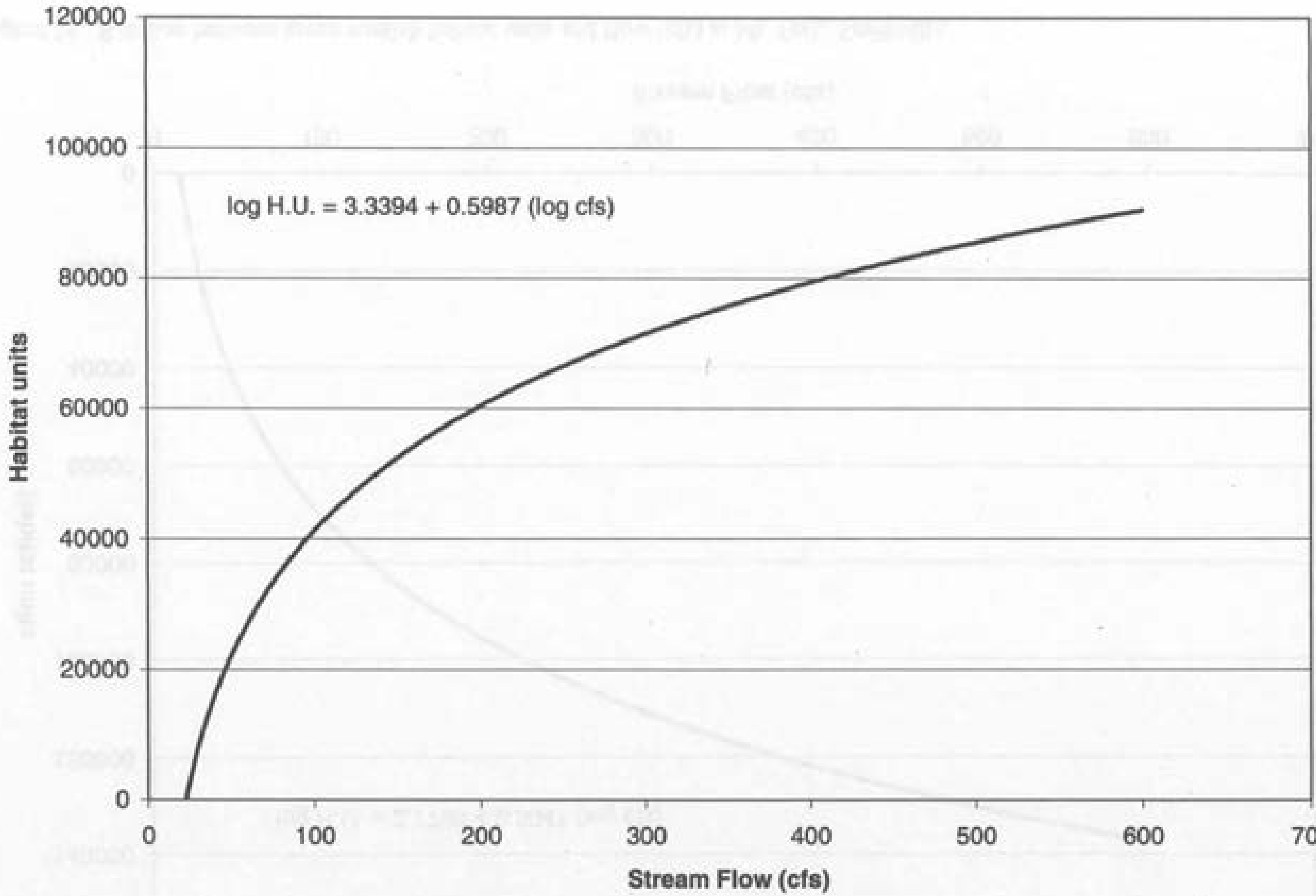

Figure 23. Relation between spotted bass habitat units and flow (cfs) at Mt. Fork, Smithville.

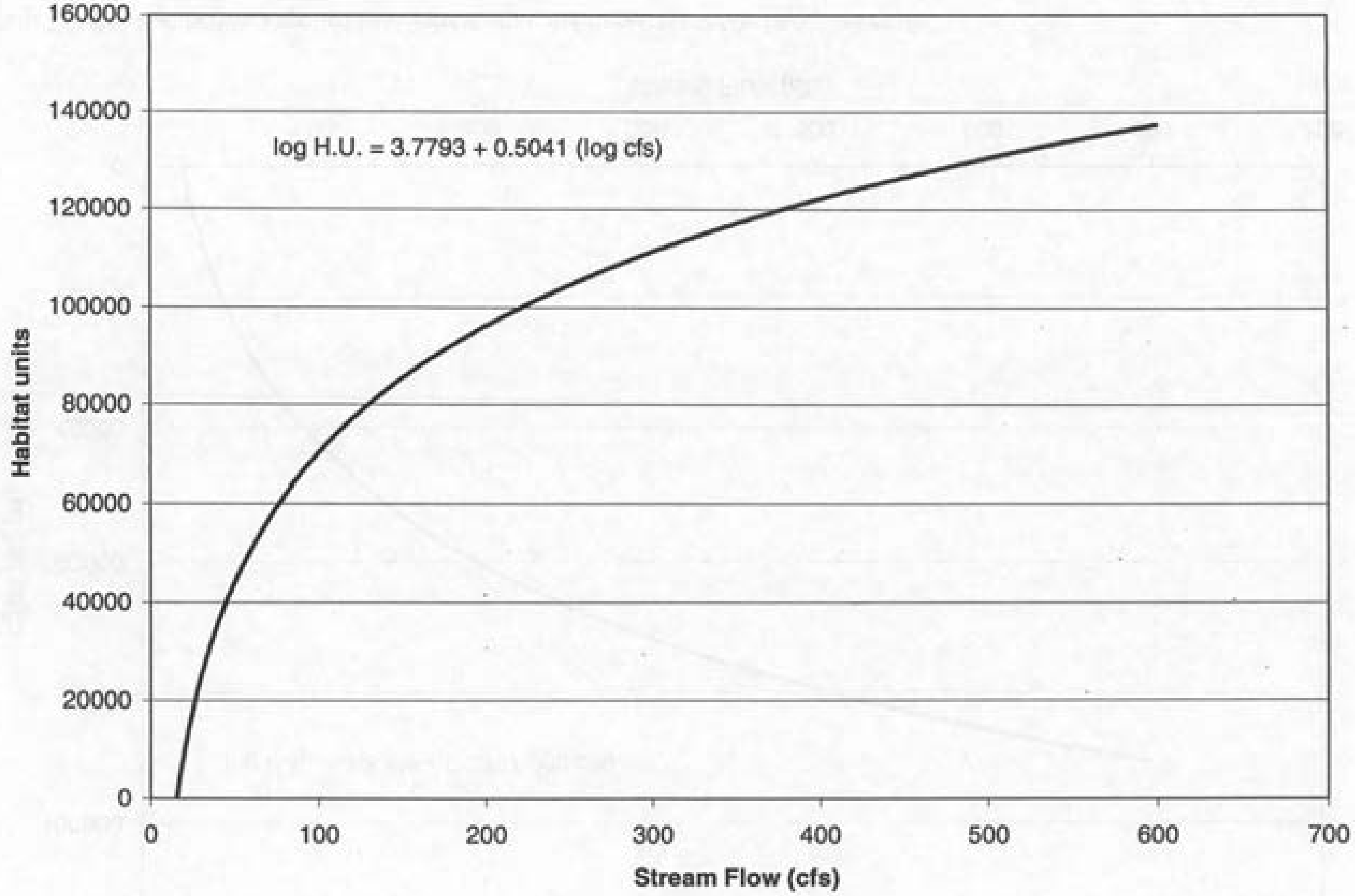

Figure 24. Relation between green sunfish habitat units and flow (cfs) at Mt. Fork, Smithville.

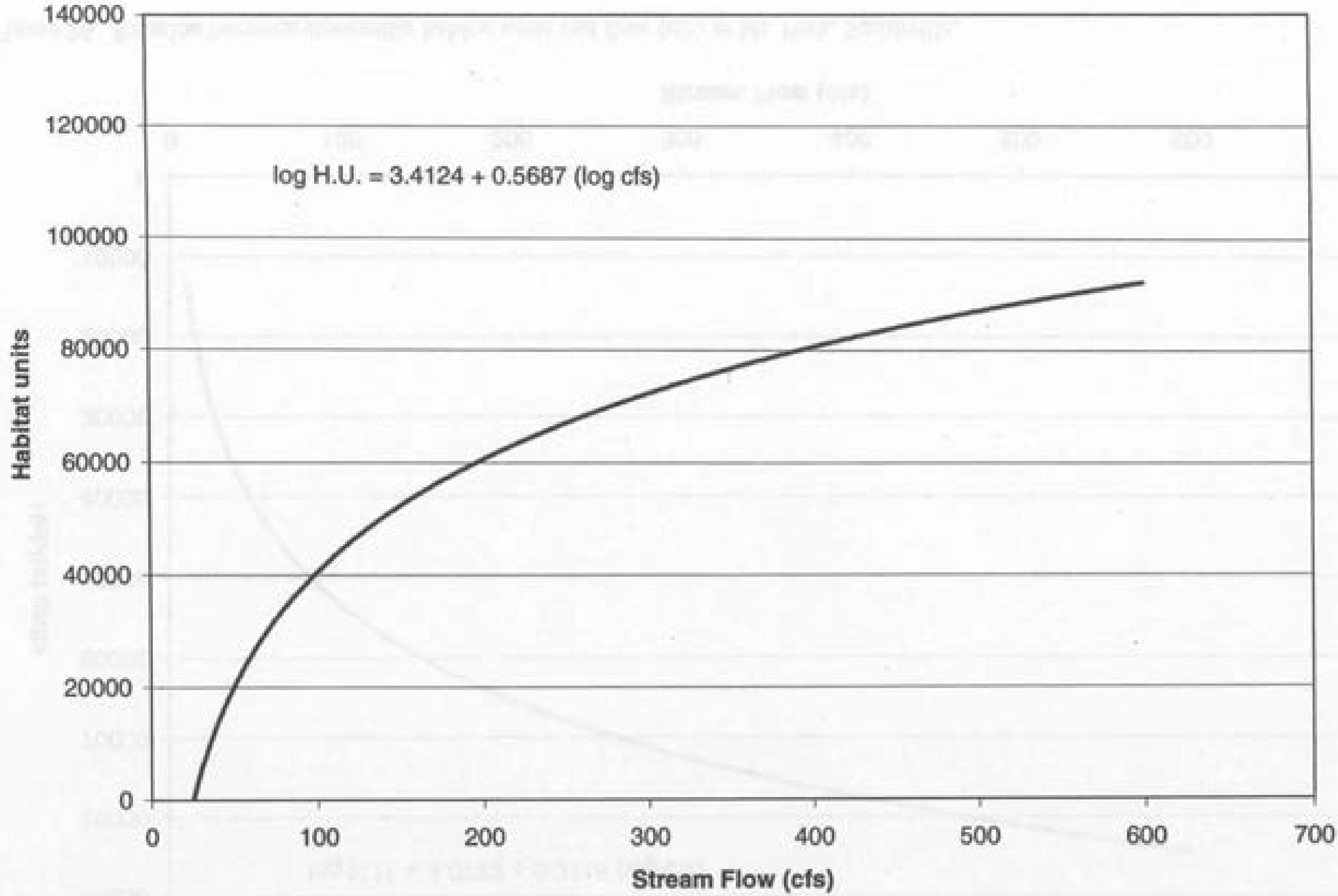

Figure 25. Relation between white crappie habitat units and flow (cfs) at Mt. Fork, Smithville.

