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NORTHWEST ARKANSAS COUNCIL

July 29, 2011

Mr. Phillip Moershel
Water Quality Standards Section
Oklahoma Water Resources Board
3800 N. Classen Boulevard
Oklahoma City, Oklahoma 73118

Dear Mr. Moershel,

The Northwest Arkansas Council is a non-profit group of key regional business and civic leaders. Representatives from area small businesses, institutions of higher education, area Chambers of Commerce and the region's largest employers are active members of the Council. Our primary goal is to ensure that Northwest Arkansas remains a vibrant and attractive community for businesses, residents, families and retirees for decades to come.

Northwest Arkansas has a direct and substantial interest in the ongoing review of the Scenic Rivers phosphorus standard by the Oklahoma Water Resources Board. A clean environment and healthy streams are important to Northwest Arkansas. The Council supports environmental regulations that are scientifically based, reasonable and necessary to protect and preserve natural resources. However, we oppose regulations that are unreasonable, lack a legitimate scientific basis or are more restrictive than necessary to protect and preserve natural resources.

We are pleased that Oklahoma has started the process of re-evaluating the Scenic Rivers Phosphorus standard. As you know, Oklahoma's 2002 mandate that phosphorus concentrations of 0.037 mg/L be met at the Arkansas/Oklahoma state line by July 1, 2012 in each of the six designated scenic rivers has been a source of much controversy and many strained relationships between the two states over the past decade. Despite the consensus view that this standard was unsound, unreasonable and unattainable, Arkansas agreed in the Statement of Joint Principles and Actions not to challenge the standard through litigation for ten years and to instead devote substantial resources to lowering phosphorus levels to the extent practicable provided that Oklahoma would "re-evaluate" 0.037 mg/L before 2012 "based upon the best scientific information available and with the full and timely participation of Arkansas officials."

Northwest Arkansas has spent hundreds of millions of dollars on phosphorus removal projects and water quality protection since 2003 in an effort to forge a positive relationship with Oklahoma and to avoid more protracted legal battles. Five Northwest Arkansas cities voluntarily agreed to accept the 1 part per million phosphorus discharge limits mandated by Oklahoma and these cities have spent approximately $225 million to upgrade wastewater treatment plants to reach this limit. In contrast, over 95% of Oklahoma wastewater treatment plants have no limit on phosphorus discharges. Only a few Oklahoma facilities have comparable permit limits and none have a limit more restrictive than the 1 part per million voluntarily accepted by Northwest Arkansas.

As promised in the Statement of Joint Principles and Actions, Arkansas passed and is enforcing comprehensive regulations pertaining to the use of poultry litter and commercial fertilizers in the IRW. In the past six years alone, Northwest Arkansas poultry companies have spent over $2 million to facilitate the transfer of poultry litter out of the Illinois River watershed. These same companies have funded $1.1 million in conservation projects through the Oklahoma Scenic Rivers Commission. Arkansas applied for and has received a $30 million CREP grant for riparian buffers and nonpoint source controls in the Arkansas side of the Illinois River watershed. Northwest Arkansas stakeholders provide matching money for this federal grant.

While phosphorus concentrations in the Scenic Rivers, particularly in the Illinois River, are on the decline, we are nowhere near consistently meeting the 0.037 mg/L phosphorus standard. The Council believes the "problem" is with the standard and not with the nature or amount of Northwest Arkansas' efforts and investments over the past decade. We hope OWRB will set aside politics and past differences and objectively re-evaluate the scientific basis, necessity and reasonableness of this water quality standard.

To assist in responding to your public call for "the best scientific information" relevant to a re-evaluation of 0.037 mg/L, we retained Wright Water Engineers, Inc., a nationally recognized water resources consulting firm based in Denver, Colorado. Wright Water prepared a review of technical information pertinent to a re-evaluation of 0.037 mg/L. A copy of Wright Water's technical findings report, which includes copies of studies and water quality data, is enclosed. We understand the information provided by Wright Water will be evaluated by the Technical Advisory Group, at least in the first instance, from a purely technical point of view. However, as stakeholders in both states know, the technical issues around 0.037 mg/L must be considered against the backdrop of the legal requirements imposed by state and federal law and the commitments made by Arkansas and Oklahoma in the 2003 Statement of Joint Principles and Actions.

In an effort to ensure that OWRB appreciates the relevance and importance of all the technical information submitted, the Northwest Arkansas Council has set forth below a short overview of four key issues at the intersection of the technical and legal roads at which both states presently stand. Our sincere desire is to identify issues early in hopes of avoiding or minimizing the potential for future disputes. These points likely will be expanded upon in future submissions by numerous stakeholders but are previewed here in a good faith attempt to identify as many relevant issues as possible before the Technical Advisory Group makes a decision or recommendation to OWRB.

1. A numeric phosphorus standard that is disconnected from demonstrated ecological endpoints in each of the Scenic Rivers is arbitrary and capricious. Phosphorus, by itself, is not readily observable in water and thus the concentration of phosphorus in a stream is relevant only when and if the abundance of this nutrient produces an observable and undesirable ecological response that impacts beneficial uses. The scientific community and Oklahoma itself have long recognized that different streams and rivers react differently to the same nutrient concentration based upon their unique physical characteristics such as stream size (e.g., order), canopy cover, flow, slope and resulting water velocity. For example, OWRB's Nutrient Criteria Development Plan (Sept. 2006 Update) states:

> Stream morphology also affects the relationship between nutrient loading and primary productivity as does flow regime and slope. The correlation between nutrient concentration and chlorophyll [an indicator of algae] is highly variable in streams. . . . [I]t is difficult to establish a cause and effect relationship between nutrient loading and beneficial use impairment in streams. . . . [While] criteria based upon nutrient concentrations would be easier to implement . . . [such criteria are] less technically defensible.

Similarly, EPA's Science Advisory Board recently stressed the importance of demonstrating a cause-and-effect relationship between numeric nutrient standards and ecological responses that result in impairment:

> For criteria to meet EPA's stated goal of protecting against environmental degradation by nutrients, the underlying causal models must be correct. . . . Numeric nutrient criteria developed and implemented without consideration of system specific conditions can lead to management actions that may have negative social and economic consequences without additional environmental protection. EPA-SAB-10-006, SAB Review of Empirical Approaches for Nutrient Criteria Derivation (April 27, 2010) at p. 38.

The question that the Technical Advisory Group must answer is – Given the unique physical characteristics (e.g., slope, velocity, canopy) of the particular stream reaches designated as scenic rivers is a concentration of 0.037 mg/L phosphorus a threshold at which algae will be produced in each of those streams at times, in locations and in amounts sufficient to impair beneficial uses? The answer may vary across each of the six designated scenic rivers. As for the scenic river portion of the Illinois River, the available data indicates quite clearly that 0.037 mg/L phosphorus is not a defensible threshold at which adverse ecological responses sufficient to impair beneficial uses occur. There is ample data to support this point, but OWRB is encouraged to consider the review of the ecological sampling data presented by Dr. John Connolly of Quantitative Environmental Analysis in the enclosed report entitled *Illinois River Watershed Water Quality and Source Assessment* (January 30, 2009).

Because 0.037 mg/L was developed without consideration and confirmation of the relevance of that standard to observable impairments of beneficial uses, it is scientifically unsound, arbitrary and capricious. To be scientifically defensible, the Technical Advisory Group's re-evaluation of this standard must include an evaluation of the cause-and-effect relationship between ecological conditions in each scenic river and the recommended nutrient criteria for each such scenic river. Northwest Arkansas should not be required to invest another round of hundreds of millions of dollars to meet a numeric water quality standard that has no cause-and-effect relationship to conditions in these rivers.

2. OWRB's use of "Reference Streams" and watersheds that are not physically similar to the Illinois River to establish, confirm or alter the Scenic River Standard is scientifically flawed. The "reference stream" approach that OWRB used to derive 0.037 mg/L phosphorus as the standard for the scenic rivers is not appropriate, at least with respect to the designated river section of the Illinois River. EPA made clear in its *Nutrient Criteria Technical Guidance Manual: Rivers and Streams,* (2000a) that when a state uses a reference stream approach to establish a numeric nutrient criterion "streams must be classified by their morphological characteristics at both the landscape and stream reach scale." The Guidance Manual explains the rationale for that requirement as follows:

> Streams with similar morphologies may have similar nutrient capacities or responses to nutrient loadings. Rivers and streams are very diverse within ecoregions. . . . The geomorphology of a river or stream – its shape, depth, channel materials – affects the way the waterbody receives, processes and distributes nutrients.

OWRB originally recognized the need to use data from "only those waters of roughly equivalent stream order" in applying a reference stream approach to the Illinois River but abandoned that approach when the cost and burden of acquiring the necessary data "became problematic." *See OWRB Rationale for Promulgation of an 0.037 mg/L Total Phosphorus Criteria for Scenic River Protection.* OWRB disregarded these well-known, scientific principles in selecting phosphorus values from "reference streams." Rather, OWRB derived 0.037 mg/L from small (lower order) streams draining small tracts of largely forested lands. *See* Clark, et al., *Nutrient Concentrations and Yield in Undeveloped Stream Basins of the United States* JOURNAL OF AMERICAN WATER RESOURCES ASSOCIATION, Vol. 36, No. 4) and http://water.usgs.gov/nawqa/nutrients/pubs/awra_v36_no4/data_rev.pdf (data supporting JAWRA Article). The physical characteristics of many of those streams and their tributary watersheds bear no resemblance to the main stem of the Illinois River. The Scenic River designated portion of the Illinois River is a sixth order stream, which means that it is a relatively large river that collects water from a large network of smaller streams draining large amounts of land. It is inappropriate to apply lower order reference stream conditions from undeveloped or protected watersheds to the Illinois River. To be scientifically defensible, any attempt by the Technical Advisory Group to reconfirm or alter 0.037 mg/L phosphorus based upon a reference stream approach must utilize data only from streams with similar physical characteristics.

3. The ability to consistently attain in-stream phosphorus concentrations at or below the level of 0.037 mg/L and the socio-economic harm caused by further regulatory requirements aimed at meeting an unattainable standard must be considered. The work of Wright Water and others clearly demonstrates that 0.037 mg/L phosphorus is not a standard that can be consistently achieved in the Illinois River absent the removal of the people, businesses and communities currently thriving in this watershed. To this point, the USGS scientist who authored the study on which OWRB based 0.037 mg/L has stated publicly that this standard cannot be achieved in a developed basin like the Illinois River Watershed. Smith, Robert J., ARKANSAS DEMOCRAT-GAZETTE (March 25, 2002), *Scientist Cautious of Limit on Rivers, Oklahoma Proposal Unrealistic He Says* ("[i]f there are no manmade impacts, in predevelopment days, those are concentrations you could achieve. Are those feasibly achievable in developed watersheds? Probably not.") The accuracy of this statement has been confirmed by the modeling performed Oklahoma State University professor, Dr. Daniel Storm, in a 2006 study commissioned by ODEQ. Dr. Storm was asked to evaluate what changes would be necessary to consistently meet 0.037 mg/L and OWRB's goal of a resulting 75% reduction of phosphorus loads to Lake Tenkiller. Dr. Storm concluded that to meet OWRB's goals would require: "eliminating all row crops/small grains, litter, cattle and point sources, cutting pastures for hay only and converting 25% of pastures to forest." *See* Storm, et al. (ODEQ 2006), *Illinois River Upland and In-stream Phosphorus Modeling Final Report*, at p. 62 (emphasis added). Water quality goals or standards that can only be achieved by replacing the homes, businesses and communities of Northwest Arkansas and Northeast Oklahoma with the uninhabited forests that existed in this region 300 years ago or more should not be the measure of environmental protection in Oklahoma or any state.

Environmental regulations inherently require a balancing of competing interests; the Scenic River standards should be no exception. Part of the balancing that must occur here involves a serious consideration of the costs (direct and indirect) of attempting to reach any numeric criteria (especially an unattainable one). The direct costs to Northwest Arkansas of additional attempts to reduce phosphorus concentrations will be substantial. The five largest cities in Northwest Arkansas estimate that they will have to spend another $90 million to $100 million in direct capital alone to upgrade POTWs that already exceed performance of virtually all other large municipal systems in the United States. Similar upgrade costs will undoubtedly be required of smaller communities such as Prairie Grove, Gentry, Lincoln, Tahlequah and Stilwell. These costs will be passed on to citizens through increased utility rates. As the work of Wright Water confirms, the combined cost of stormwater controls in the urban and residential areas of the watershed could easily exceed the hundreds of millions of dollars already spent by the municipalities on POTW upgrades. Additional taxes or development fees will be required to fund such controls.

These costs and the limitations imposed on land use and public utilities by implementation of a standard equal to or below 0.037 mg/L present a very real possibility of stifling economic growth and further development in Northwest Arkansas and Northeast Oklahoma; all in the interest of attempting to reach a flawed water quality standard that is not attainable. The Council urges OWRB to be realistic with the citizens of the two states about what type of water quality improvements are actually achievable and the significant costs that communities would bear in order to achieve additional improvements in water quality.

4. <u>It is Improper to justify, expand or alter the Scenic River Standard based upon Lake Tenkiller</u>. OWRB's call for technical information suggests the protection of Lake Tenkiller is now a factor to be considered by the Technical Advisory Group's "re-evaluation" of the scenic rivers standard. OWRB has already established a water quality standard for Lake Tenkiller based upon chlorophyll. That standard was not part of the 2003 Statement of Joint Principles and Actions and should not be part of the review of the scenic rivers standard.

The water quality standard under review was adopted by OWRB under the authority of the Oklahoma Scenic Rivers Act (Okla. Stat. Tit 82, Ch. 21). The purpose of the Scenic Rivers Act is to protect and preserve water quality in certain designated reaches of six specific rivers. Nowhere in the Scenic Rivers Act is OWRB authorized to promulgate an in-stream water quality standard for the purpose of protecting the use of waterbodies other than the designated scenic rivers. If OWRB desires to adopt a phosphorus-based, water quality standard for the protection of Lake Tenkiller, it should do so in a separate rulemaking authorized by and conducted in accordance with legislation other than the Oklahoma Scenic Rivers Act.

Moreover, from a technical point of view, the differing physical characteristics and processes in a lake, as opposed to a river, preclude the adoption of a numeric in-stream nutrient criteria for the purpose of protecting lake water quality or beneficial uses. OWRB's own Nutrient Criteria Development Plan (Sept. 2006 Update) recognized the necessity of treating lakes differently. Less than five years ago, OWRB acknowledged in that document that because of the differing characteristics and processes "nutrient criteria for streams will likely be of a different type than for lakes." OWRB should not abandon this well-recognized, scientific principle now.

In closing, the Northwest Arkansas Council wants OWRB and the Technical Advisory Committee to know that we appreciate the process they have commenced and look forward to the results of the re-evaluation. Northwest Arkansas has been and will continue to be a good economic and environmental partner with Oklahoma. We simply ask that OWRB and the Committee be mindful of the significance of the decision being made and proceed with an honest, scientifically sound, objective and transparent review of all the issues.

Sincerely,

Mike Malone
President and CEO
Northwest Arkansas Council

cc: Steve Drown, Arkansas Department of Environmental Quality
Edward Swaim, Arkansas Natural Resources Commission
Shanon Philips, Oklahoma Conservation Commission
Quang Pham, Oklahoma Department of Agriculture
Shellie Chard-McClary, Oklahoma Department of Environmental Quality
Cara Cowan Watts
Melinda McCoy, U.S. Environmental Protection Agency, Region VI
Derek Smithee, Oklahoma Water Resources Board

Expert Report

Illinois River Watershed Water Quality and Source Assessment

Prepared for:

Illinois River Watershed Joint Defense Group

Prepared by:

Quantitative Environmental Analysis, LLC

Montvale, NJ

January 30, 2009

SECTION 1
DECLARATION AND SUMMARY OF FINDINGS

1.1 DECLARATION

My name is John P. Connolly, and I am the President and Senior Managing Engineer for Quantitative Environmental Analysis, LLC, located in Montvale, New Jersey. I hold a BE degree in Civil Engineering from Manhattan College, a ME in Environmental Engineering from Manhattan College, and a PhD in Environmental Health Engineering from The University of Texas at Austin. I am a registered professional engineer in New York and Texas, a Diplomate by Eminence in the American Academy of Environmental Engineers and a member of the United States Environmental Protection Agency (USEPA) Science Advisory Board. For the past 30 years I have studied the fate and impact of pollutants in surface waters as a research engineer at Manhattan College, a research scientist with the USEPA, a professor of Environmental Engineering at Manhattan College and a consulting engineer. My work has focused on understanding and predicting the relationships between pollutant discharges and water quality. I have worked on more than 50 water quality projects and on several major projects related to the issues of algal blooms and dissolved oxygen depletion. Among these are studies of eutrophication in Lake Erie, the Delaware Estuary, Mirror Lake, NH, the Androscoggin River, ME and a series of reservoirs along the Lower Colorado River in Texas. I have been involved in government funded research to advance the state of the art of eutrophication modeling and contributed to the development of the USEPA supported Water Quality Analysis and Simulation Program (WASP) model commonly used to model algae growth in reservoirs. Many of my projects have involved developing an understanding of the contributions of multiple potential sources to observed water quality problems. My full resume can be found in Appendix A.