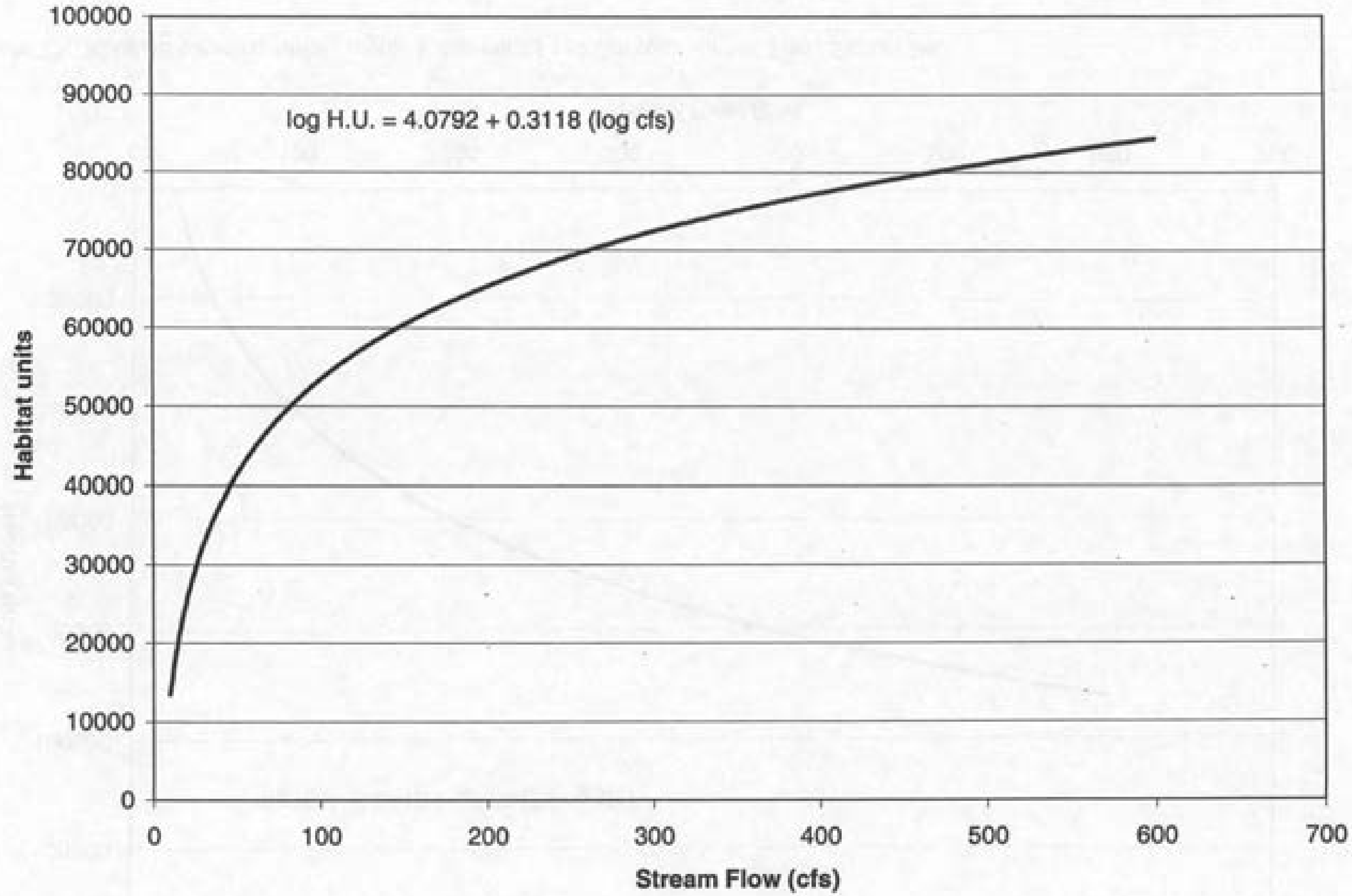

Figure 26. Relation between stoneroller habitat units and flow (cfs) at Mt. Fork, Smithville.

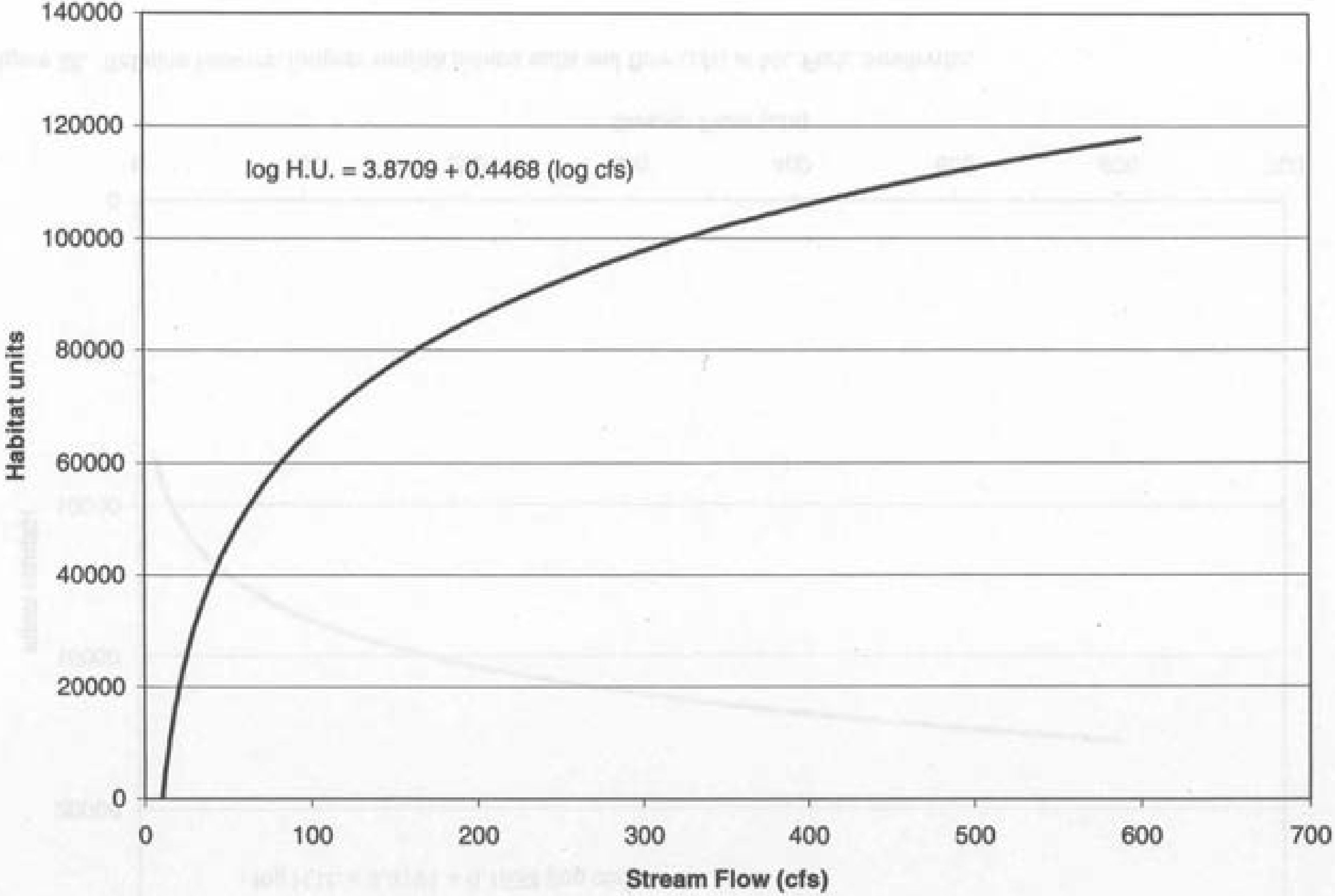

Figure 27. Relation between smallmouth bass habitat units and flow (cfs) at Mt. Fork, Smithville.

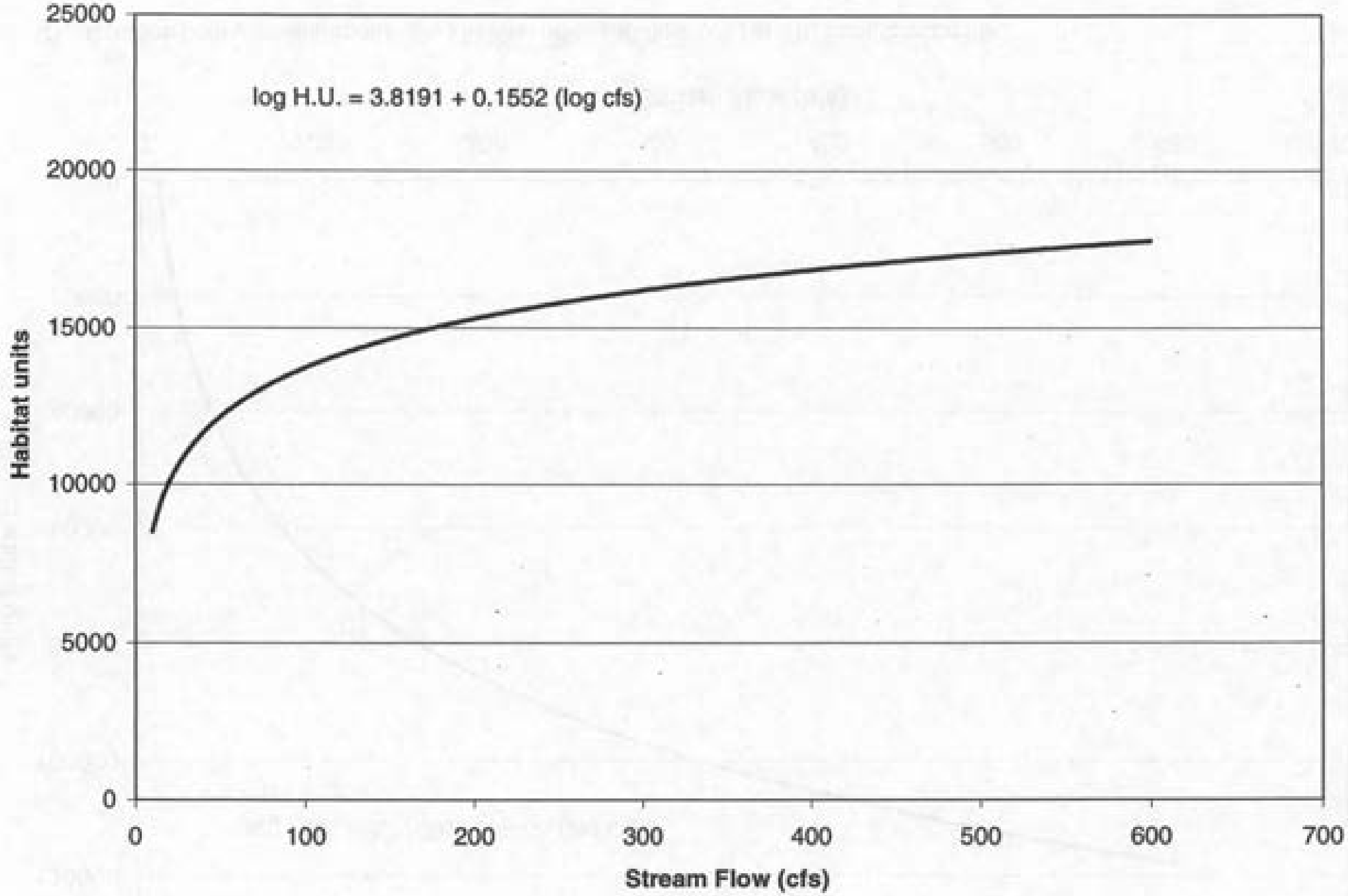

Figure 28. Relation between longear sunfish habitat units and flow (cfs) at Mt. Fork, Smithville.