I was asked to evaluate whether the use of poultry litter as a fertilizer in the Illinois River Watershed is causing water quality problems in the Illinois River and Lake Tenkiller.

My investigation consisted of assessing the water quality of the Illinois River and Lake Tenkiller and investigating the factors controlling that quality. I focused on nutrient (specifically phosphorus) and bacterial pollution as these are the primary focus of allegations made by the plaintiffs in this case. I also considered other chemicals that were used by the Plaintiffs' consultants as tracers of pollutant sources. Quantitative Environmental Analysis, LLC was compensated at a rate of $348 per hour for the time I devoted to this project.

1.2 SUMMARY OF FINDINGS

1. Poultry litter is not the major source of phosphorus to the Illinois River in Oklahoma.

2. Phosphorus has minimal impact on the water quality of the Illinois River in Oklahoma.

3. Phosphorus impacts only a small portion of Lake Tenkiller.

4. Bacteria sources cause little risk of gastrointestinal illness for recreational users of the Illinois River in Oklahoma.

5. The water quality in the Illinois River Watershed is comparable to other waters in Oklahoma.

6. Water quality is improving in the Illinois River and Lake Tenkiller.

7. The water quality modeling conducted by the Plaintiffs' consultants is flawed and provides no means to assess phosphorus impacts.

8. The ambiguity of the standard operating procedures written for the field staff, as well as the lack of field documentation, calls into question the quality of some of the data collected by the Plaintiff.

SECTION 3
PHOSPHORUS HAS MINIMAL IMPACT ON THE ILLINOIS RIVER IN OKLAHOMA

3.1 SUMMARY OF DETAILED FINDINGS

- Phosphorus is not causing excessive growth of phytoplankton in the Illinois River.
- Benthic algae are rarely at densities considered a nuisance.
- The frequency of dissolved oxygen criteria violation in the Illinois River are minimal and can not be connected to any one land use.
- The fisheries in the Illinois River in Oklahoma are not damaged.

3.2 PHOSPHORUS IS NOT CAUSING EXCESSIVE GROWTH OF PHYTOPLANKTON IN THE ILLINOIS RIVER

Like other photosynthesizing life-forms, phytoplankton growth depends on light, temperature, and nutrients. The Illinois River in Oklahoma contains enough nutrients for phytoplankton to grow. Bioavailable phosphorus (BP; measured as soluble reactive phosphorus), which is in shorter supply than bioavailable nitrogen (BN; measured as ammonia plus nitrate), is typically found at concentrations close to 100 μg/L; about five times above levels at which growth begins to slow appreciably. Yet, phytoplankton concentrations in the river are relatively low, typically peaking at levels much less than 10 μg chlorophyll-a/L. The fact is illustrated in Figure 3-1, which shows chlorophyll-a and soluble reactive phosphorus at Watts, OK and Tahlequah, OK stations that are representative of the upper and lower portions of the river in Oklahoma. Phosphorus is not causing excessive growth of phytoplankton in the river.

Phytoplankton concentrations in the river are low despite the availability of phosphorus because water flows too quickly through the river for phytoplankton to grow. The river has a relatively steep slope, dropping about 230 ft. between Watts and Tahlequah (based on the USGS datum at the Watts and Tahlequah flow gages). Under a typical summer flow of 400 cfs at Tahlequah, the river is about three feet deep, it moves at about 2 ft. per second and it takes about

1.5 days to travel from Watts to Tahlequah (See Figure 2-31).[17] If conditions are perfect for growth, phytoplankton might increase by a factor three in 1.5 days.[18] This means that if chlorophyll-a starts out at 2 μg/L at Watts, under ideal conditions it might increase to about 6 μg/L by Tahlequah, not accounting for dilution that would occur as water enters the river between Watts and Tahlequah. There is insufficient time to reach levels that affect the aesthetic quality of the water, which are certainly greater than 10 μg/L. A study of 116 Florida lakes (Hoyer et al. 2004) found that the chlorophyll-a level of water whose algal content was perceived to slightly impair swimming and aesthetic enjoyment averaged 14 μg/L and the chlorophyll-a level of water whose algal content substantially reduced the desire to swim averaged 17 μg/L. A similar study of Texas lakes found that the chlorophyll-a level associated with a substantial reduction in the desire to swim averaged 27 μg/L (Texas Water Conservation Association [TWCA] 2005). Consistent with these findings, the State of Minnesota uses chlorophyll-a levels of 20 μg/L for lakes and reservoirs in the Northern Lakes and Forests and North Central Hardwood Ecosystems and 30 μg/L for water bodies in the Western Corn Belt Plains and Northern Glacial Plains Ecosystems as thresholds for a nuisance algae bloom (MPCA 2004). The State of Oregon defines a nuisance algae bloom in a reservoir as a chlorophyll-a concentration of 15 μg/L, which is specified as the concentration representative of the average over a depth range from the surface to twice the Secchi depth and the time average for a three-month period (Oregon Department of Environmental Quality 2008). The Montana Department of Environmental Quality recommended a maximum chlorophyll-a concentration of 20 μg/L for wadeable streams in Montana's Hi-line region (Suplee 2004). In a study of over 200 North American and New Zealand streams and rivers, Dodds et al. (1998) suggested the mesotrophic-eutrophic boundary is at 20 μg/L.

[17] Velocity calculated using Manning's equation with a Manning's roughness coefficient of 0.04.

[18] Growth rate of 1.2/day estimated using the parameters used by Dr. Wells to describe phytoplankton growth, no nutrient limitation and a secchi depth of 4 meters. It is important to note that algae will move with water currents and therefore, rivers with high velocities will not experience maximum algae growth because the algae will not be "exposed" to the nutrients long enough in one place to reach maximum growth.

3.3 BENTHIC ALGAE ARE RARELY AT DENSITIES CONSIDERED A NUISANCE

Dr. Jan Stevenson, a Plaintiffs' consultant, cites two studies in his report indicating that benthic algae become a nuisance at densities greater than 10-15 μg chlorophyll-a/cm^2. Above these threshold densities filamentous species tend to dominate and cover greater than 20% of the stream bottom (Welsh et al. 1988). The USEPA reports that below 15 μg/cm^2 the aesthetic quality use will probably not be appreciably degraded by filamentous mats or other adverse effects attributed to dense mats of filamentous algae (USEPA 2000). Biggs (2000) recommended setting maximum algal biomass of 20 μg/cm^2 with a 30% maximum coverage of visible stream bed by filamentous algae for the protection of aesthetic and trout fishing values for rivers and streams in New Zealand. In a study of over 200 North American and New Zealand streams and rivers, Dodds et al. (1998) suggested the mesotrophic-eutrophic boundary of 20 μg/cm^2. In 2004, Montana Department of Environmental Quality recommended the several numeric criteria for wadeable streams in Montana's Hi-line region, a region covered mainly with semi-arid grasslands used extensively for livestock grazing and growing cereal grain crops. The criteria included maximum streambed cover by filamentous algae of 30% and benthic algae maximum density of 11 μg/cm^2 (Suplee 2004).

The measurements of benthic algae conducted in the Oklahoma portion of the Illinois River and its tributaries by the Plaintiffs' consultants, which are summarized as frequency distributions in Figure 3-2, show that nuisance densities are rare.[19] In summer 2006, the maximum density was 13.8 μg chlorophyll-a/cm^2 and about 95% of the stations had densities less than 10 μg chlorophyll-a/cm^2. In spring 2007, the maximum density was 33.5 μg chlorophyll-a/cm^2, but almost 90% of the stations had densities less than 10 μg chlorophyll-a/cm^2. Densities above 10 μg chlorophyll-a/cm^2 occurred principally in tributaries and frequently downstream of WWTPs. Only one station in the Illinois River in each sampling year had a value greater than 10. Higher values were prevalent in Spring Creek and Sager Creek

[19] The rarity of nuisance benthic algal blooms also invalidates Dr. Stevenson's use of 0.027 mg/L total phosphorus as a benchmark to understand when a particular river or stream in the Illinois River Watershed would have aesthetic issues or "damages". Nuisance levels of benthic algae are rarely measured, yet surface water concentrations of total phosphorus in the Illinois River are routinely above 0.027 mg/L. This fact promotes the establishment of a site-specific benchmark using the available data, as suggested in Stevenson et al. 2006 and Dodds et al. 1997.

as shown in Figure 3-3. On both tributaries, the higher values were found downstream of WWTPs; Siloam Springs on Sager Creek and Springdale on Spring Creek.

The influence of WWTPs on benthic algae is also evident in a USEPA Region 6 2003 study of diel dissolved oxygen variations upstream and downstream of WWTPs (Parsons and UA 2004). Diel dissolved oxygen variations downstream of the Prairie Grove WWTP on Muddy Fork are much greater than exist upstream (Figure 3-4a), indicating a high density of benthic algae. In contrast, little upstream to downstream change is evident around the Rogers WWTP on Puppy Creek (Figure 3-4b). A notable difference between the sites is the slope of the receiving stream; Puppy Creek slopes about 2 feet/mile, whereas Muddy Fork slopes about 1 ft/mile. The steeper slope of Puppy Creek probably means higher velocities, which could limit the density of benthic algae.

Dr. Stevenson examined percent cover by filamentous green algae in addition to benthic algae density. I was not able to replicate his presentation of these data (Figure 2.21 in his May 2008 report), but relying on his presentation, it appears that most stations had less than 30 percent cover. Reading from his graph, I estimate that 30 percent was exceeded at only 4 of 69 stations in 2006 and 27 of 70 stations in 2007. Not being able to replicate his presentation, I was unsure of the validity of the dataset in my possession and did not attempt to locate the high percent cover stations, but the density data suggest they would likely be in small tributaries downstream of WWTPs.

3.4 THE FREQUENCY OF DISSOLVED OXYGEN CRITERIA VIOLATIONS IN THE ILLINOIS RIVER ARE MINIMAL AND CAN NOT BE CONNECTED TO ANY ONE LAND USE

Drs. Cooke and Welch argue that low levels of dissolved oxygen have a strong negative impact on ecosystems of the water bodies of the Illinois River Watershed, and that much of the reduction in dissolved oxygen levels can be traced to land application of poultry litter. Dissolved oxygen data collected throughout the watershed refute this assertion.

Oklahoma regulations consider a stream to support the designated beneficial use of a cool water aquatic community if "no more than 10% of the samples from a stream are less than the screening level for DO" (OWRB 2008). As Figure 3-5 illustrates, for 2004-2007, the standard was met; only 3.4% of summer dissolved oxygen measurements, and 3.8% of dissolved oxygen measurements taken during the remainder of the year were below the associated criteria.

Of the 171 river and stream miles of the Illinois River Watershed that Oklahoma lists as not meeting water quality standards, only a 1.6 mile stretch of Flint Creek is listed as impaired due to dissolved oxygen (OWRB 2008). Nine potential sources are listed for the dissolved oxygen impairment of this stream segment.

Illinois River Watershed stream locations with sufficient dissolved oxygen data to assess water quality during 2004-2007 are indicated on Figure 3-6.[20] In 2007, 11% of the dissolved oxygen readings at the Flint Creek location were below the criteria. All other locations assessed had fewer than ten percent of the dissolved oxygen readings below the criteria for each year of the assessment. Land uses are also indicated on this map, and as can be seen, the majority of the land draining to locations with reduced dissolved oxygen is classified as deciduous forest or developed open space.

These data showing minimal dissolved oxygen violations, and the multiple potential sources of the dissolved oxygen impairments listed by the Oklahoma DEQ do not support the conclusion that poultry litter has impacted oxygen levels in the Illinois River Watershed.

3.5 THE FISHERIES IN THE ILLINOIS RIVER IN OKLAHOMA ARE NOT DAMAGED

In his report, Dr. Jan Stevenson evaluated fisheries in the Illinois River Watershed, from 37 locations in Arkansas and Oklahoma. His stated objective was "to document the injuries of fish species composition that are related to poultry house activities and nutrient pollution"

(Stevenson 2008; Section 4.1, p. 37). However, the analysis presented in his report fails to assess if the fisheries are actually injured, let alone injured due to poultry litter application and/or nutrient pollution.

Pollutants and other environmental stresses may simplify ecosystems by reducing the number of species present and by shifting the relative abundances of the surviving populations toward dominance by stress resistant species (Odum 1969; Woodwell 1970). The data collected in 2007 was intended to provide a basis to assess overall fish composition and abundance.[21] Most study sites contained species expected to occur within streams in the Ozark Highlands Ecoregion (with percids, cyprinids, and centrarchids typically most abundant [Dauwalter et al. 2003; Table 3-1]). The most common species collected in 2007 from the 37 Plaintiffs' locations were fluvial specialists such as stonerollers (*Campostoma spp*), cardinal shiner (*Luxilus cardinalis*), orangethroat darter (*Etheostoma spectabile*), and banded sculpin (*Cottus carolinae*). These four stream dwelling species prefer clear gravel bottom streams and require flowing water during some portion of their life history. Additionally, cardinal shiner is reported as one of the most intolerant fishes in Oklahoma of degradation to both water quality and habitat (Jester et al. 1992). Therefore, the presence of the cardinal shiner would indicate that water quality is not degraded. This species accounted for more than 2% of the overall abundance in 27 out of 37 locations (73%), and averaged 14% of the abundance at all locations (Table 3-1).

The overall composition and representativeness of species at each location provide additional insights regarding fishery health. We calculated Shannon-Weiner diversity and evenness for each location. Diversity values ranged from 1.01 to 2.58 with the two reference sites (Little Lee Creek RS-10003 and RS-10004)[22] at 2.09 and 2.11, respectively (Table 3-1). The lower diversity values, which may suggest some impact or may be due to smaller order streams being less diverse, are scattered throughout the watershed with no evident spatial patterns (Figure 3-7). Evenness was calculated to assess the relative spread of species and

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[20] Only locations with at least eight records in at least two years were considered. In addition, to ensure year-round oxygen status, only locations with at least one DO records in at least 3 quarters (three-month periods) were considered.

[21] Note: not all data used in this analysis were provided from the Plaintiffs' laboratory sheets. Additional data were used from Stevenson's considered materials; specifically: "Fish analysis.mdb" and "Database CDM 20080518.mdb."

evaluate if sites were dominated by one species. Values can range from zero for sites with one species dominant to one for sites were all species are found in equal numbers. Within the Illinois River Watershed, evenness ranged from 0.369 to 0.917; with values at the two reference sites of 0.753 and 0.656 (Table 3-1). While a few sites were dominated by one or two species, the majority of sites had fairly good representation of several stream species.

The index of biotic integrity (IBI) is a valuable metric that was developed to provide a straightforward and relatively quick method to assess local stream conditions based on the fish community (Karr et al. 1986). Fish integrate many trophic levels, providing a broad view of the biological community. The IBI is calculated and general descriptions given to each range of scores (e.g., good, fair, poor; see Chadwick 2009 for complete description of the IBI).

While initially developed for Midwestern streams, the IBI has been modified for several ecoregions throughout the United States, Mexico, and Europe. Recently, Dauwalter et al. (2003) developed an IBI for the Ozark Highlands Ecoregion in Arkansas. After review of the model, it was applied to the 37 locations in the Illinois River Watershed sampled in 2007. The final IBI is based on seven metrics representing taxonomic, trophic, reproductive, and health characteristics of fish asssemblages (Dauwalter et al. 2003).[23] Most of the final metrics were most significantly correlated with nutrients, chloride, land use, road densities, and sedimentation (Dauwalter et al. 2003), and should provide a robust method for assessing overall integrity.

Results of the IBI analysis within the Illinois River Watershed indicate most sites are in good condition (Table 3-1 and Figure 3-8). The majority of the sites rated as "good" are found in Oklahoma. To further evaluate the IBI score, comparisons were made between the IBI and local watershed characteristics, including:

- subwatershed area (Figure 3-9);
- poultry house density (Figure 3-10);
- road density (Figure 3-11);

[22] Note: the two reference sites are located outside of the Illinois River watershed.

- percent developed area (Figure 3-12);
- percent forested area (Figure 3-13);
- percent pasture area (Figure 3-14);
- density of WWTP discharges (Figure 3-15);
- distance to nearest road (Figure 3-16);
- distance to nearest urban land use classification (Figure 3-17); and
- distance to nearest poultry house (Figure 3-18).