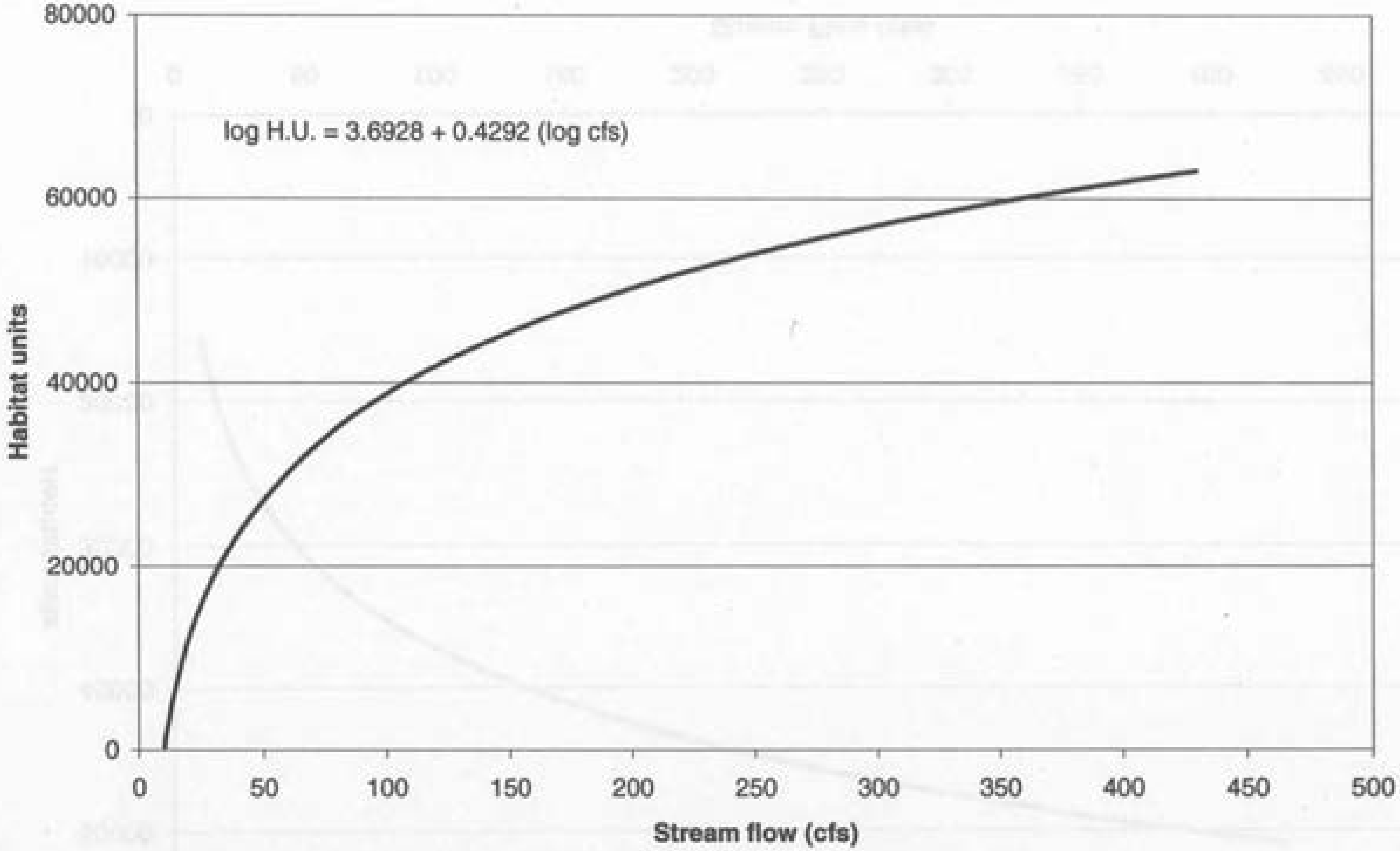

Figure 29. Relation between channel catfish habitat units and flow (cfs) at Glover River, Glover.

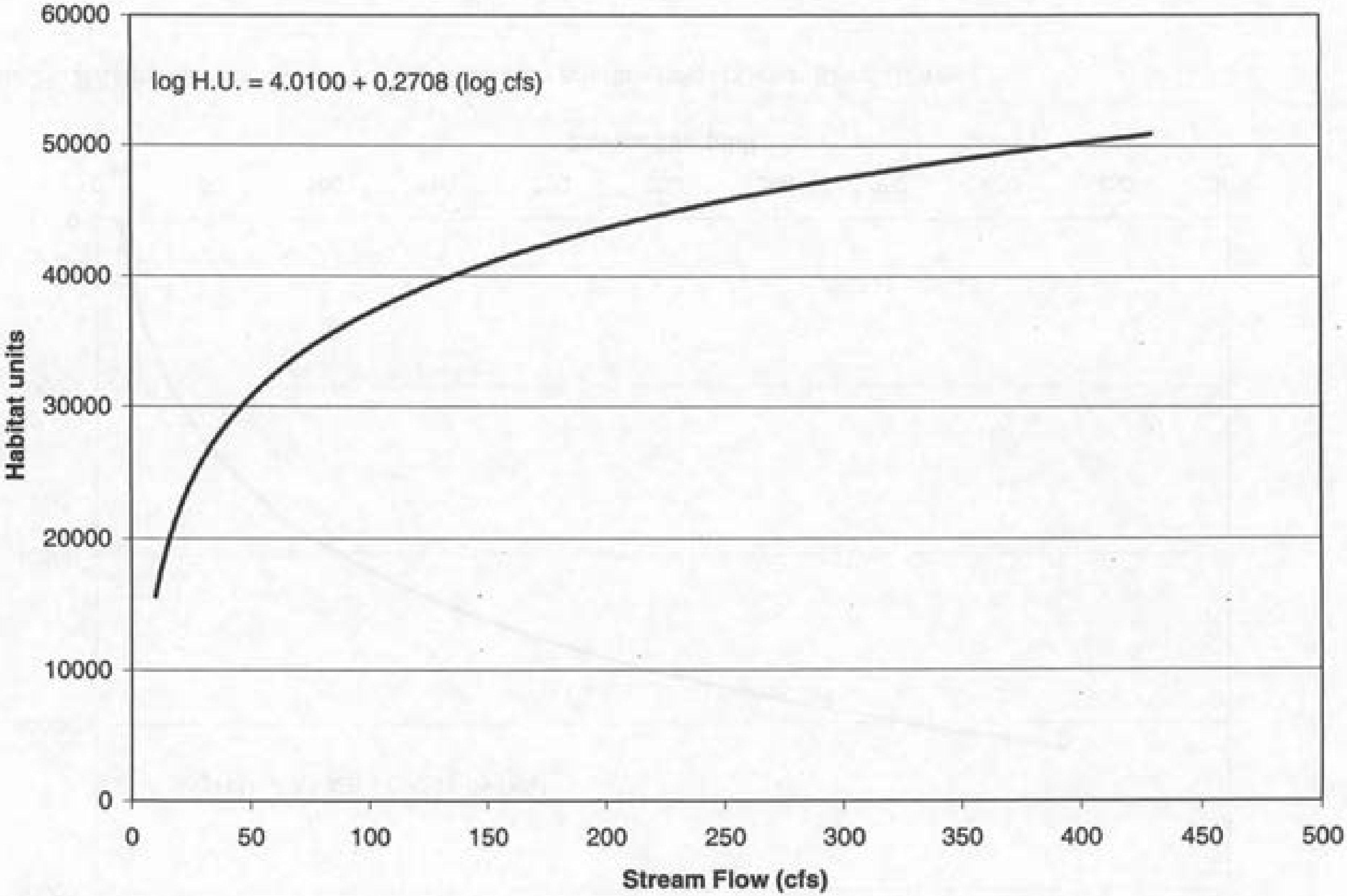

Figure 30. Relation between spotted bass habitat units and flow (cfs) at Glover River, Glover.

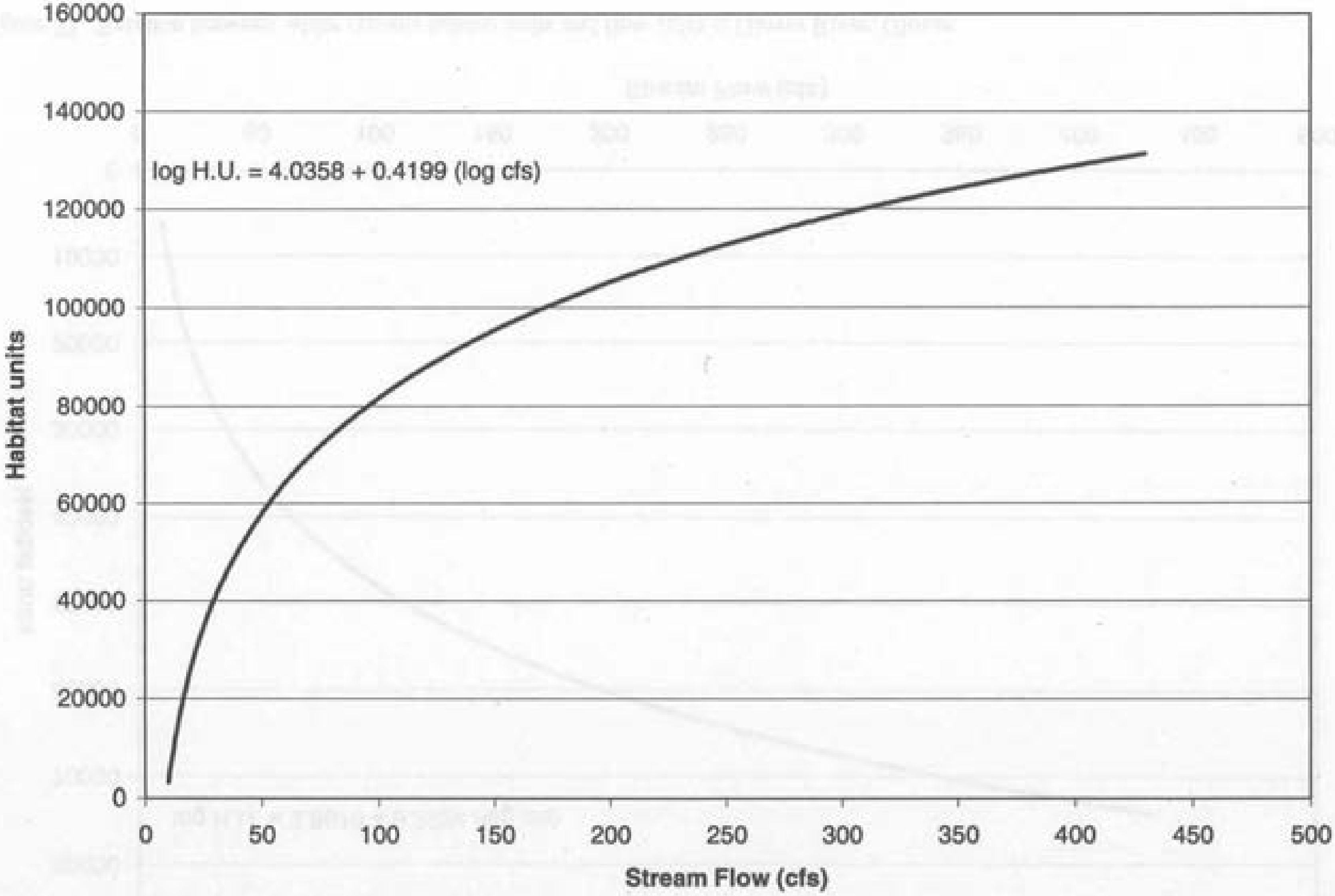

Figure 31. Relation between green sunfish habitat units and flow (cfs) at Glover River, Glover.

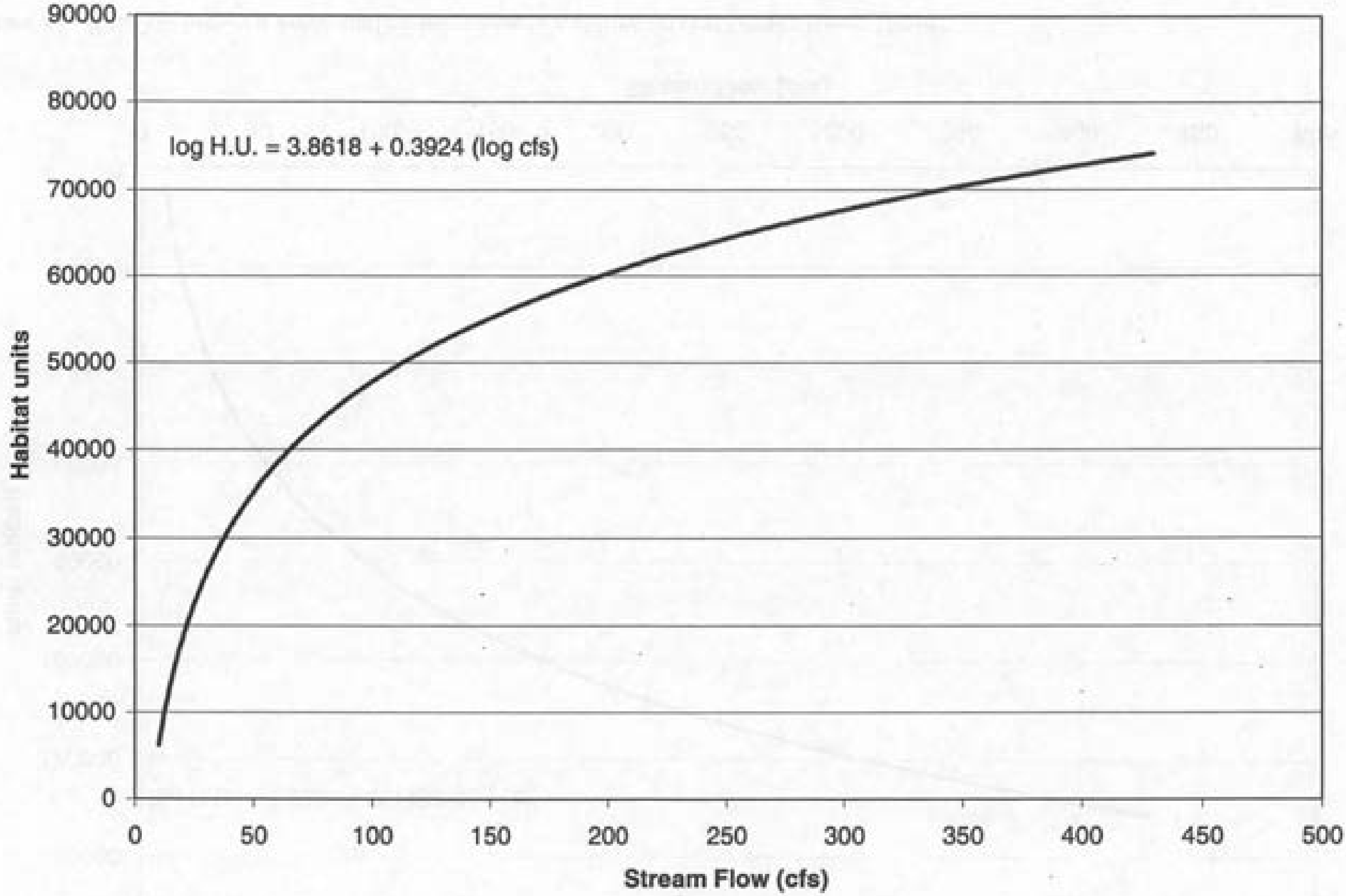

Figure 32. Relation between white crappie habitat units and flow (cfs) at Glover River, Glover.