There was no statistically significant relationship between the IBI value and any of these variables. For stations that had values below the minimum value for good scores (less than 60), points were scattered along the x-axis, rather than being clumped around any one value.

In summary, the fish community within the Illinois River Watershed is not highly degraded due to water quality impacts. While diversity is low in some locations, this is not unexpected due to the size of the streams (smaller streams will support fewer species). Stevenson also observed a direct relationship between fish species number and watershed size with fewer species in smaller watersheds (Stevenson 2008, Section 4.3.2.1., p. 40). There are limited data available on habitat parameters, so habitat quality can not be assessed at this time. However, it is possible that sites with lower IBI and/or diversity index scores may be more impacted by habitat availability than water quality degradation. Jester et al. (1992) reported that the majority of Oklahoma fish species are more sensitive to habitat degradation than they are to water quality degradation. Finally, the protocol used to sample fish may underestimate the diversity of fish within the watershed. Electrofishing consisted of sampling a habitat unit (e.g., riffle, pool) for three minutes (five minutes for boat shocking) and collecting stunned fish. In some cases, it appears that a second or third one- to three-minute period was sampled, although the exact protocols for this were not defined in the Standard Operating Procedures (SOP). It is fairly remarkable that the diversity within the watershed is as high as it is based on the low effort expended sampling each location. Diversity likely would be higher if more effort was expended

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[23] Note: metric number 2 – percent with black spot or anomaly - was excluded due to insufficient data in the database.

at each site, especially in terms of the larger fish that more easily escape capture in a short period of time.

Table 3-1. Summary of species composition in the Illinois River Watershed based on the Plaintiff's 2007 data.

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
Ballard Creek	AR	RS-399	Campostoma spp.	298	73.0	3	1.03	0.447	57	Fair
		RS-399	Etheostoma spectabile	42	10.3					
		RS-399	Luxilus cardinalis	25	6.1					
		RS-399	Lepomis cyanellus	17	4.2					
		RS-399	Phoxinus erythrogaster	14	3.4					
		RS-399	Other (5 spp)	12	2.9					
	OK	BS-62A	Campostoma spp.	192	28.6	3	1.95	0.704	78	Good
		BS-62A	Cottus carolinae	127	18.9					
		BS-62A	Luxilus cardinalis	127	18.9					
		BS-62A	Etheostoma spectabile	84	12.5					
		BS-62A	Lepomis megalotis	62	9.2					
		BS-62A	Other (9 spp)	33	4.9					
		BS-62A	Noturus exilis	24	3.6					
		BS-62A	Lepomis macrochirus	23	3.4					
Flint Creek	AR	RS-160	Cottus carolinae	148	46.5	4	1.64	0.747	63	Good
		RS-160	Phoxinus erythrogaster	59	18.6					
		RS-160	Semotilus atromaculatus	36	11.3					
		RS-160	Etheostoma flabellare	19	6.0					
		RS-160	Campostoma spp.	17	5.3					
		RS-160	Etheostoma spectabile	16	5.0					
		RS-160	Catostomus commersoni	15	4.7					
		RS-160	Other (2 spp)	8	2.5					
	OK	RS-902	Cottus carolinae	117	35.2	4	1.74	0.641	74	Good
		RS-902	Campostoma spp.	102	30.7					
		RS-902	Luxilus cardinalis	45	13.6					
		RS-902	Other (9 spp)	23	6.9					
		RS-902	Noturus exilis	20	6.0					
		RS-902	Etheostoma spectabile	18	5.4					
		RS-902	Micropterus dolomieu	7	2.1					
		RS-421	Etheostoma spectabile	221	45.6	4	1.62	0.614	75	Good
		RS-421	Campostoma spp.	99	20.4					
		RS-421	Luxilus cardinalis	60	12.4					
		RS-421	Noturus exilis	45	9.3					
		RS-421	Semotilus	23	4.7					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
			atromaculatus							
		RS-421	Etheostoma punctulatum	20	4.1					
		RS-421	Other (8 spp)	17	3.5					
Upper Illinois River	AR	RS-234	Campostoma spp.	320	39.0	3	1.96	0.678	68	Good
		RS-234	Luxilus cardinalis	142	17.3					
		RS-234	Lepomis megalotis	94	11.5					
		RS-234	Other (11 spp)	75	9.1					
		RS-234	Lepomis cyanellus	70	8.5					
		RS-234	Etheostoma spectabile	65	7.9					
		RS-234	Pimephales notatus	36	4.4					
		RS-234	Etheostoma blennioides	18	2.2					
Middle Illinois River	OK	RS-757	Luxilus cardinalis	229	32.0	6	2.16	0.635	58	Fair
		RS-757	Lepomis megalotis	192	26.9					
		RS-757	Other (21 spp)	76	10.6					
		RS-757	Moxostoma erythrurum	68	9.5					
		RS-757	Lepomis macrochirus	37	5.2					
		RS-757	Pimephales notatus	33	4.6					
		RS-757	Dorosoma cepedianum	26	3.6					
		RS-757	Campostoma spp.	22	3.1					
		RS-757	Lepomis cyanellus	17	2.4					
		RS-757	Micropterus punctulatus	15	2.1					
Lower Illinois River	OK	RS-433A	Luxilus cardinalis	401	64.3	6	1.52	0.471	70	Good
		RS-433A	Notropis boops	66	10.6					
		RS-433A	Other (19 spp)	64	10.3					
		RS-433A	Lepomis megalotis	33	5.3					
		RS-433A	Campostoma spp.	26	4.2					
		RS-433A	Micropterus dolomieu	19	3.0					
		RS-433A	Pimephales notatus	15	2.4					
		RS-654	Pimephales notatus	153	18.1	6	2.58	0.767	62	Good
		RS-654	Notropis boops	127	15.1					
		RS-654	Luxilus cardinalis	94	11.2					
		RS-654	Lepomis megalotis	92	10.9					
		RS-654	Other (18 spp)	82	9.7					
		RS-654	Dorosoma cepedianum	64	7.6					
		RS-654	Dorosoma petenense	61	7.2					
		RS-654	Hypentelium nigricans	52	6.2					
		RS-654	Notropis nubilus	33	3.9					
		RS-654	Campostoma spp.	32	3.8					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
		RS-654	Lepomis macrochirus	28	3.3					
		RS-654	Moxostoma erythrurum	25	3.0					
Trib to Lower Illinois River	OK	RS-604	Luxilus cardinalis	587	51.2	4	1.2	0.502	69	Good
		RS-604	Etheostoma spectabile	305	26.6					
		RS-604	Campostoma spp.	209	18.2					
		RS-604	Other (8 spp)	46	4.0					
Unnamed tributary to Illinois River	OK	RS-772	Cottus carolinae	187	53.4	3	1.34	0.642	53	Fair
		RS-772	Phoxinus erythrogaster	81	23.1					
		RS-772	Campostoma spp.	30	8.6					
		RS-772	Semotilus atromaculatus	30	8.6					
		RS-772	Etheostoma spectabile	13	3.7					
		RS-772	Other (3 spp)	9	2.6					
Bush Creek	AR	BS-HF22	Phoxinus erythrogaster	69	24.3	3	2.11	0.8	68	Good
		BS-HF22	Campostoma spp.	51	18.0					
		BS-HF22	Cottus carolinae	49	17.3					
		BS-HF22	Etheostoma spectabile	42	14.8					
		BS-HF22	Semotilus atromaculatus	21	7.4					
		BS-HF22	Noturus exilis	13	4.6					
		BS-HF22	Other (4 spp)	11	3.9					
		BS-HF22	Etheostoma punctulatum	9	3.2					
		BS-HF22	Etheostoma flabellare	7	2.5					
		BS-HF22	Lepomis cyanellus	6	2.1					
		BS-HF22	Luxilus cardinalis	6	2.1					
Cincinnati Creek	AR	RS-392	Phoxinus erythrogaster	124	38.5	3	1.7	0.661	68	Good
		RS-392	Etheostoma spectabile	70	21.7					
		RS-392	Campostoma spp.	54	16.8					
		RS-392	Cottus carolinae	30	9.3					
		RS-392	Luxilus cardinalis	25	7.8					
		RS-392	Other (8 spp)	19	5.9					
		RS-386	Etheostoma spectabile	130	29.3		1.8	0.752	77	Good
		RS-386	Campostoma spp.	99	22.3	3				

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
		RS-386	Luxilus cardinalis	79	17.8					
		RS-386	Etheostoma punctulatum	61	13.8					
		RS-386	Cottus carolinae	39	8.8					
		RS-386	Semotilus atromaculatus	11	2.5					
		RS-386	Noturus exilis	10	2.3					
		RS-386	Phoxinus erythrogaster	10	2.3					
		RS-386	Other (3 spp)	4	0.9					
		BS-68	Campostoma spp.	169	29.9	4	1.69	0.641	75	Good
		BS-68	Luxilus cardinalis	168	29.7					
		BS-68	Etheostoma spectabile	117	20.7					
		BS-68	Noturus exilis	54	9.6					
		BS-68	Other (8 spp)	23	4.1					
		BS-68	Etheostoma punctulatum	17	3.0					
		BS-68	Semotilus atromaculatus	17	3.0					
Fly Creek	AR	BS-35	Campostoma spp.	344	45.1	3	1.41	0.551	74	Good
		BS-35	Etheostoma spectabile	257	33.7					
		BS-35	Luxilus cardinalis	76	10.0					
		BS-35	Other (8 spp)	40	5.2					
		BS-35	Cottus carolinae	26	3.4					
		BS-35	Lepomis cyanellus	20	2.6					
Muddy Fork	AR	RS-233	Lepomis megalotis	75	24.0	4	2.48	0.827	65	Good
		RS-233	Etheostoma spectabile	35	11.2					
		RS-233	Campostoma spp.	33	10.5					
		RS-233	Luxilus cardinalis	29	9.3					
		RS-233	Lepomis cyanellus	26	8.3					
		RS-233	Pimephales notatus	20	6.4					
		RS-233	Other (8 spp)	19	6.1					
		RS-233	Etheostoma blennioides	19	6.1					
		RS-233	Cottus carolinae	18	5.8					
		RS-233	Lepomis macrochirus	11	3.5					
		RS-233	Noturus exilis	10	3.2					
		RS-233	Etheostoma zonale	9	2.9					
		RS-233	Lepomis gulosus	9	2.9					
Spring Creek	AR	RS-121	Etheostoma spectabile	63	27.2	4	1.95	0.76	54	Fair
		RS-121	Campostoma spp.	45	19.4					
		RS-121	Luxilus cardinalis	43	18.5					
		RS-121	Noturus exilis	34	14.7					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
		RS-121	Lepomis megalotis	15	6.5					
		RS-121	Lepomis cyanellus	12	5.2					
		RS-121	Other (6 spp)	11	4.7					
		RS-121	Lepomis macrochirus	9	3.9					
Baron Fork	OK	RS-682	Cottus carolinae	181	51.4	4	1.53	0.597	66	Good
		RS-682	Campostoma spp.	77	21.9					
		RS-682	Etheostoma spectabile	27	7.7					
		RS-682	Luxilus cardinalis	23	6.5					
		RS-682	Other (7 spp)	17	4.8					
		RS-682	Noturus exilis	16	4.5					
		RS-682	Etheostoma punctulatum	11	3.1					
		RS-649	Campostoma spp.	410	37.2	6	1.83	0.574	78	Good
		RS-649	Luxilus cardinalis	334	30.3					
		RS-649	Other (18 spp)	100	9.1					
		RS-649	Etheostoma spectabile	92	8.4					
		RS-649	Cottus carolinae	83	7.5					
		RS-649	Noturus exilis	57	5.2					
		RS-649	Lepomis megalotis	25	2.3					
Bidding Springs	OK	RS-706	Luxilus cardinalis	68	23.7	2	2.1	0.714	77	Good
		RS-706	Etheostoma flabellare	64	22.3					
		RS-706	Campostoma spp.	50	17.4					
		RS-706	Etheostoma spectabile	29	10.1					
		RS-706	Lepomis cyanellus	26	9.1					
		RS-706	Other (11 spp)	18	6.3					
		RS-706	Fundulus olivaceus	17	5.9					
		RS-706	Cottus carolinae	9	3.1					
		RS-706	Semotilus atromaculatus	6	2.1					
Caney Creek	OK	RS-728	Campostoma spp.	527	48.1	2	1.04	0.578	61	Good
		RS-728	Etheostoma spectabile	417	38.0					
		RS-728	Phoxinus erythrogaster	142	13.0					
		RS-728	Other (3 spp)	10	0.9					
		RS-704	Cottus carolinae	304	37.0	4	1.56	0.65	61	Good
		RS-704	Campostoma spp.	214	26.0					
		RS-704	Phoxinus erythrogaster	168	20.4					
		RS-704	Luxilus cardinalis	77	9.4					
		RS-704	Other (6 spp)	31	3.8					
		RS-704	Etheostoma spectabile	28	3.4					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
Evansville Creek	OK	RS-693	Campostoma spp.	304	47.7	4	1.54	0.602	72	Good
		RS-693	Etheostoma spectabile	159	25.0					
		RS-693	Lepomis megalotis	54	8.5					
		RS-693	Lepomis cyanellus	41	6.4					
		RS-693	Luxilus cardinalis	33	5.2					
		RS-693	Noturus exilis	24	3.8					
		RS-693	Other (7 spp)	22	3.5					
Little Lee Creek	OK	RS-10003	Campostoma spp.	105	33.2		2.09	0.753	96	Reference
		RS-10003	Luxilus cardinalis	56	17.7					
		RS-10003	Etheostoma spectabile	36	11.4					
		RS-10003	Lepomis megalotis	31	9.8					
		RS-10003	Etheostoma flabellare	24	7.6					
		RS-10003	Noturus exilis	15	4.7					
		RS-10003	Other (6 spp)	14	4.4					
		RS-10003	Micropterus dolomieu	13	4.1					
		RS-10003	Etheostoma blennioides	8	2.5					
		RS-10003	Lepomis cyanellus	7	2.2					
		RS-10003	Semotilus atromaculatus	7	2.2					
		RS-10004	Lepomis megalotis	181	26.2		2.11	0.656	96	Reference
		RS-10004	Luxilus cardinalis	178	25.7					
		RS-10004	Campostoma spp.	98	14.2					
		RS-10004	Etheostoma flabellare	85	12.3					
		RS-10004	Other (18 spp)	79	11.4					
		RS-10004	Noturus exilis	35	5.1					
		RS-10004	Etheostoma spectabile	19	2.7					
		RS-10004	Etheostoma blennioides	17	2.5					
Park Hill Branch	OK	RS-518	Campostoma spp.	751	77.6	3	1.02	0.369	64	Good
		RS-518	Other (11 spp)	74	7.6					
		RS-518	Etheostoma spectabile	63	6.5					
		RS-518	Cottus carolinae	29	3.0					
		RS-518	Semotilus	27	2.8					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
			atromaculatus							
		RS-518	Etheostoma flabellare	23	2.4					
Peacheater Creek	OK	BS-208	Luxilus cardinalis	47	19.7	4	2.22	0.82	76	Good
		BS-208	Cottus carolinae	46	19.3					
		BS-208	Campostoma spp.	30	12.6					
		BS-208	Semotilus atromaculatus	28	11.8					
		BS-208	Etheostoma flabellare	25	10.5					
		BS-208	Etheostoma spectabile	17	7.1					
		BS-208	Phoxinus erythrogaster	15	6.3					
		BS-208	Nocomis asper	11	4.6					
		BS-208	Etheostoma punctulatum	7	2.9					
		BS-208	Noturus exilis	6	2.5					
		BS-208	Other (5 spp)	6	2.5					
Peavine Creek	OK	RS-657	Phoxinus erythrogaster	258	30.6	3	1.67	0.631	69	Good
		RS-657	Cottus carolinae	252	29.9					
		RS-657	Campostoma spp.	148	17.5					
		RS-657	Etheostoma spectabile	116	13.7					
		RS-657	Other (9 spp)	47	5.6					
		RS-657	Luxilus cardinalis	23	2.7					
Sager Creek	OK	BS-HF04	Etheostoma spectabile	179	53.8	3	1.52	0.613	80	Reference
		BS-HF04	Semotilus atromaculatus	54	16.2					
		BS-HF04	Campostoma spp.	24	7.2					
		BS-HF04	Cottus carolinae	23	6.9					
		BS-HF04	Etheostoma punctulatum	19	5.7					
		BS-HF04	Luxilus cardinalis	19	5.7					
		BS-HF04	Noturus exilis	10	3.0					
		BS-HF04	Other (5 spp)	5	1.5					
Scraper Hollow Creek	OK	RS-667	Phoxinus erythrogaster	45	35.2	3	1.73	0.83	57	Fair
		RS-667	Cottus carolinae	26	20.3					
		RS-667	Semotilus atromaculatus	26	20.3					
		RS-667	Etheostoma spectabile	10	7.8					
		RS-667	Campostoma spp.	7	5.5					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
		RS-667	Lepomis cyanellus	6	4.7					
		RS-667	Noturus exilis	6	4.7					
		RS-667	Other (1 spp)	2	1.6					
Shell Branch	OK	RS-793	Phoxinus erythrogaster	23	20.2	2	1.91	0.917	76	Good
		RS-793	Etheostoma punctulatum	20	17.5					
		RS-793	Etheostoma spectabile	19	16.7					
		RS-793	Cottus carolinae	18	15.8					
		RS-793	Luxilus cardinalis	18	15.8					
		RS-793	Etheostoma flabellare	9	7.9					
		RS-793	Noturus exilis	6	5.3					
		RS-793	Other (1 spp)	1	0.9					
Tahlequah Creek	OK	RS-630	Etheostoma flabellare	290	64.3	4	1.12	0.694	62	Good
		RS-630	Phoxinus erythrogaster	69	15.3					
		RS-630	Campostoma spp.	35	7.8					
		RS-630	Etheostoma spectabile	34	7.5					
		RS-630	Semotilus atromaculatus	23	5.1					
		RS-578	Campostoma spp.	291	40.5	4	1.66	0.556	74	Good
		RS-578	Luxilus cardinalis	230	32.0					
		RS-578	Etheostoma spectabile	67	9.3					
		RS-578	Other (14 spp)	50	7.0					
		RS-578	Noturus exilis	36	5.0					
		RS-578	Cottus carolinae	25	3.5					
		RS-578	Etheostoma flabellare	20	2.8					
Tate Paris Creek	OK	RS-770	Etheostoma flabellare	150	36.2	3	1.69	0.66	78	Good
		RS-770	Etheostoma spectabile	112	27.1					
		RS-770	Luxilus cardinalis	57	13.8					
		RS-770	Campostoma spp.	50	12.1					
		RS-770	Other (7 spp)	21	5.1					
		RS-770	Etheostoma punctulatum	13	3.1					
		RS-770	Semotilus atromaculatus	11	2.7					
Tyner Creek	OK	RS-541	Phoxinus erythrogaster	226	52.3	3	1.01	0.628	53	Fair
		RS-541	Cottus carolinae	157	36.3					
		RS-541	Etheostoma flabellare	42	9.7					
		RS-541	Other (2 spp)	7	1.6					

Creek Name	State	Location	Name	Count	Percent	Stream Order	SW Diversity	SW Evenness	IBI Score	IBI Description
		RS-548	Cottus carolinae	292	47.9	5	1.53	0.614	62	Good
		RS-548	Phoxinus erythrogaster	128	21.0					
		RS-548	Campostoma spp.	86	14.1					
		RS-548	Etheostoma flabellare	41	6.7					
		RS-548	Luxilus cardinalis	26	4.3					
		RS-548	Semotilus atromaculatus	15	2.5					
		RS-548	Other (6 spp)	21	3.4					

SECTION 10
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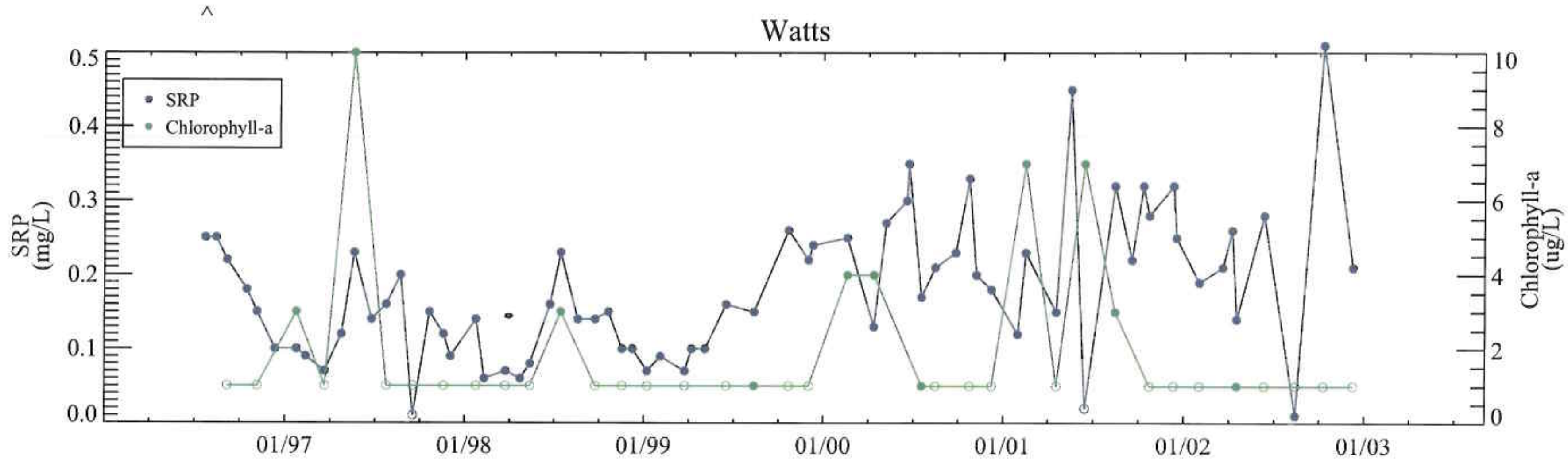

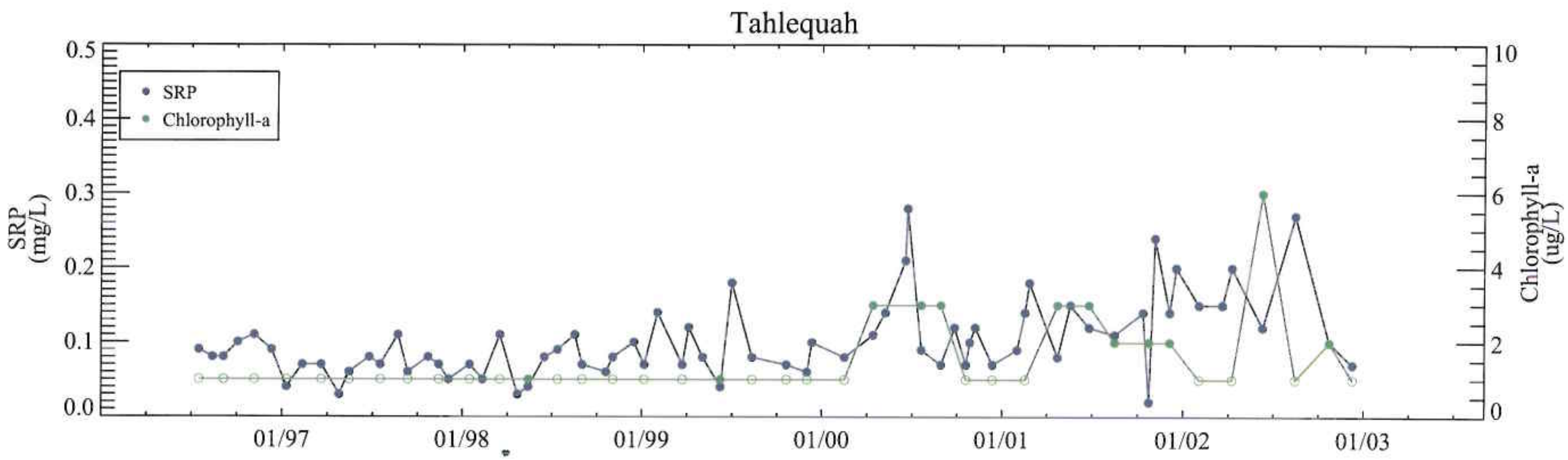

Figure 3-1. SRP and chlorophyll-a concentrations versus time at Watts and Tahlequah.

Watts data from USGS station 07195500. Tahlequah data from USGS station 07196500.
Chlorophyll-a data from USGS parameter 32211 (chlorophyll-a, phytoplankton, spectrophotometric acid method).
Non-detects included at detection limit and indicated by open symbols.

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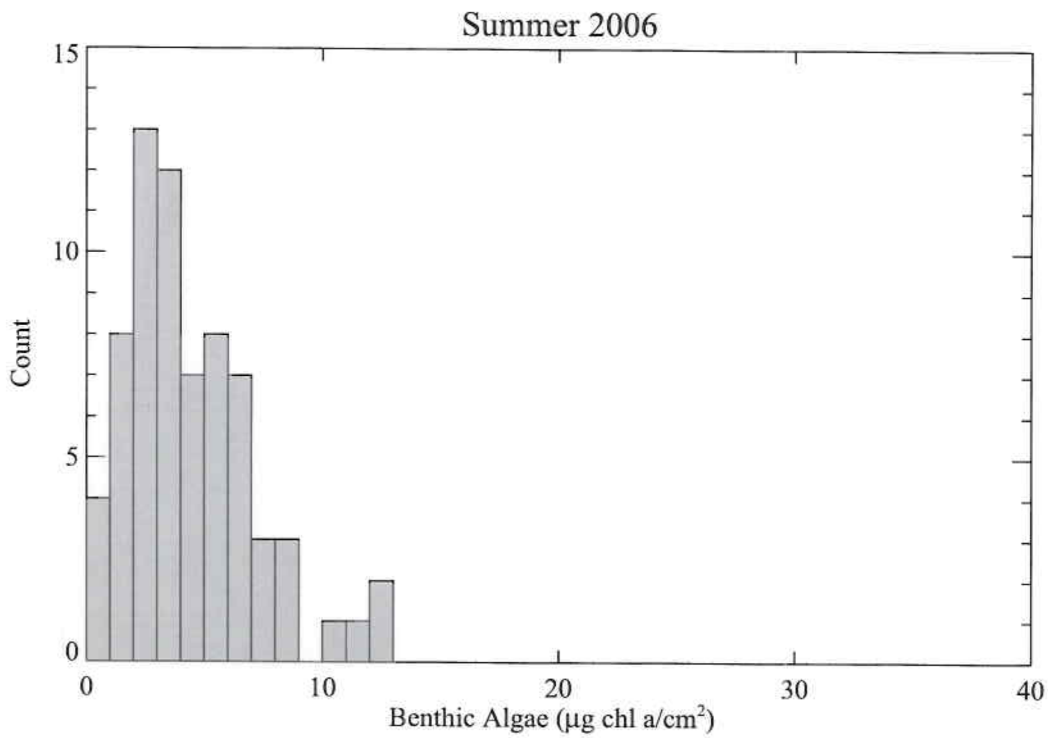


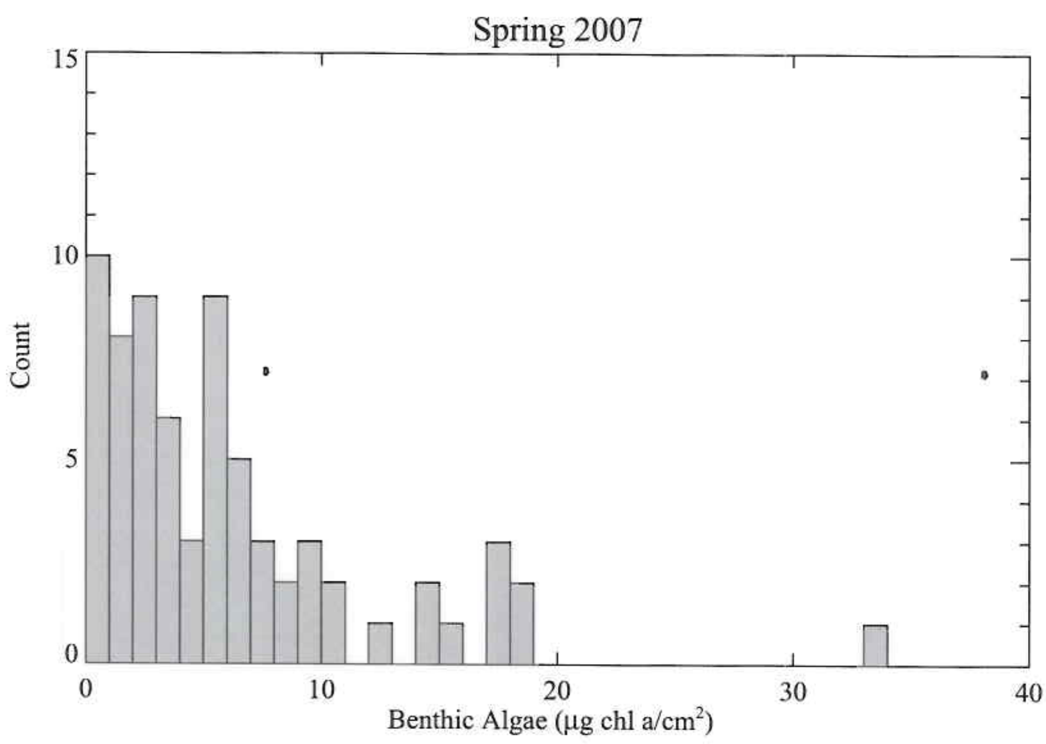
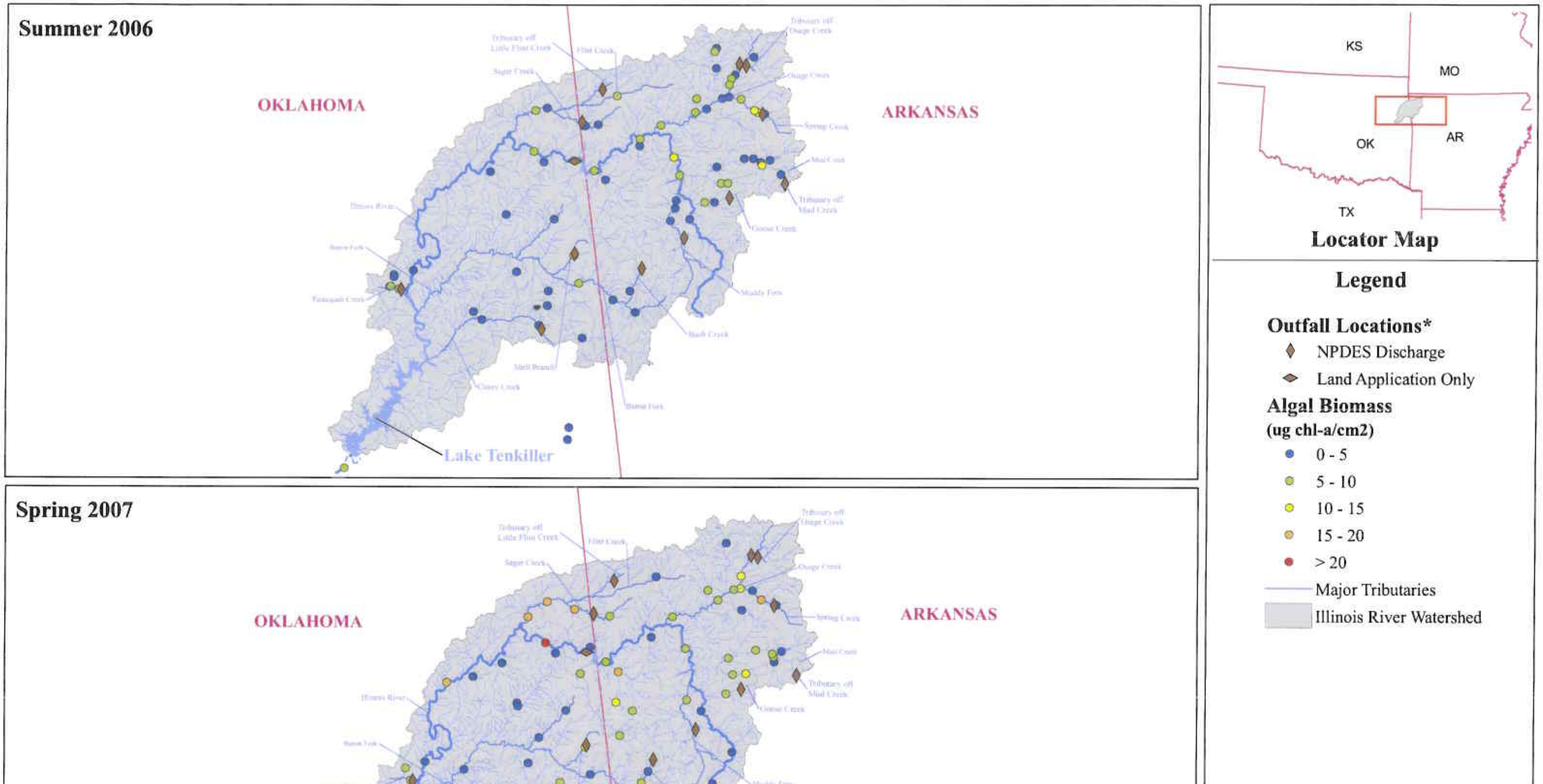


Figure 3-2. Count of benthic algae algal biomass at stations sampled in Summer 2006 and Spring 2007.