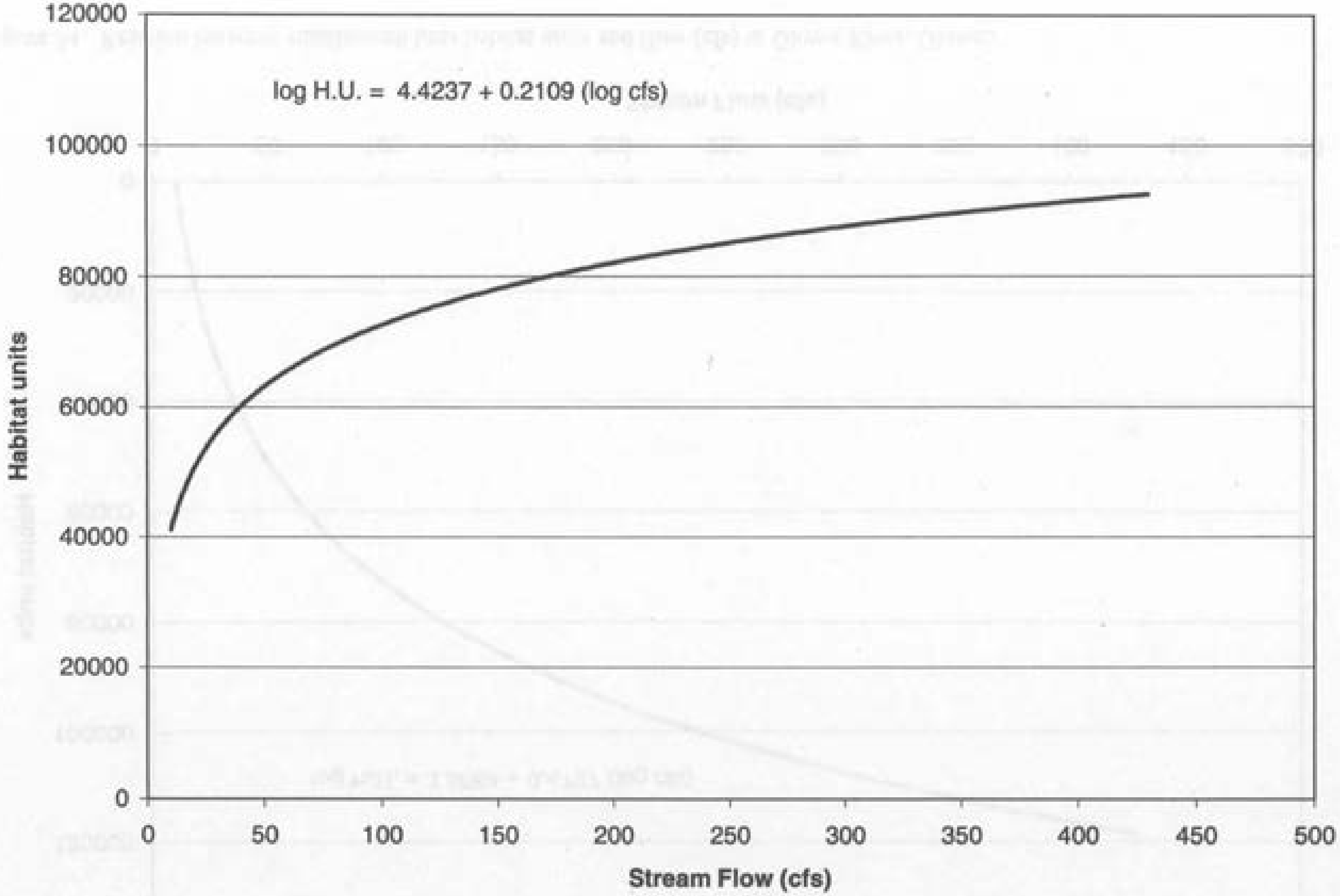

Figure 33. Relation between stoneroller habitat units and flow (cfs) at Glover River, Glover.

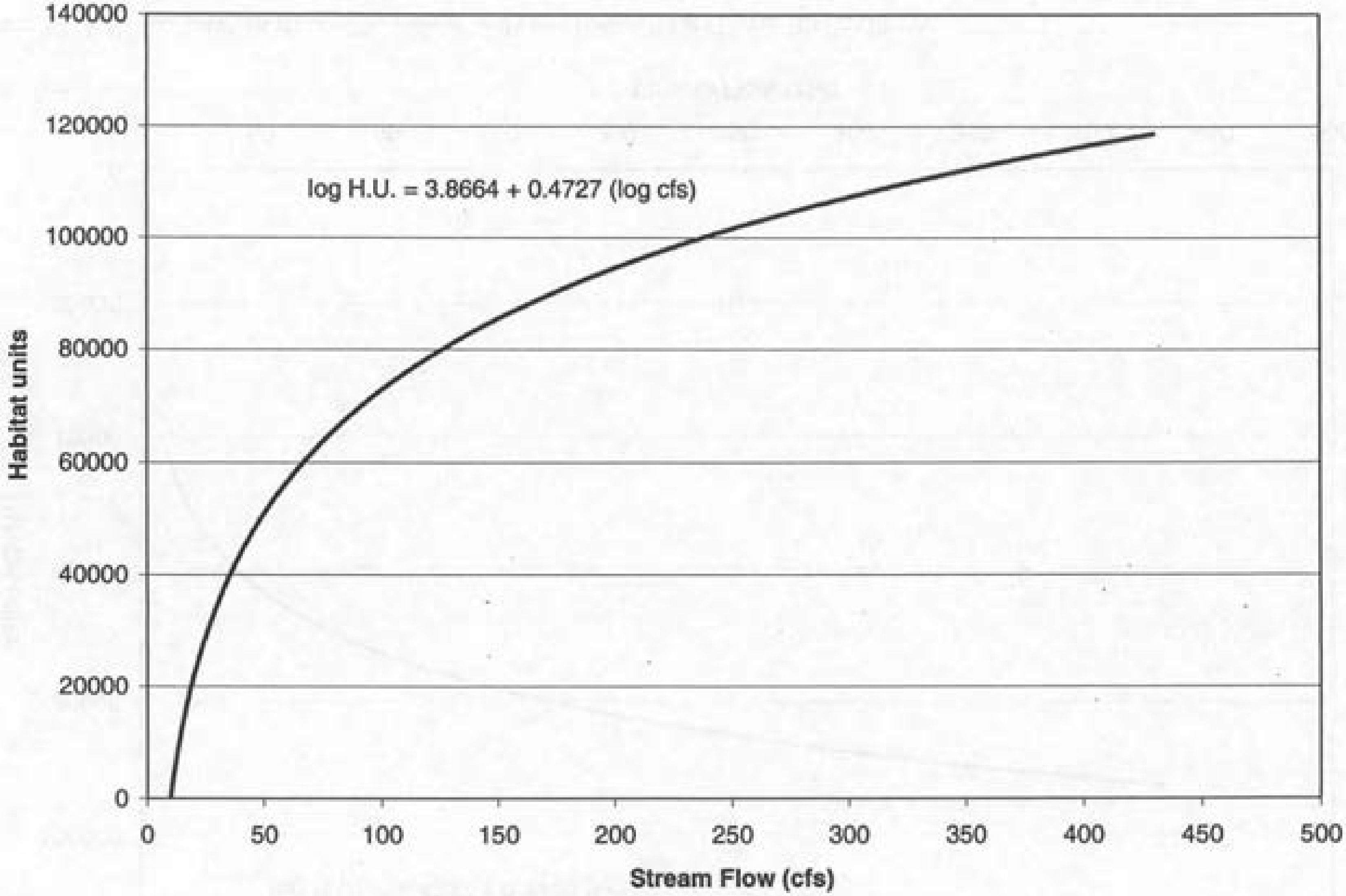

Figure 34. Relation between smallmouth bass habitat units and flow (cfs) at Glover River, Glover.

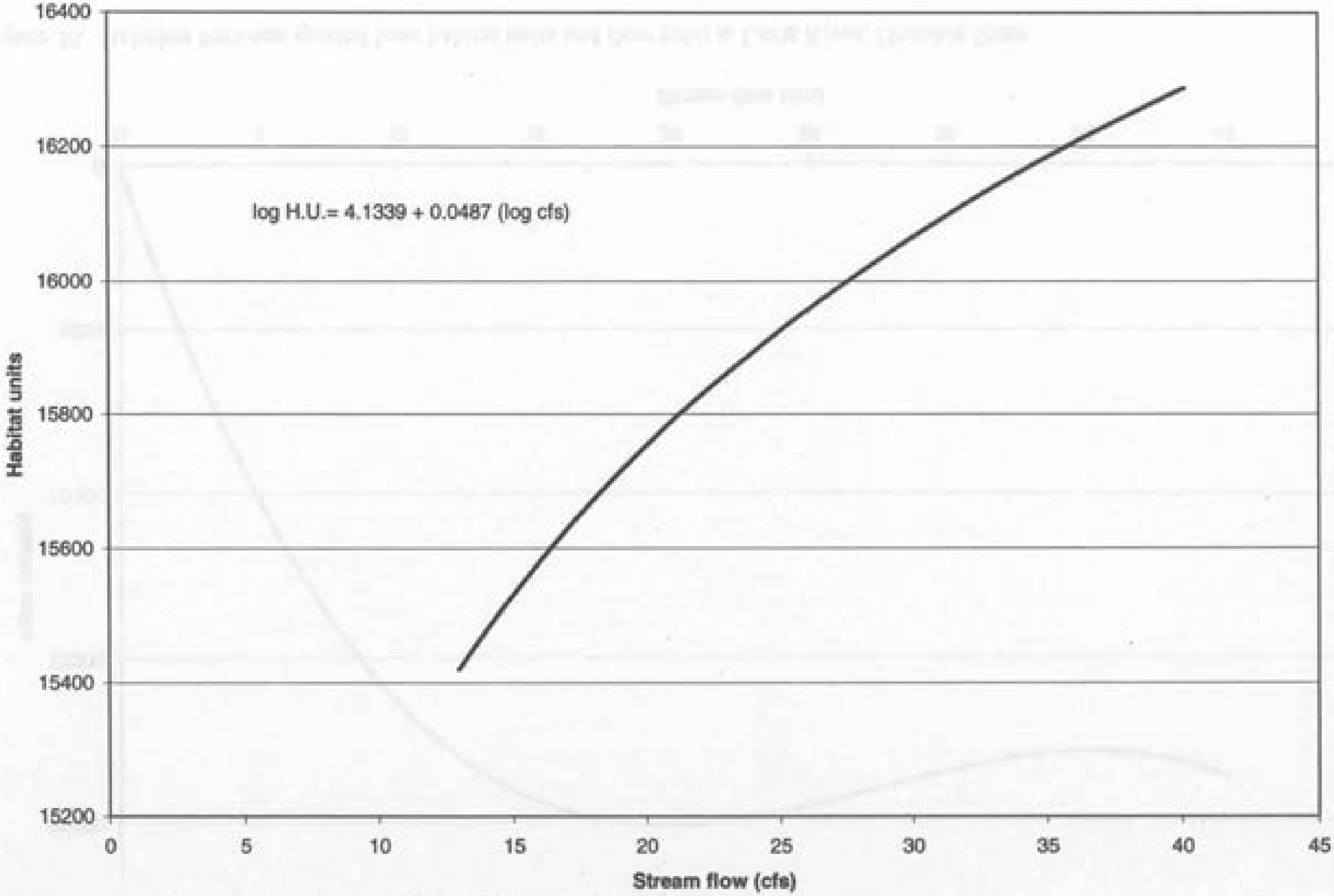

Figure 35. Relation between channel catfish habitat units and flow (cfs) at Little River, Honobia Store.