Data has been confirmed with reasonable confidence by GEI Consultants during data discovery; data based on samples collected by Stevenson.



*Jarman, 2008.
Data source: Figure 2.2.1, Stevenson.

Figure 3-3.
Benthic algae biomass at stations sampled in Summer 2006 and Spring 2007.

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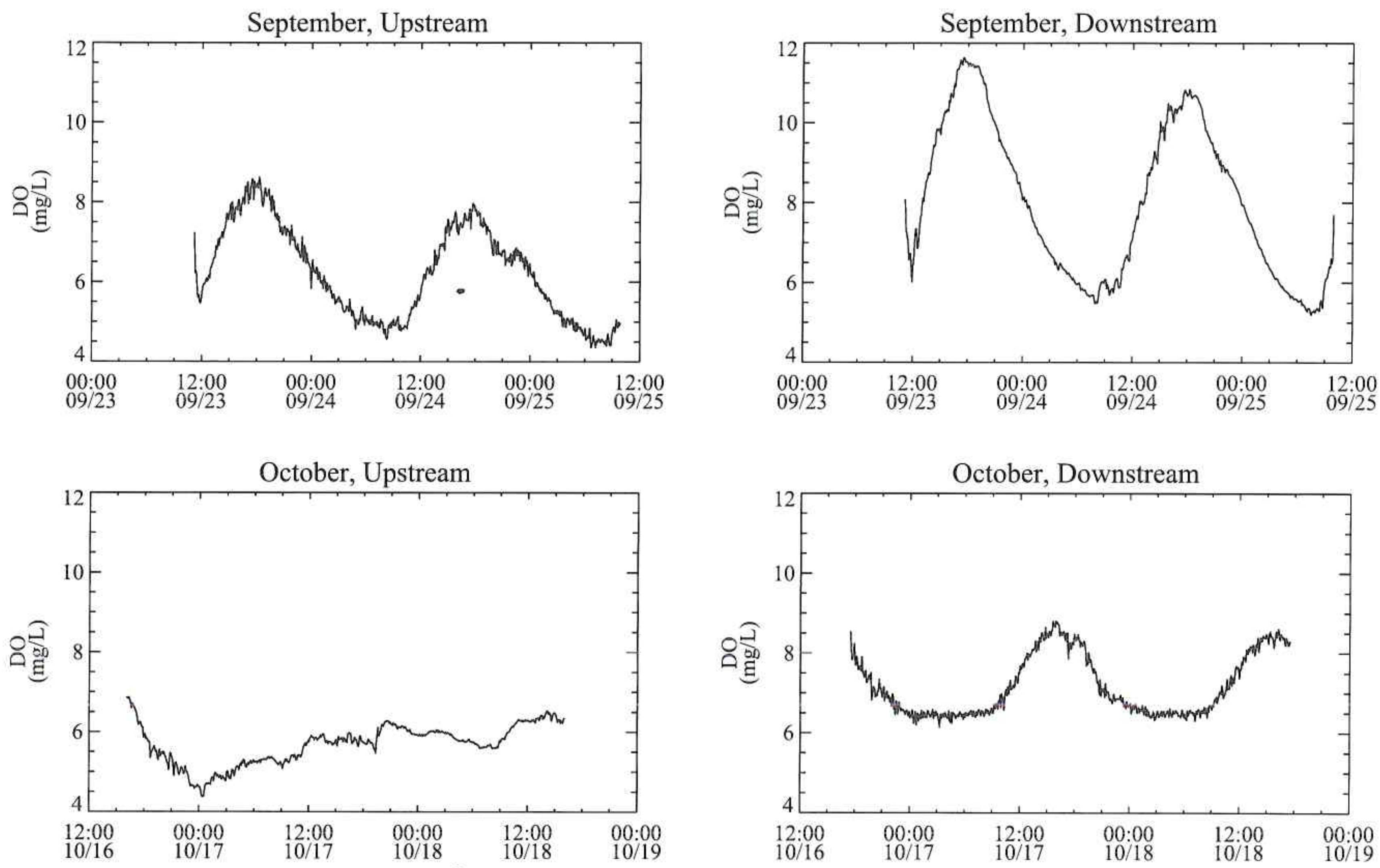

Figure 3-4a. Dissolved oxygen, Prairie Grove WWTP. River slope = 1 ft / 1000 ft.

Data collected in 2003 by U.S. EPA Region 6 water quality and biological assessment of Illinois River and King River basins. Upstream measurements taken ~4800 ft upstream of outfall. Downstream measurements taken ~9300 ft downstream of outfall.

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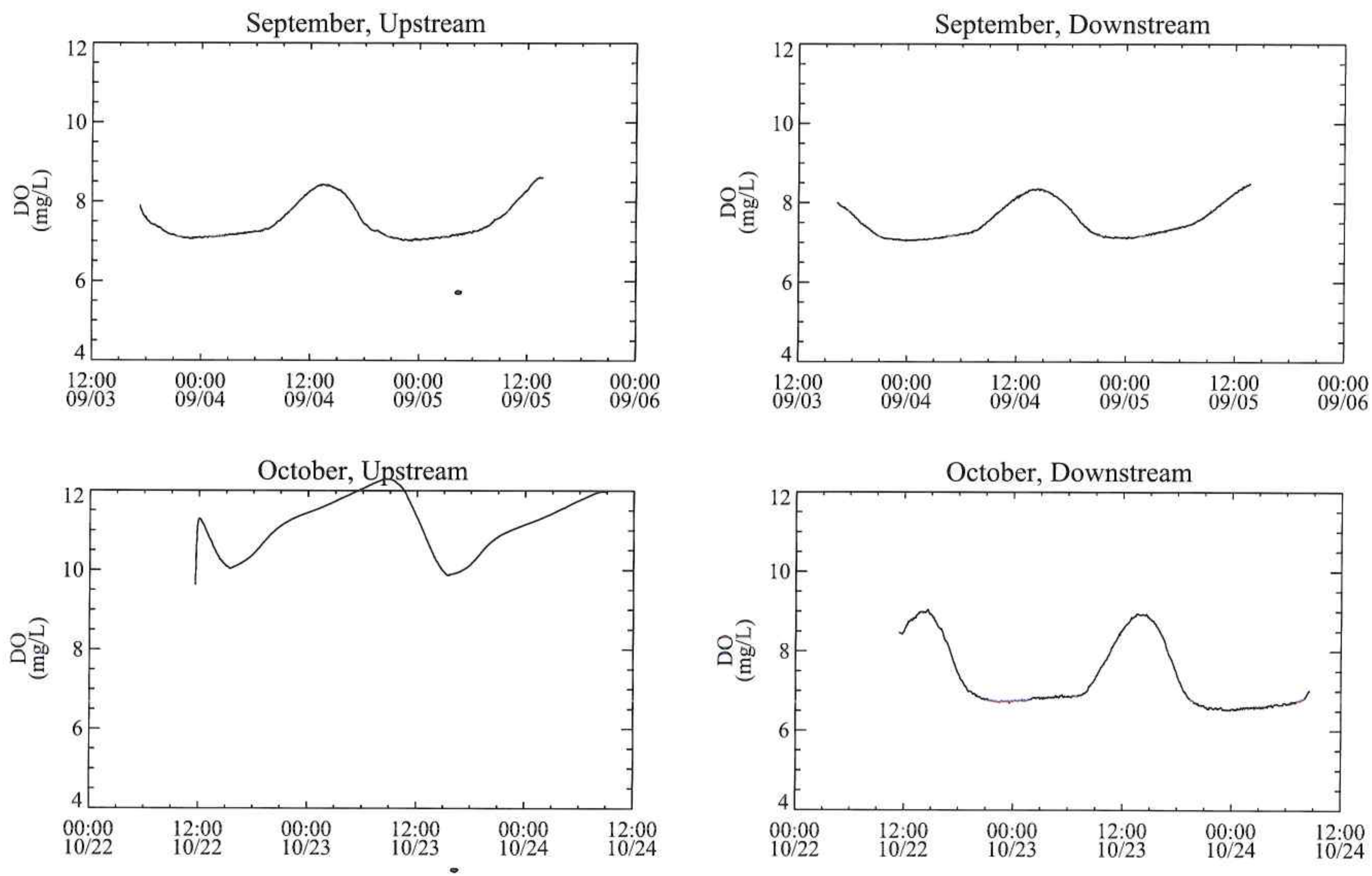

Figure 3-4b. Dissolved oxygen, Rogers WWTP. River slope = 2 ft / 1000 ft.

Data collected in 2003 by U.S. EPA Region 6 water quality and biological assessment of Illinois River and King River basins. Upstream measurements taken ~850 ft upstream of outfall. Downstream measurements taken ~2500 ft downstream of outfall.

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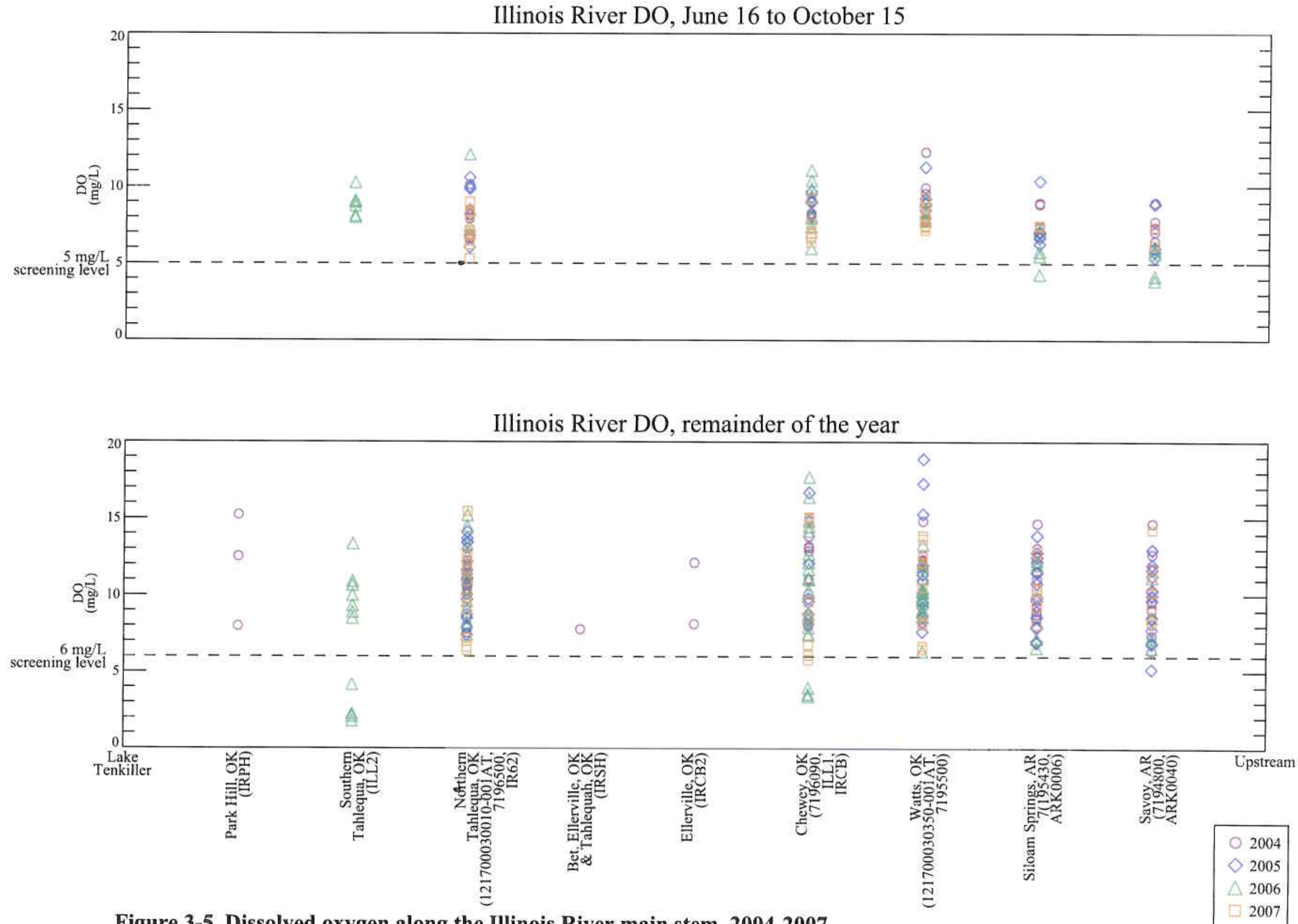

Figure 3-5. Dissolved oxygen along the Illinois River main stem, 2004-2007.

Data sources: Arkansas Dept. of Environmental Quality, Cherokee Nation (Oklahoma), Oklahoma Dept. of Environmental Quality, OWRB, USGS

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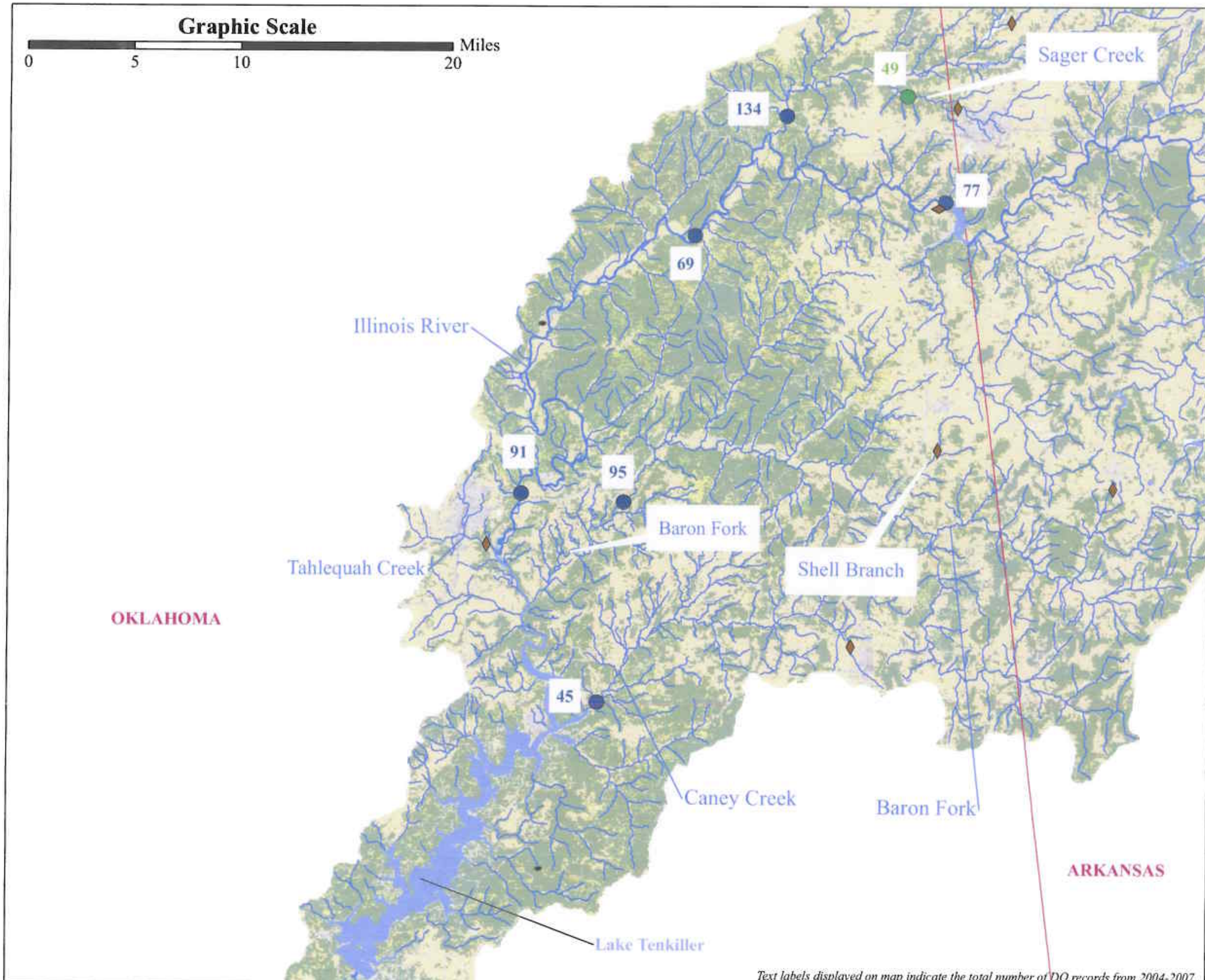
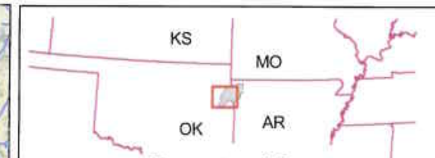
Wed Jan 21 15:53:16 2009





Legend

Outfall Locations
- NPDES Discharge
- Land Application Only

Dissolved oxygen*
- 0 years with > 10% below screening level
- 1 year with > 10% below screening level
- 2 years with > 10% below screening level
- 3 years with > 10% below screening level
- 4 years with > 10% below screening level
- Lakes
- Major Tributaries and Tributaries with Outfall Locations

Landuse
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

**These values represent the number of years that a given station exceeded the standard and for rivers and streams only.*

Notes:
1) This analysis is based on habitat specific DO screening levels:
a) For warm water habitat 4.0 mg/L between June 16 and October 15 and 5.0 mg/L for the rest of the year.
b) For cold water habitat 5.0 mg/L between June 16 and October 15 and 6.0 mg/L for the rest of the year.
2) Data sources: ADEQ, OWRB, USGS, Storet, Storet-Modern and Plaintiffs' data collected 2005 - 2007.
3) To assure sufficient data for determining frequency of exceedance, all sampling stations which meet the following criteria are shown:
- 8 or more DO records per year in at least 2 years from 2004-2007
- 1 or more DO records per quarter (3-month period) for at least 3 quarters each year.
4) Outfall locations are from Jarman, 2008.
5) Landuse data source: NLCD 2001.

Figure 3-6.
Dissolved oxygen exceedances in rivers and streams for the Illinois River Watershed, 2004-2007.

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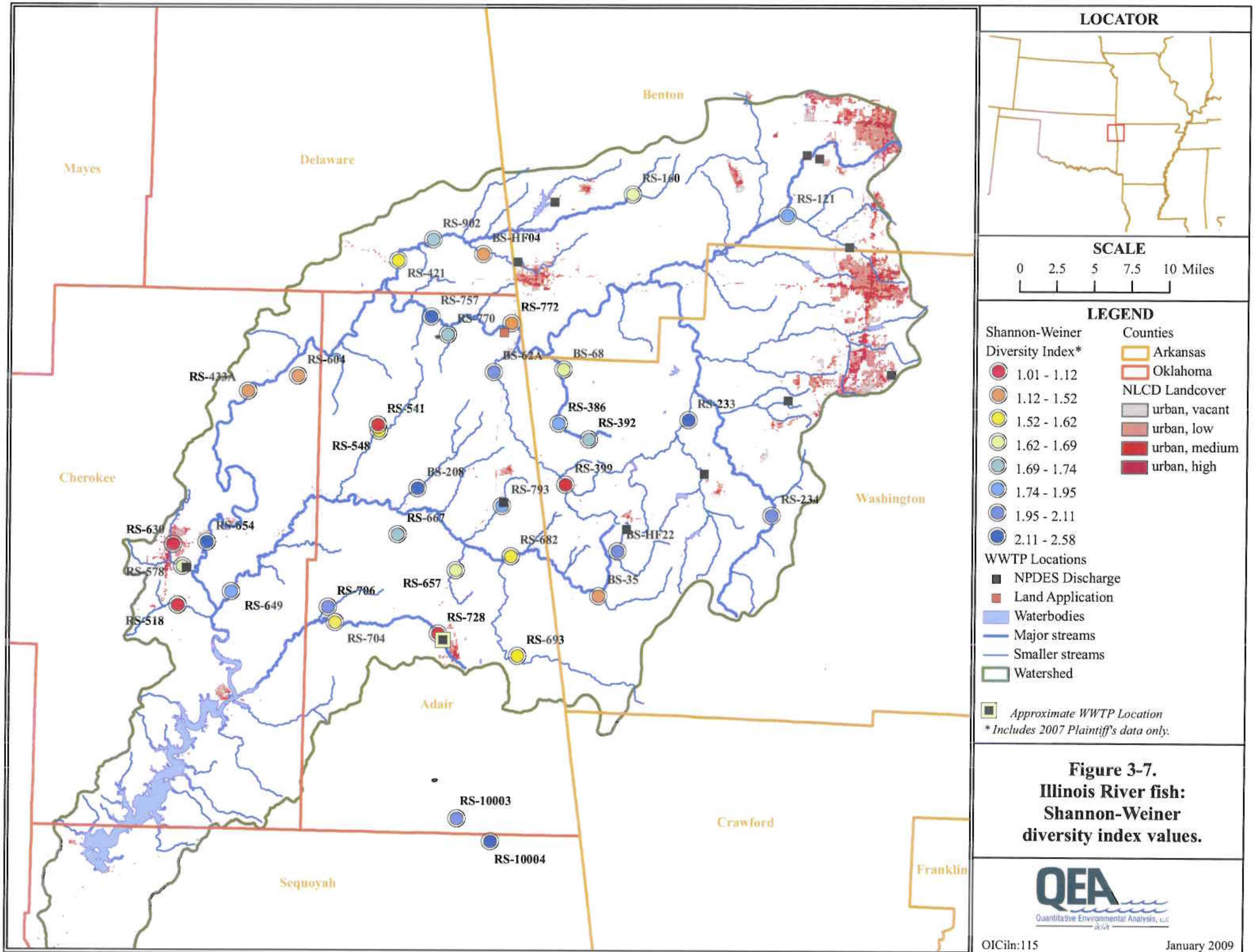

Figure 3-7. Illinois River fish: Shannon-Weiner diversity index values.

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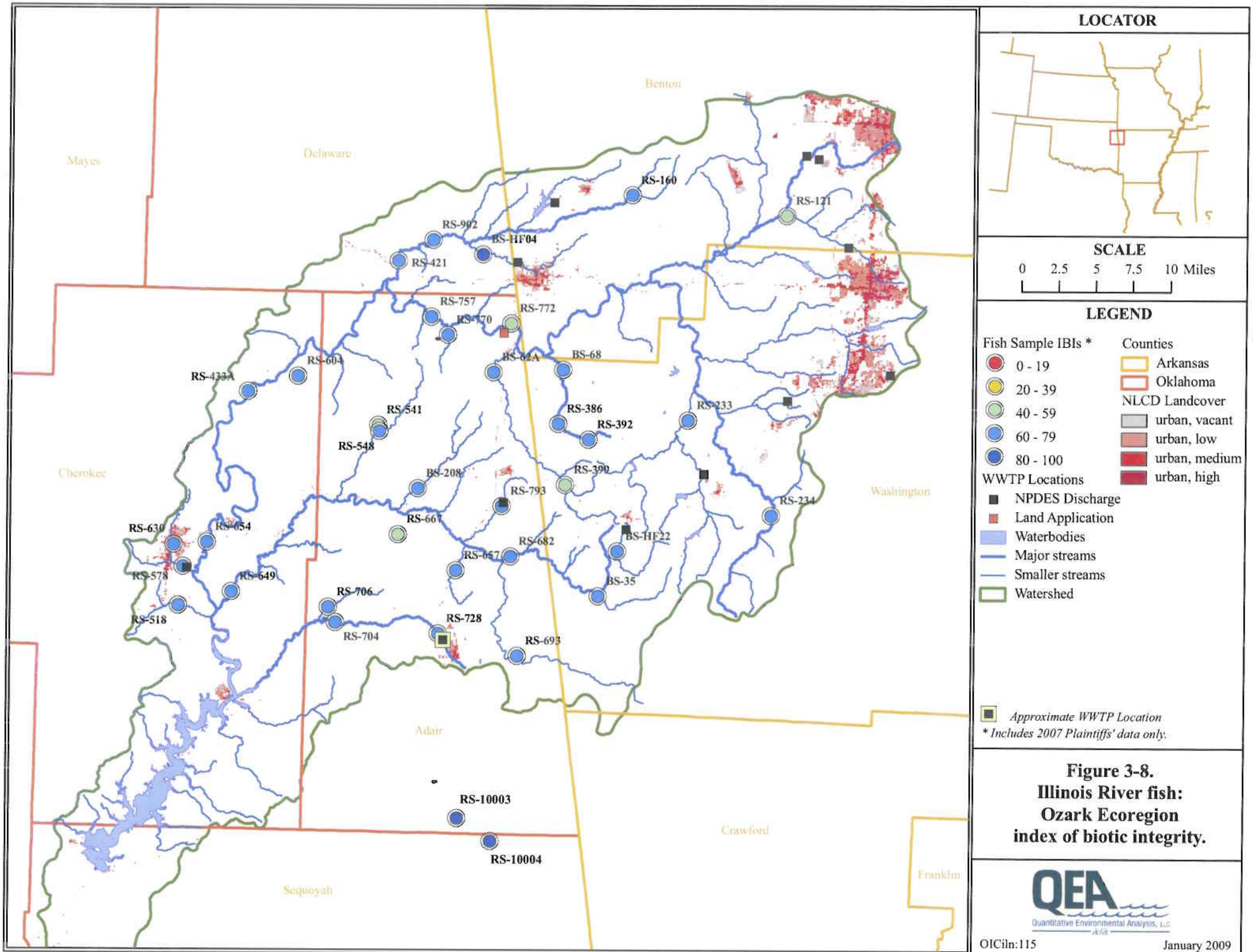

Figure 3-8.
Illinois River fish:
Ozark Ecoregion
index of biotic integrity.

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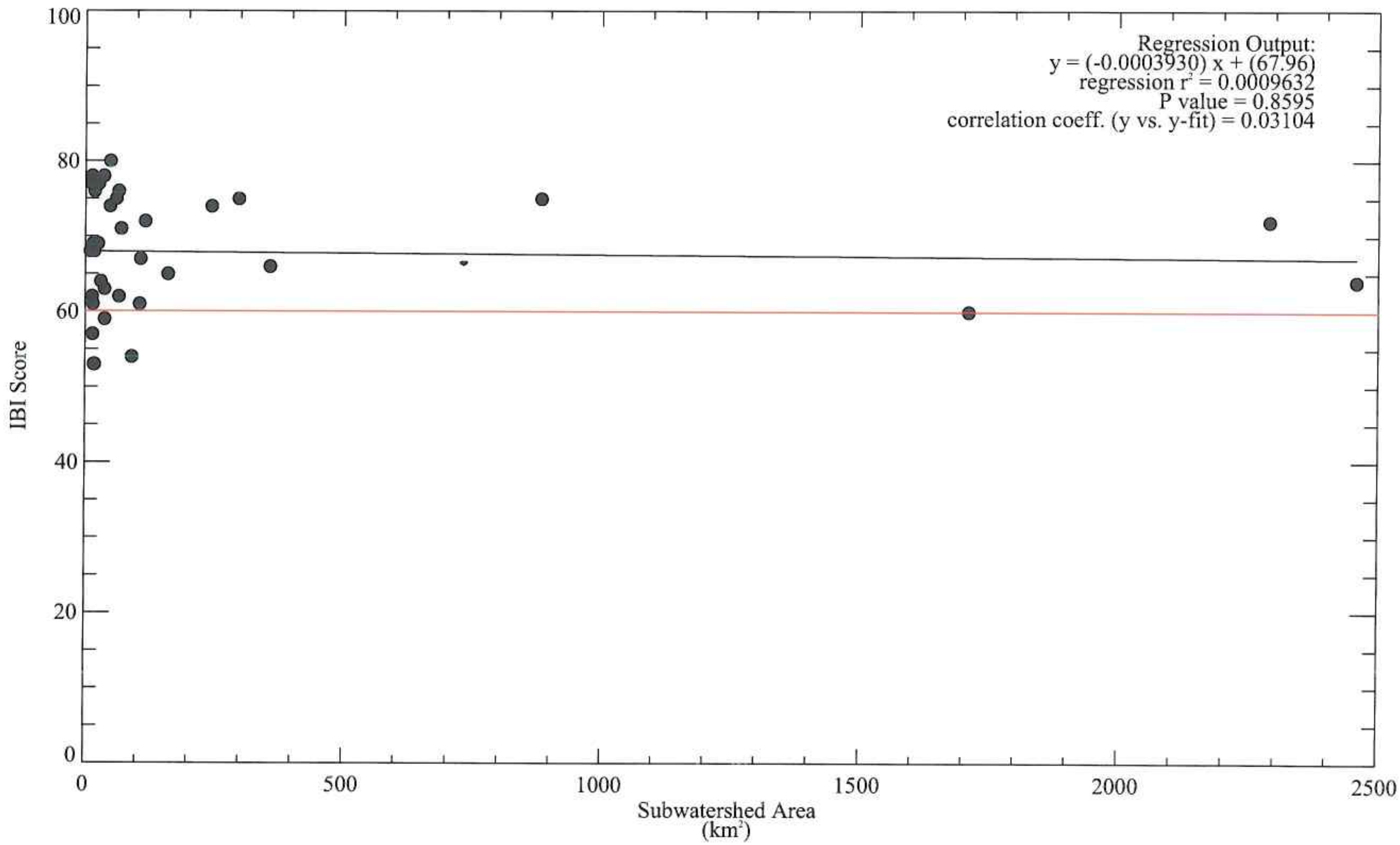

Figure 3-9. IBI score vs. sub-watershed area: 2007 Plaintiffs' data only.

Note: Subwatershed areas based on manual subdivision of NHD subwatersheds.
The horizontal red line denotes the minimum IBI score (60) for sites considered in good condition.

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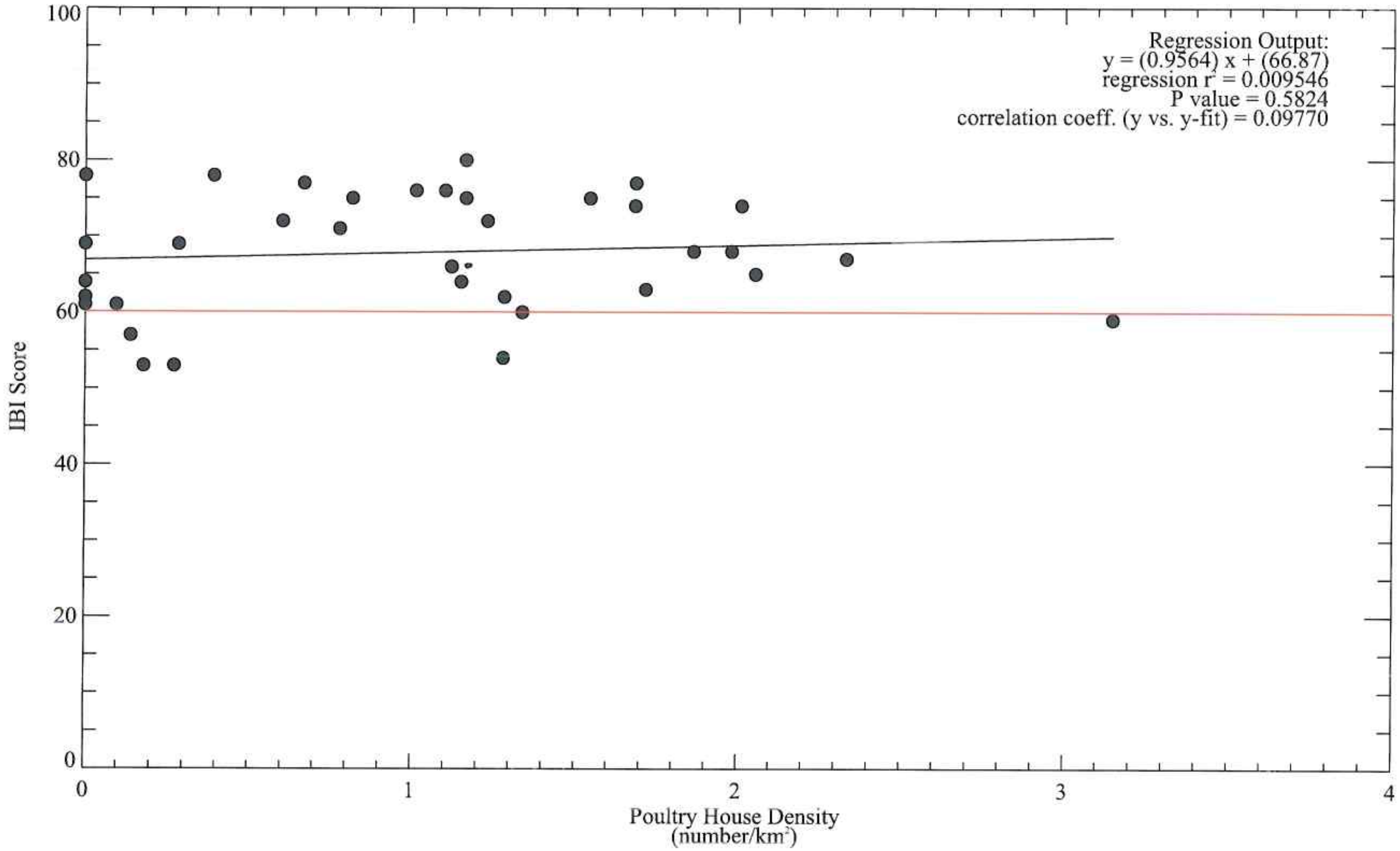

Figure 3-10. IBI score vs. poultry house density in the sub-watershed: 2007 Plaintiffs' data only.