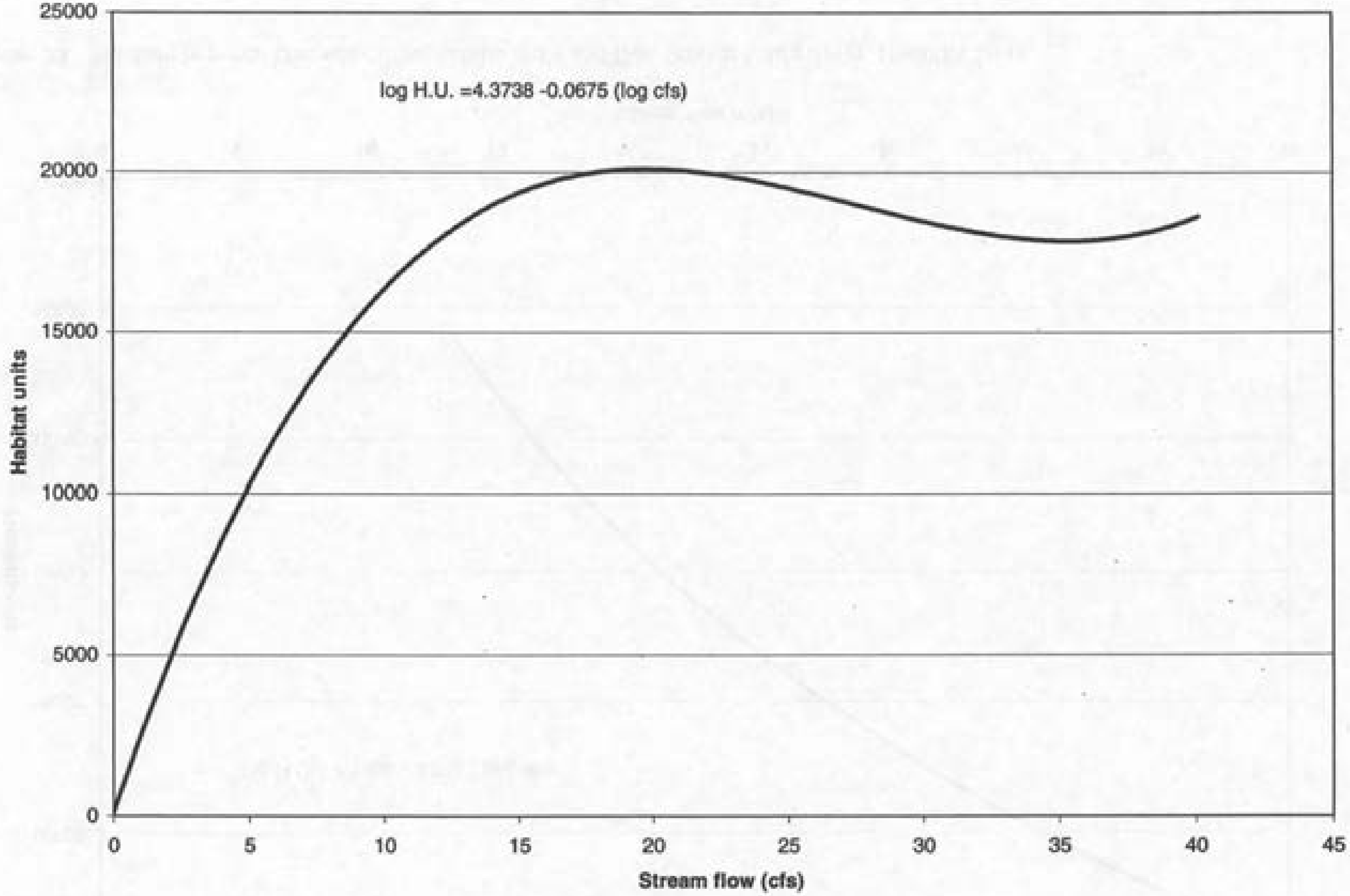

Figure 36. Relation between spotted bass habitat units and flow (cfs) at Little River, Honobia Store.

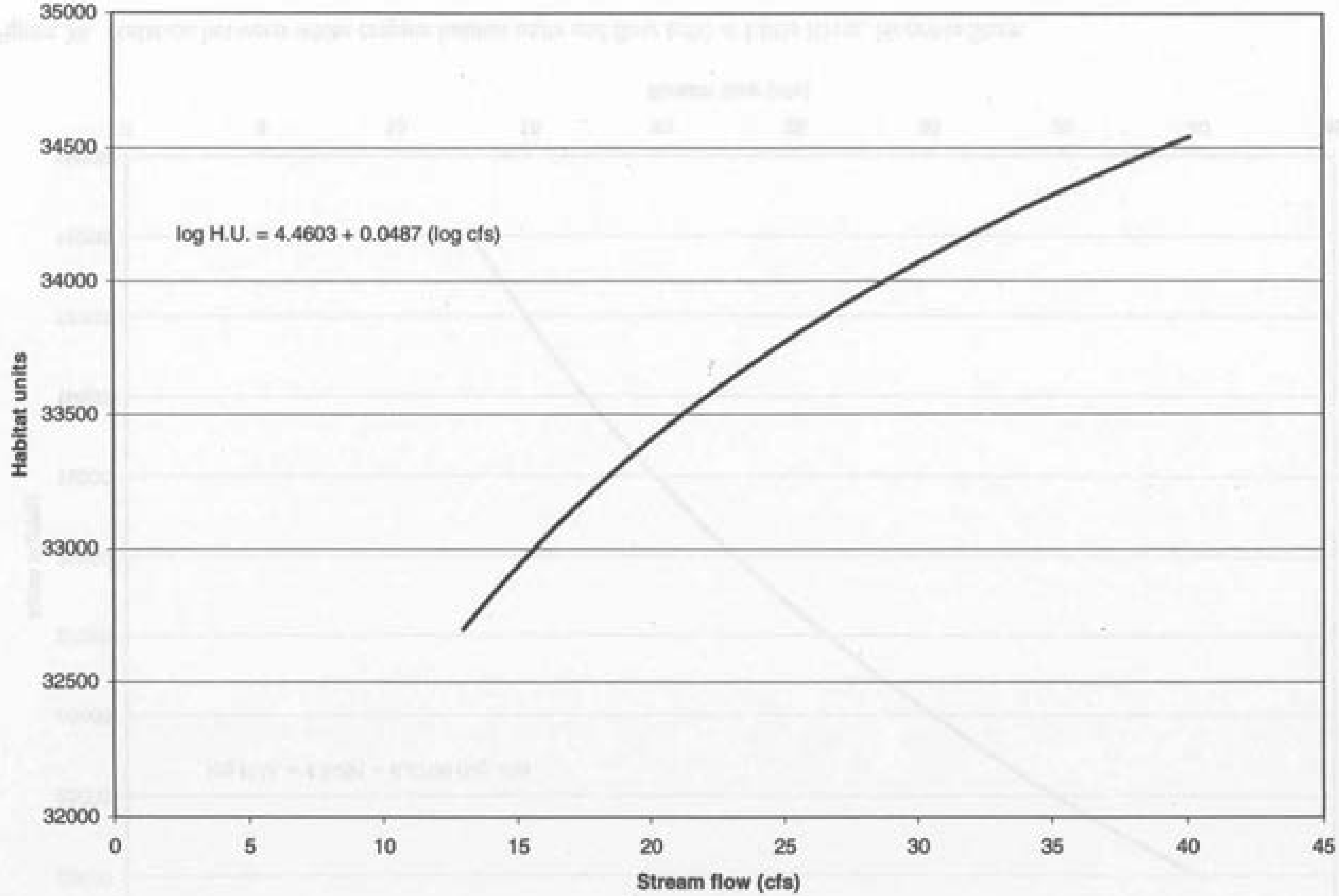

Figure 37. Relation between green sunfish habitat units and flow (cfs) at Little River, Honobia Store.

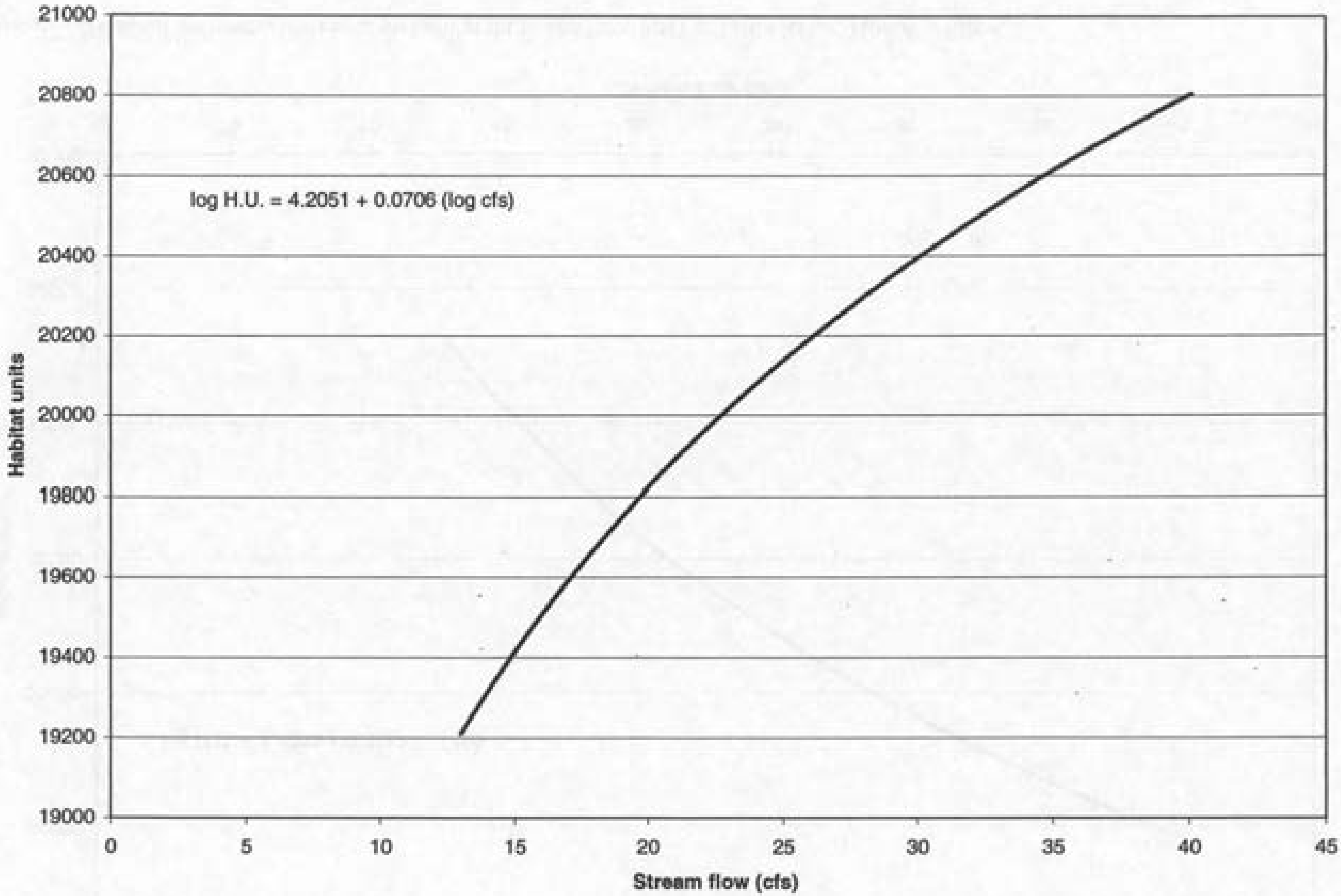

Figure 38. Relation between white crappie habitat units and flow (cfs) at Little River, Honobia Store.

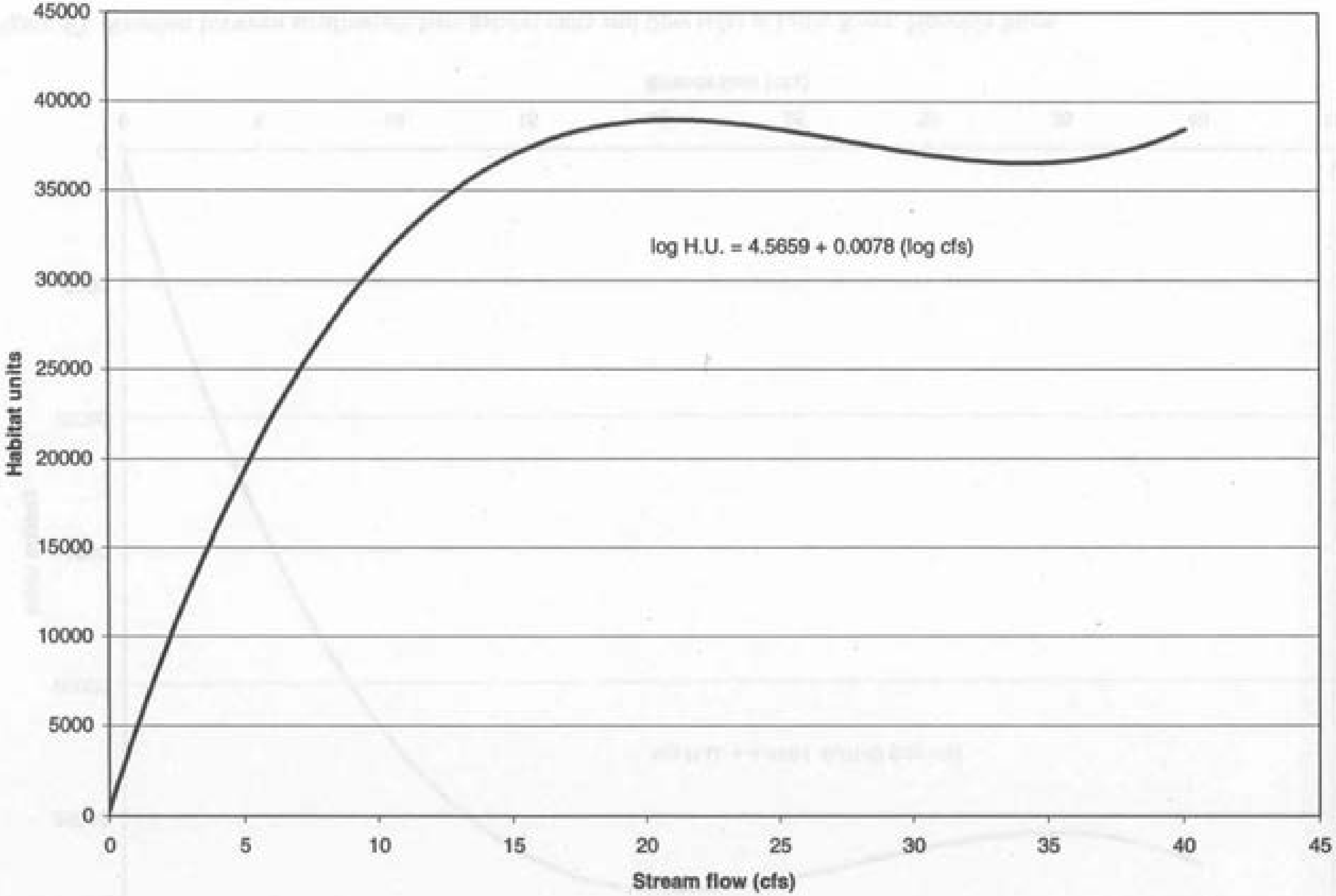

Figure 39. Relation between stoneroller habitat units and flow (cfs) at Little River, Honobia Store.

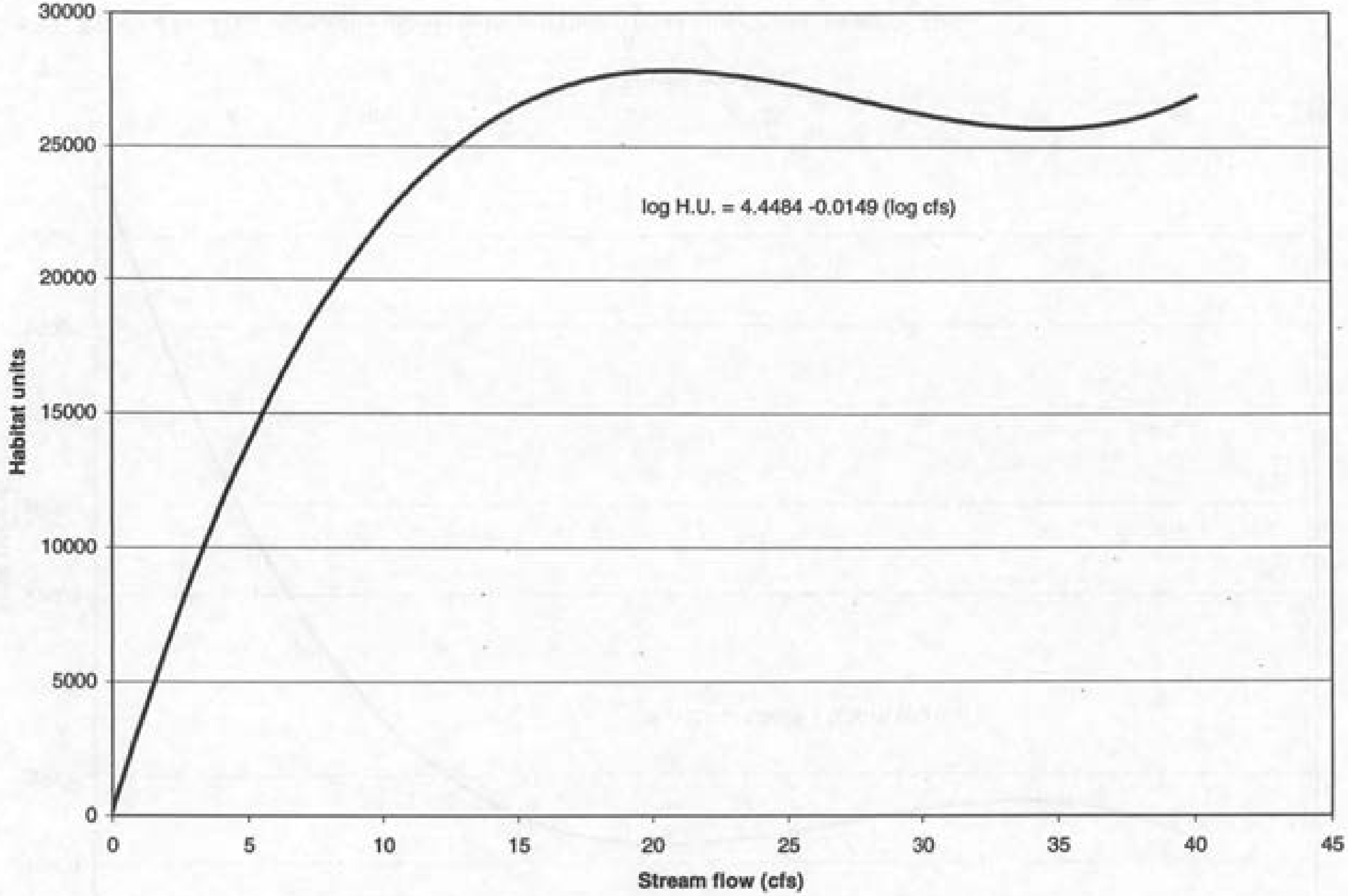

Figure 40. Relation between smallmouth bass habitat units and flow (cfs) at Little River, Honobia Store.

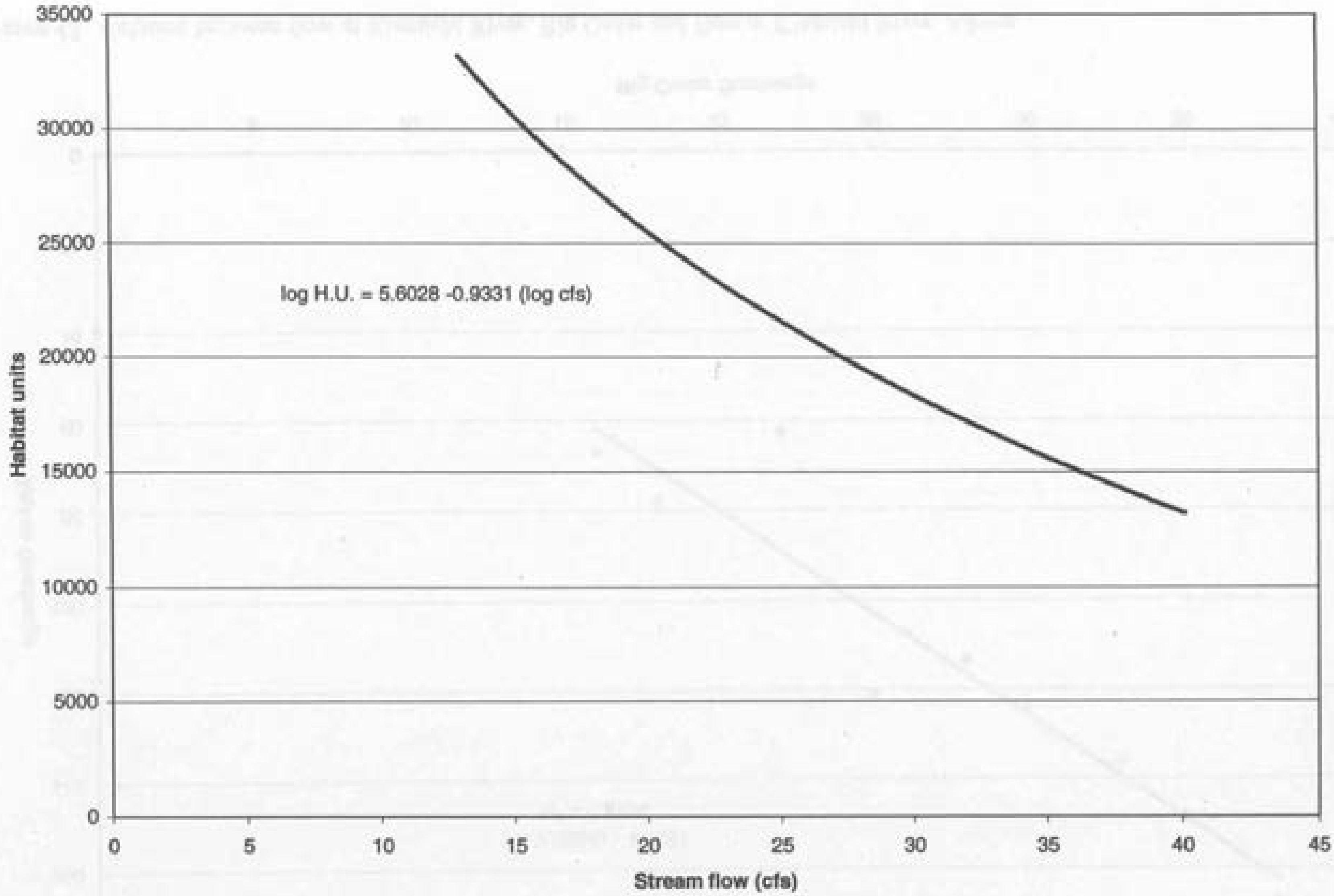

Figure 41. Relation between longear sunfish habitat units and flow (cfs) at Little River, Honobia Store.