Note: Poultry house density was determined using Prof. Fisher's data coverage.
The horizontal red line denotes the minimum IBI score (60) for sites considered in good condition.

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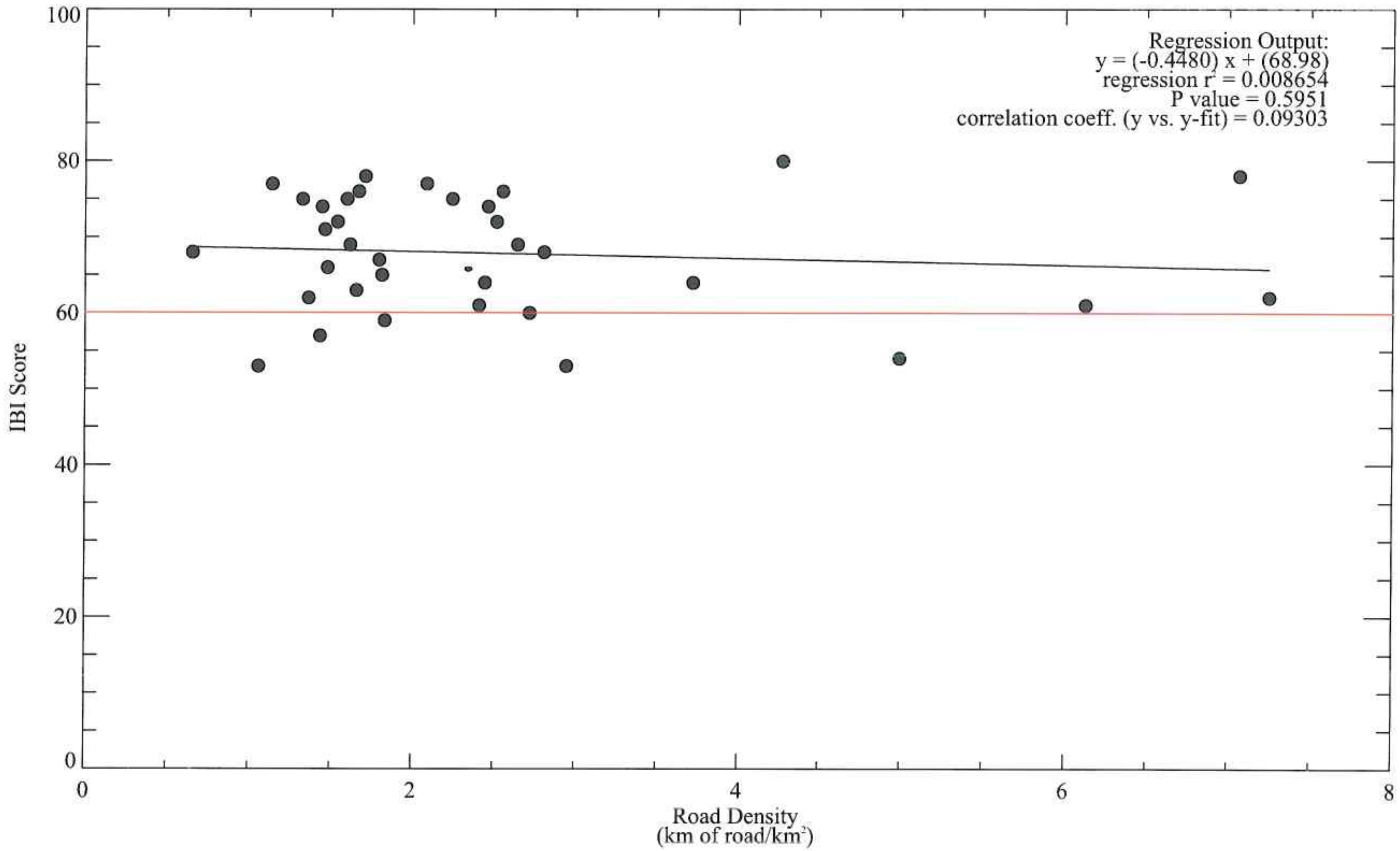

Figure 3-11. IBI score vs. road density in the sub-watershed: 2007 Plaintiffs' data only.

Note: Road density determined using the U.S. Census Bureau's 2007 road coverage.
The horizontal red line denotes the minimum IBI score (60) for sites considered in good condition.

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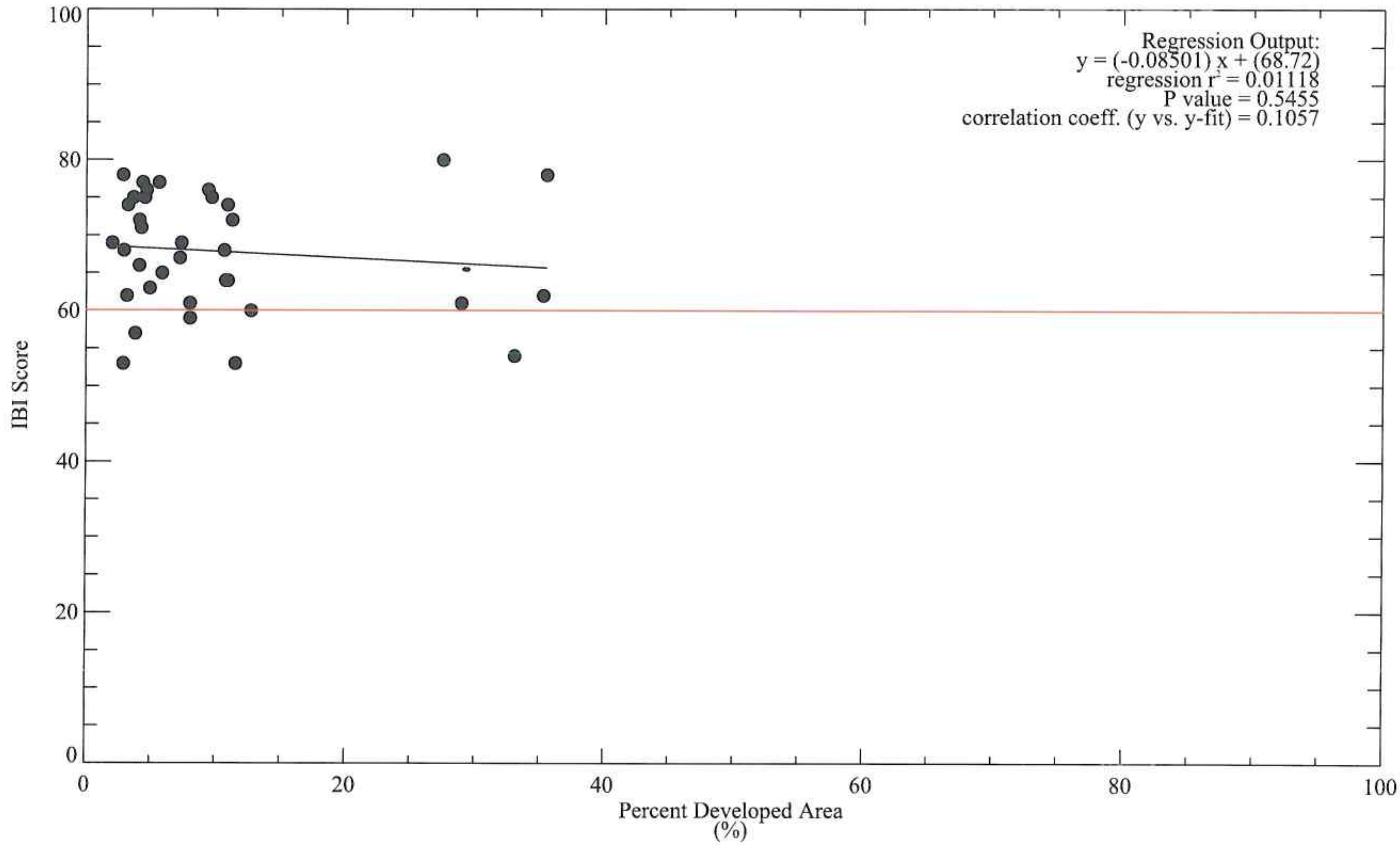

Figure 3-12. IBI score vs. percent developed area of the sub-watershed: 2007 Plaintiffs' data only.

Note: Includes roads and low, mid, and high density urban land-use classifications from the NLCD (2001). The horizontal red line denotes the minimum IBI score (60) for sites considered in good condition.

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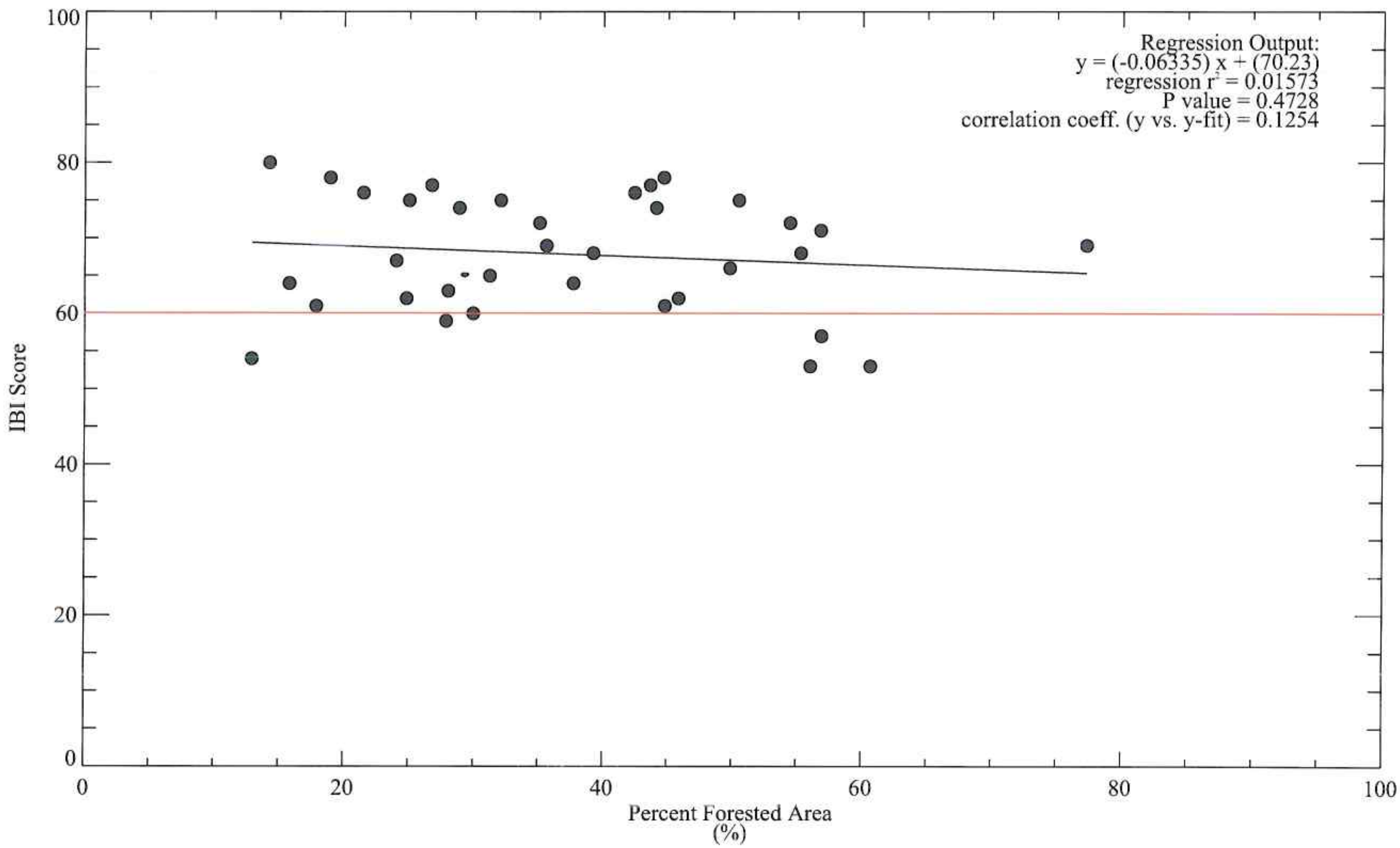

Figure 3-13. IBI score vs. percent forested area of the sub-watershed: 2007 Plaintiffs' data only.

Note: Forested area was determined from the 2001 NLCD land use data.
The horizontal red line denotes the minimum IBI score (60) for sites considered in good condition.

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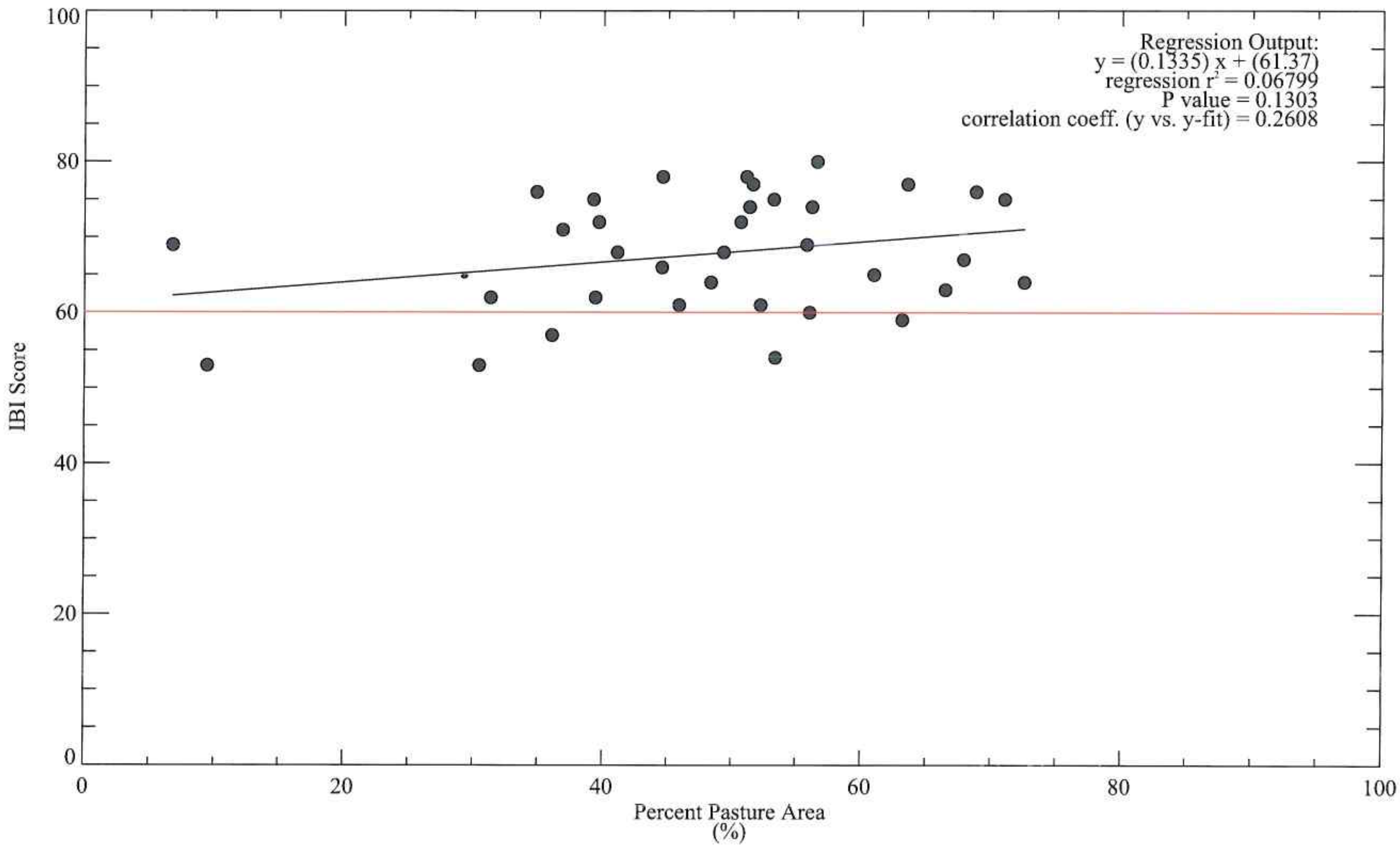

Figure 3-14. IBI score vs. percent pasture area of the sub-watershed: 2007 Plaintiffs' data only.