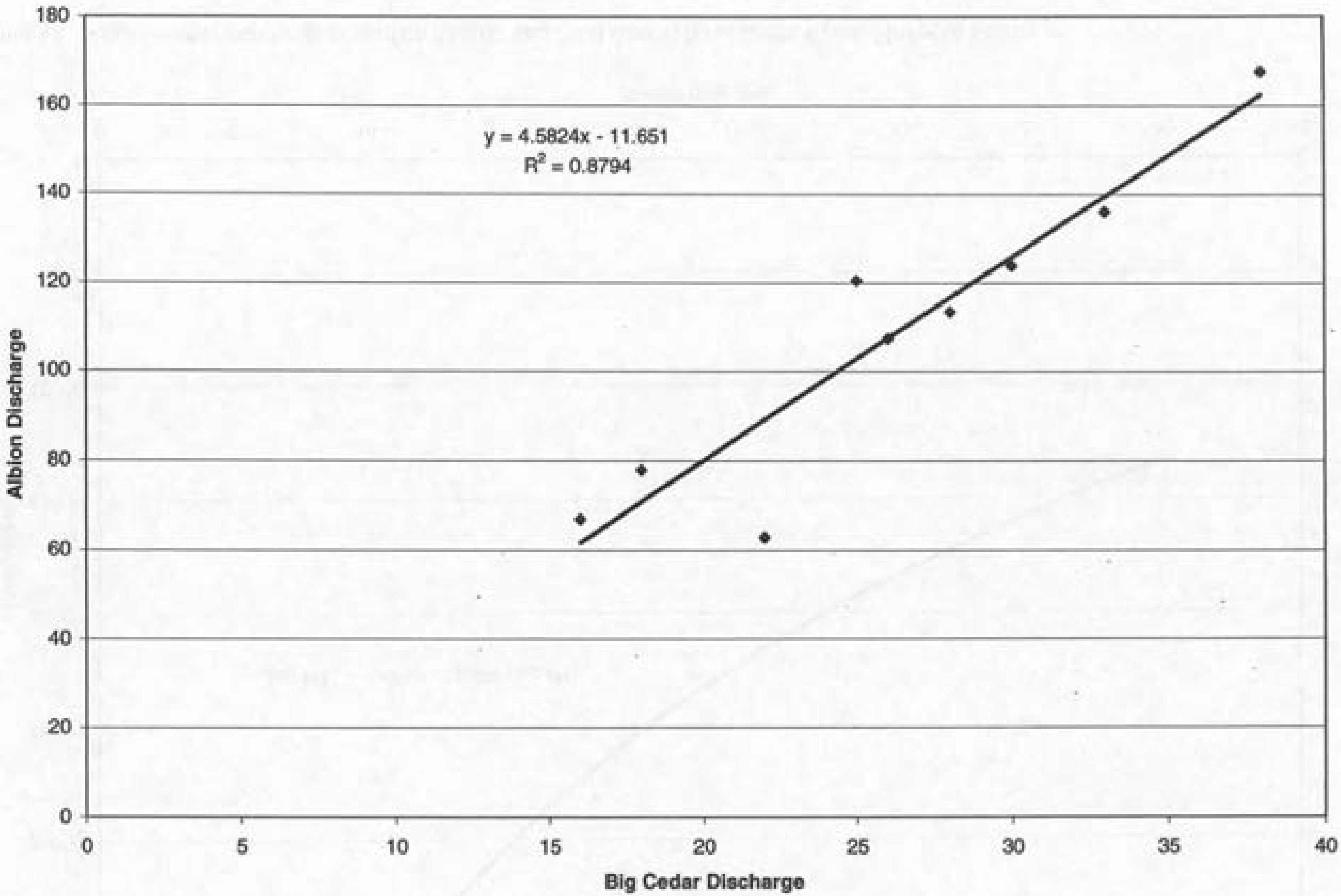

Figure 42. Relation between flow at Kiamichi River, Big Cedar and flow at Kiamichi River, Albion.

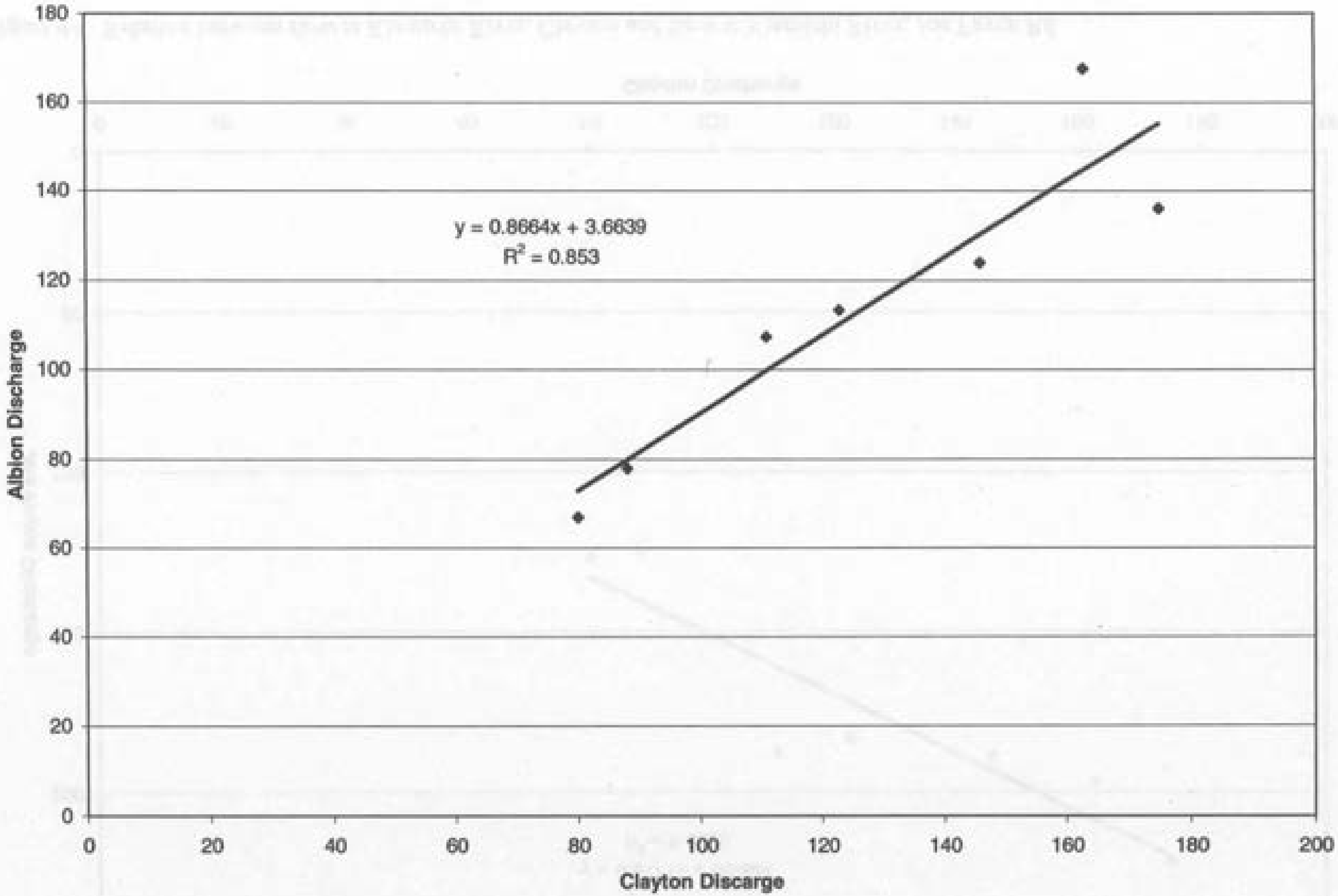

Figure 43. Relation between flow at Kiamichi River, Albion and flow at Kiamichi River, Clayton.

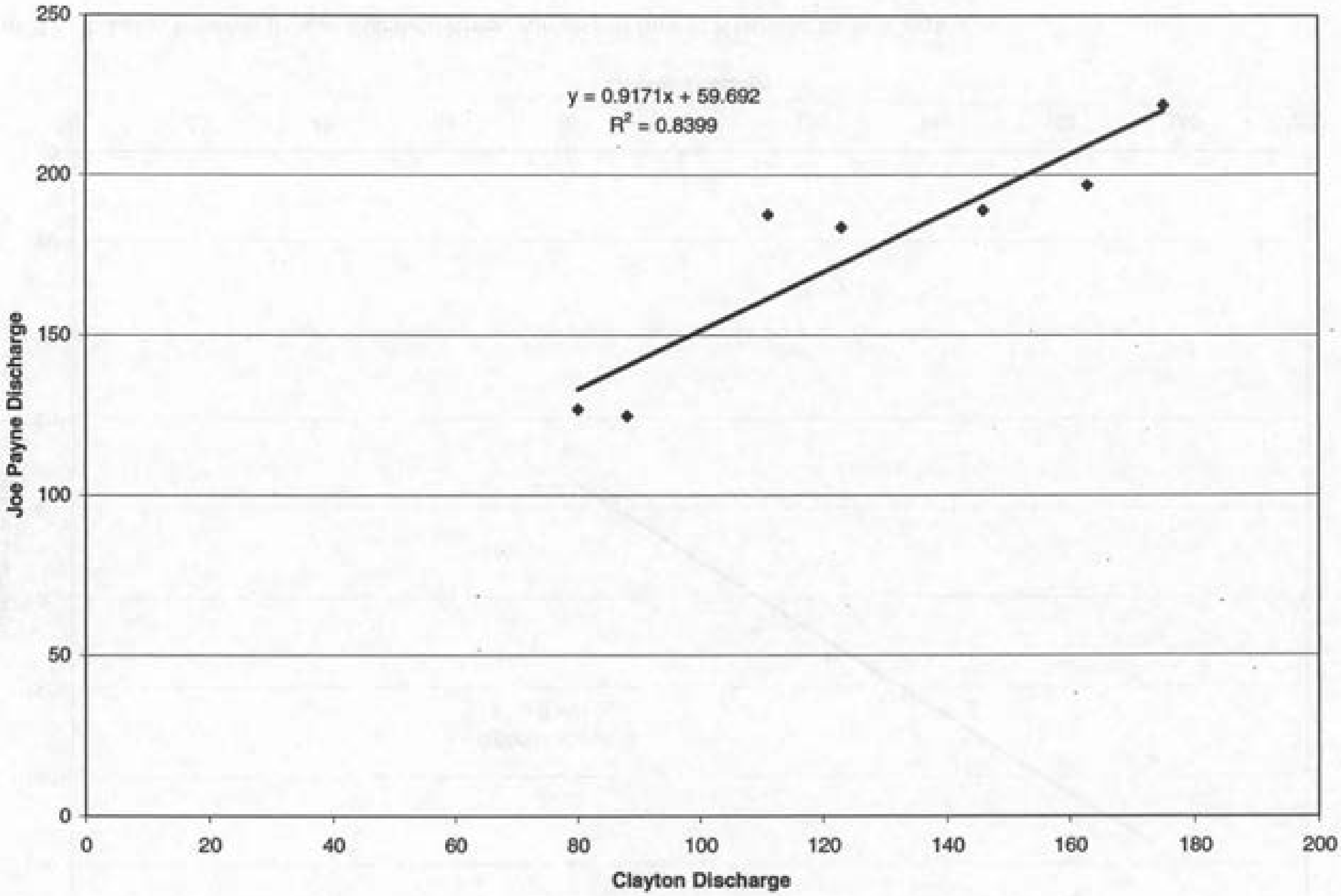

Figure 44. Relation between flow at Kiamichi River, Clayton and flow at Kiamichi River, Joe Payne Rd.

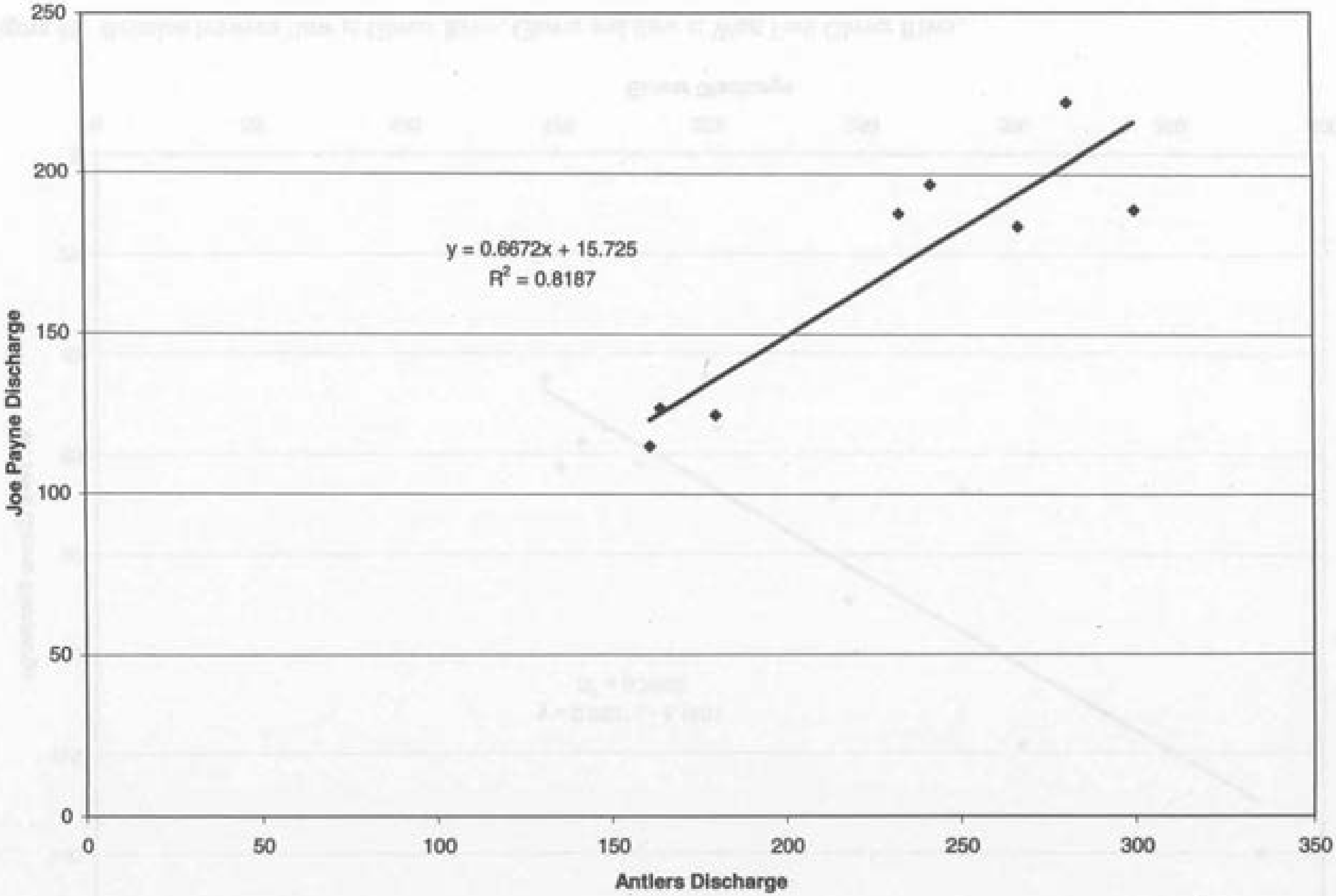

Figure 45. Relation between flow at Kiamichi River, Joe Payne Rd. and flow at Kiamichi River, Antlers.

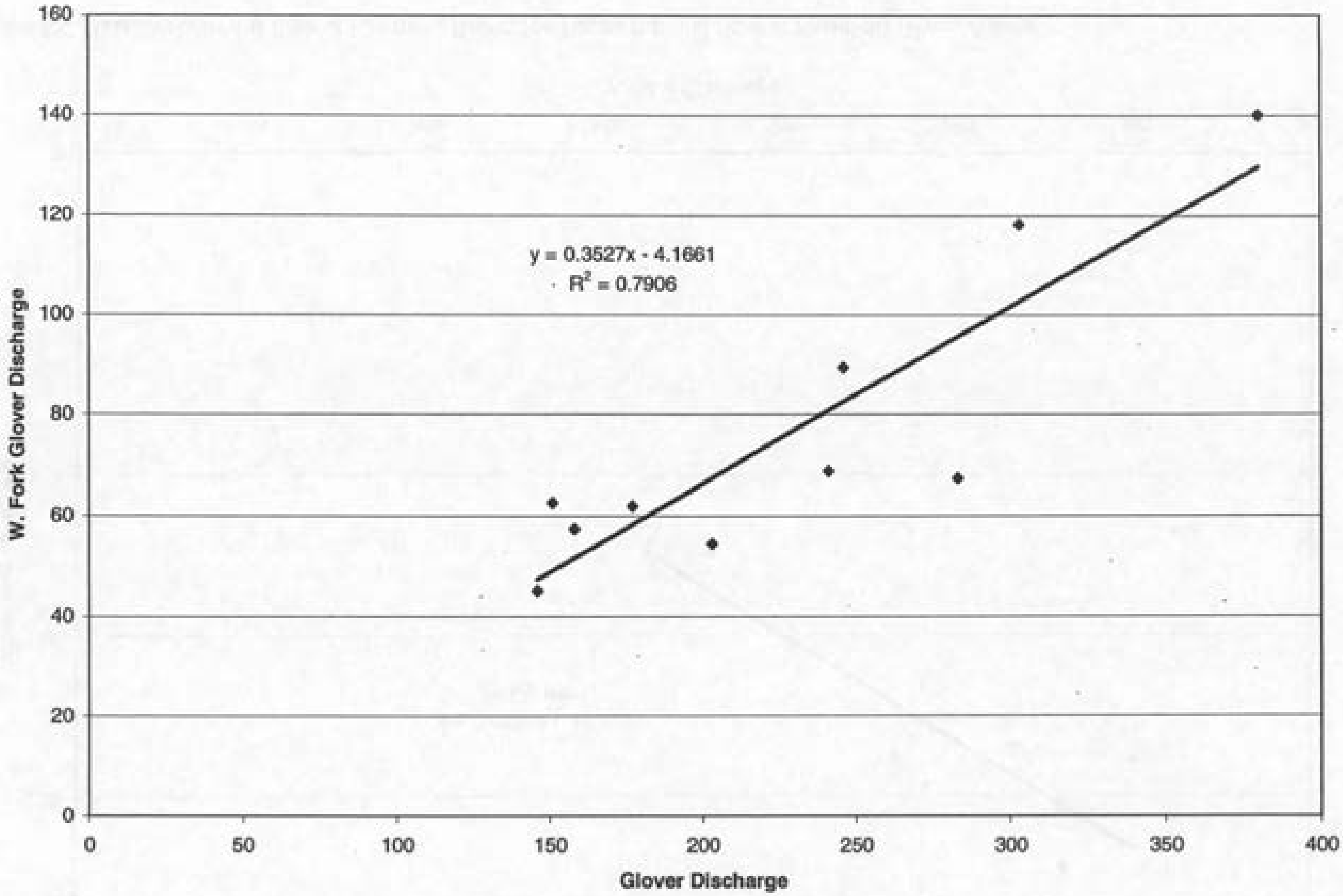

Figure 46. Relation between flow at Glover River, Glover and flow at West Fork Glover River.

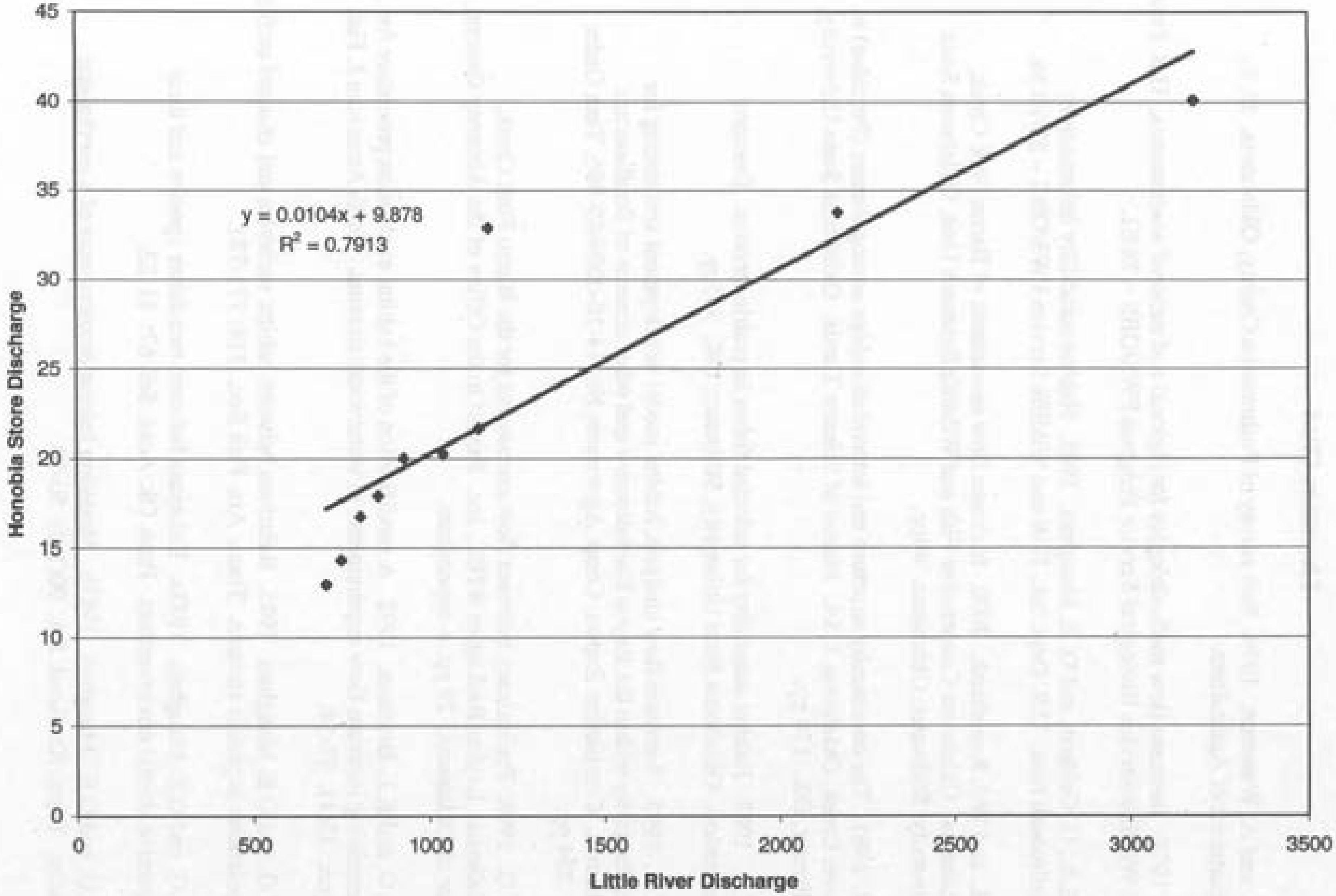

Figure 47. Relation between flow at Little River and flow at Little River, Honobia Store.

Literature Cited

Bain, W.R. and A. Waterson. 1979. Soil survey of Pushmataha County, Oklahoma. U. S. Department of Agriculture.

Bayha, K. 1978. Instream flow methodologies for regional and national assessments. U.S. Fish and Wildlife Service Biological Service Program FWS/OBS – 78/61.

Edwards, E.A., G. Gebhart, and O. E. Maughan. 1983. Habitat suitability information: Smallmouth bass. U.S. Dept. Int., Fish and Wildlife Service FWS/OBS – 82/10.36.

Fisher, W.L. and W.J. Remshardt. 2000. Instream flow assessment of Baron Fork Creek, Oklahoma. Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University, Stillwater, Oklahoma. 44pp.

Jones, R.N. 1981. The community structure and interrelationships among darters (Percidae) in Glover Creek, Oklahoma, USA. Master of Science Thesis. Oklahoma State University, Stillwater, OK. 174 pp.

Layher, W.G. 1983. Habitat suitability for selected fishes in prairie streams. Doctoral dissertation. Oklahoma State University, Stillwater, OK. 333pp.

Layher, W.G. 1995. Instream flow analysis, habitat model development and testing for transferability within the Bayou Bartholomew and other streams of Southeastern Arkansas. Completion Report, Coop. Agreement No. 14-16-0009-89-966, Task Order 19. 324 pp.

Layher, W.G. 1998. Preliminary instream flow assessment for the Baron Fork Creek, Oklahoma. Layher BioLogics RTEC, Inc. Report to the Office of the Attorney General, State of Oklahoma. 29 pp. + appendices.

Layher, W.G. and K.L. Brunson. 1992. A modification of the habitat evaluation procedure for determining instream flow requirements in warmwater streams. North American J. Fish Mgmt. 12(1): 47-54.

Layher, W.G. and O.E. Maughan. 1985. Relations between habitat variables and channel catfish populations in prairie streams. Trans. Am. Fish Soc. 114: 771-781.

Layher, W.G. and O.E. Maughan. 1987a. Relations between two darter species and their respective abiotic environments. Proc. Ok. Acad. Sci. 67: 11-22.

Layher, W.G. and O.E. Maughan. 1987b. Modeling habitat requirements of a euryhabitat species. Trans. Ks. Acad. Sci. 90(1-2): 50-70.

Layher, W.G. and O.E. Maughan. 1988. Using stream survey data to predict directional change in fish populations following physiochemical stream perturbations. J. Env. Toxicology and Chemistry. 7: 689-699.

Layher, W.G., O.E. Maughan, and W.D. Warde. 1987. Spotted bass habitat suitability related to fish occurrence and biomass and measurements of physicochemical variables. North Am. J. Fish Mgmt. 7: 238-251.

Layher, W.G. and J.W. Phillips. 2000. Determination of instream flow recommendations for the Bayou Bartholomew based on historic flow information. Layher BioLogics RTEC, Inc. Final report to the Arkansas Game and Fish Commission. Contract No. 0019868. 48 pp.

Layher, W.G. and J.W. Phillips. 2001. Determination of instream flow recommendations for the Middle Fork Saline River using proportional analysis methodology. Layher BioLogics RTEC, Inc. Final report to the Arkansas Game and Fish Commission. Contract No. 0021133. 63 pp. + appendices.

Orth, D. 1980. Evaluation of a methodology for recommending instream flows for fishes. Doctoral dissertation. Oklahoma State University, Stillwater, OK. 174 pp.

The Nature Conservancy. 2003. The Kiamichi River. Oklahoma Chapter, Unpublished Report.

U.S. Army Corps of Engineers. 1975. Draft environmental statement, Lukfuta Lake, Glover Creek, Oklahoma. United States Army Corps of Engineers, Tulsa District, Tulsa, OK.

WRB. 1998. Findings of fact, conclusions of law and board order for Adair County Rural Water District #5, #93 – 34. State of Oklahoma, Water Resource Board.

III. TOTAL COST $112,038.99

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