Note: Pasture area was determined from the 2001 NLCD land use data.
The horizontal red line denotes the minimum IBI score (60) for sites in good condition.

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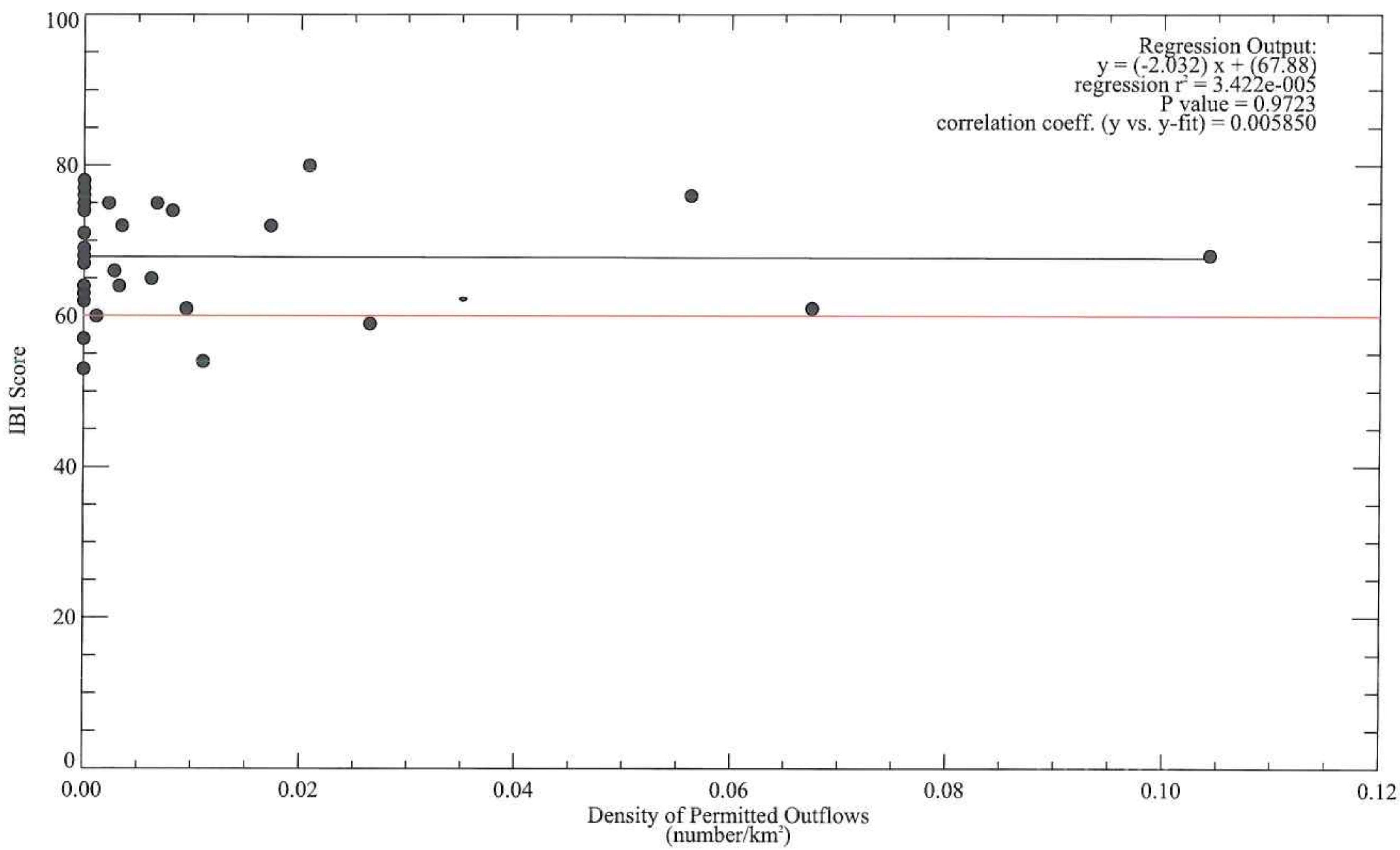

Figure 3-15. IBI score vs. the density of permitted outflows in the sub-watershed: 2007 Plaintiffs' data only.

Note: Waste-water treatment plants with current discharge data in EPA's PCS system are included. The horizontal red line denotes the minimum IBI score (60) for sites in good condition.

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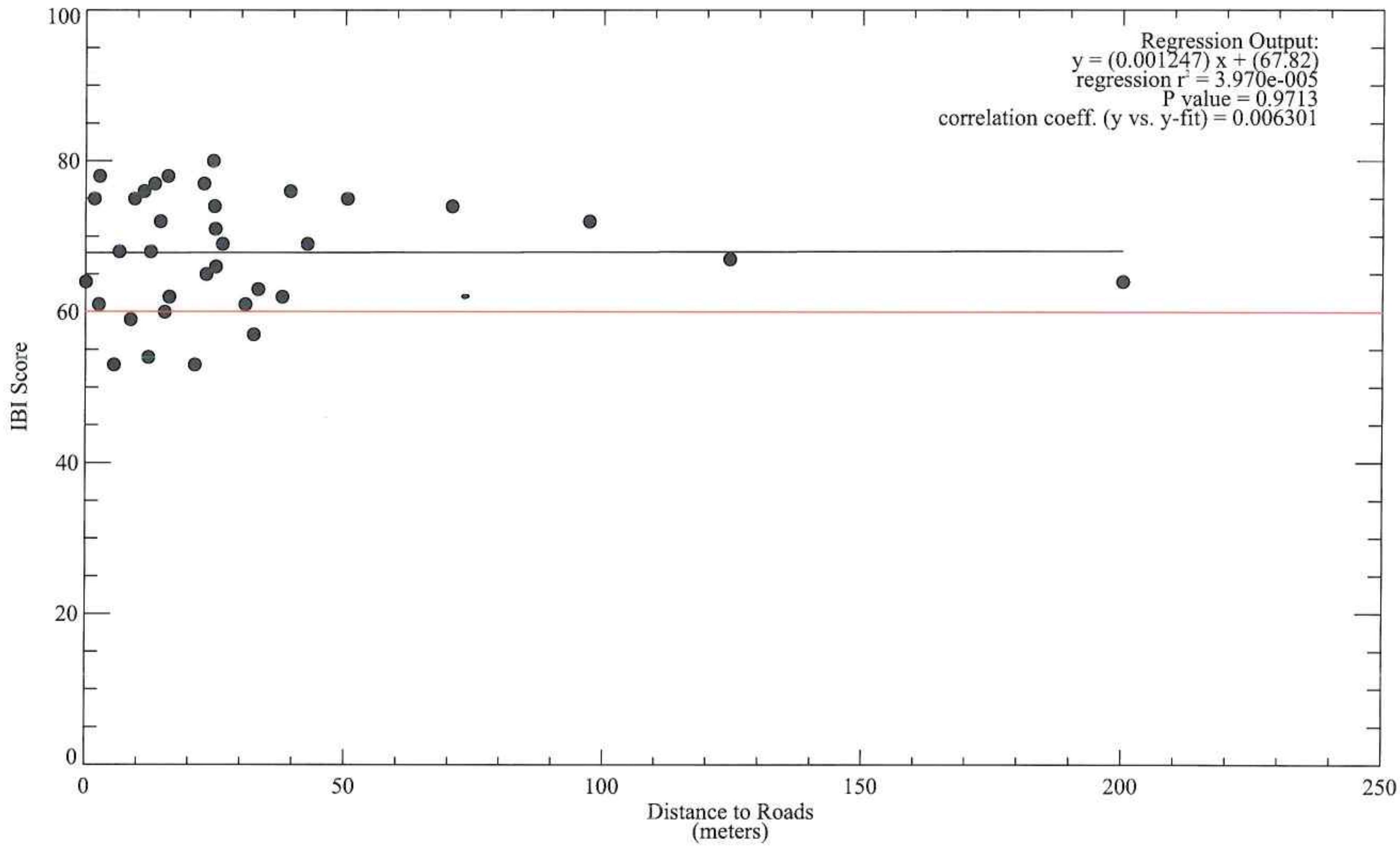

Figure 3-16. IBI score vs. distance to the nearest road: 2007 Plaintiffs' data only.

Note: Road proximity determined using the U.S. Census Bureau's 2007 road coverage. The horizontal red line denotes the minimum IBI score (60) for sites in good condition.

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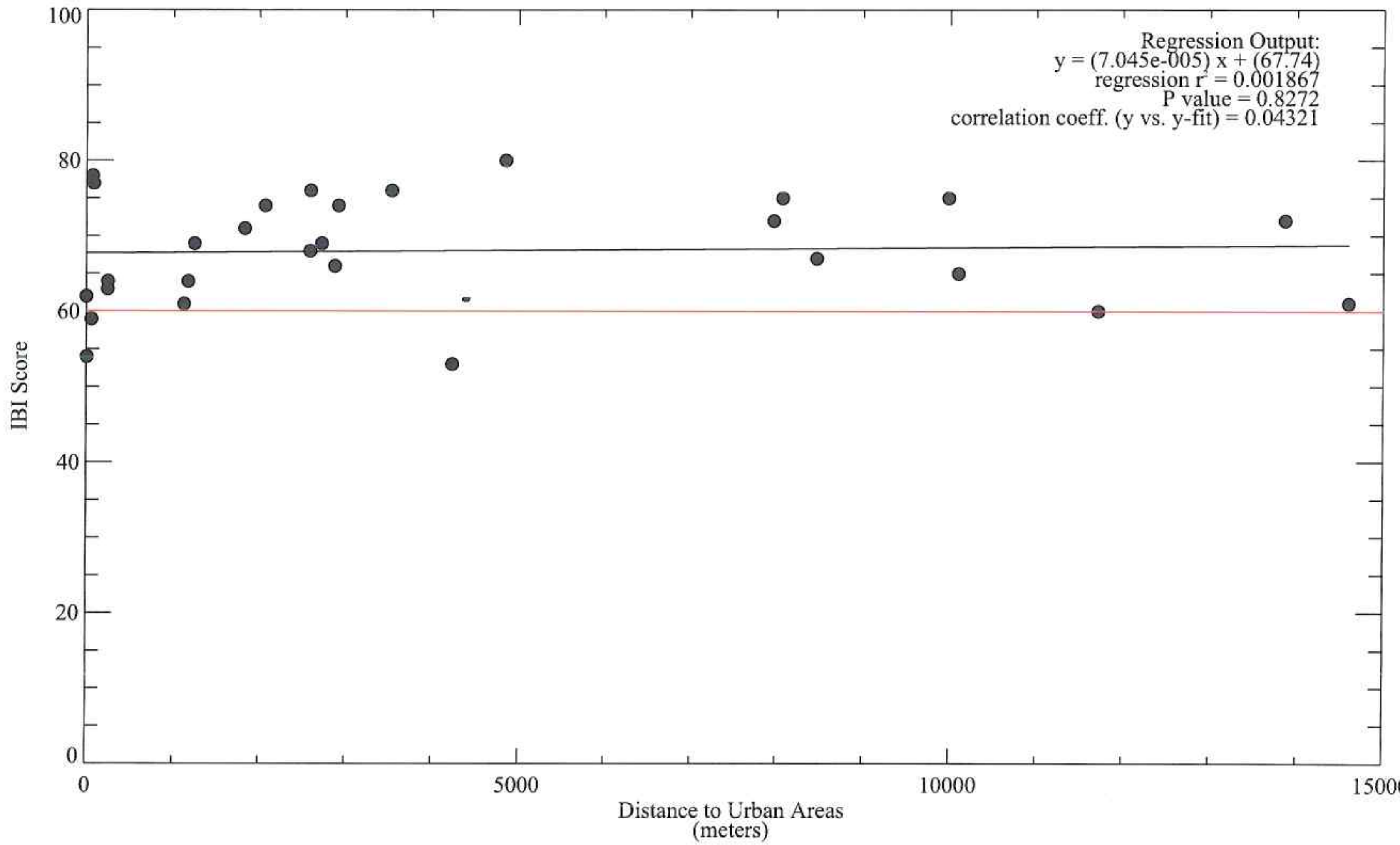

Figure 3-17. IBI score vs. distance to the nearest urban land-use classification: 2007 Plaintiffs' data only.

Note: Urban land-use includes low, mid, and high density urban land-use classifications from the NLCD (2001). The horizontal red line denotes the minimum IBI score (60) for sites in good condition.

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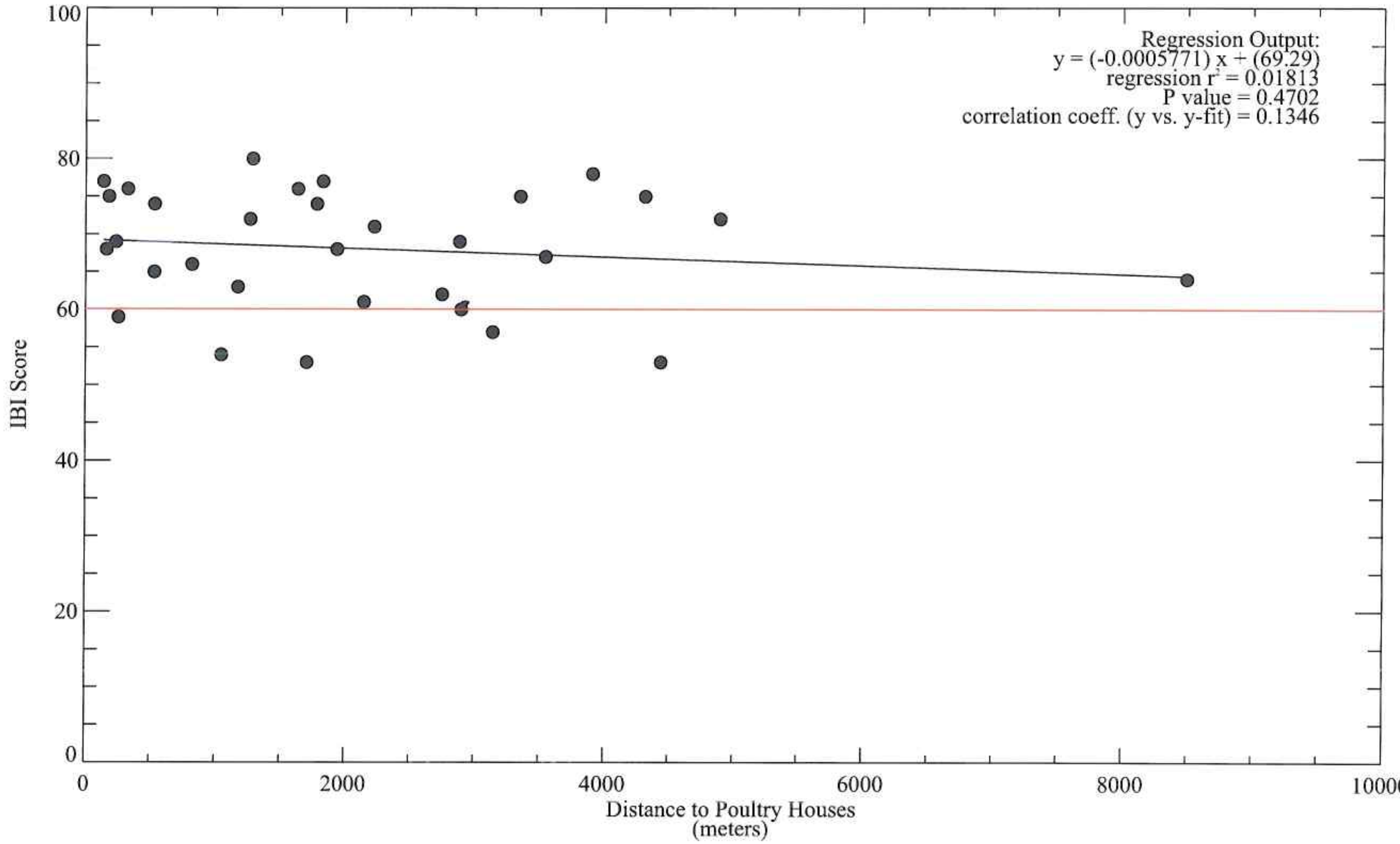

Figure 3-18. IBI score vs. distance to the nearest poultry house: 2007 Plaintiffs' data only.

Note: Poultry house proximity was determined using Prof. Fisher's data coverage.
The horizontal red line denotes the minimum IBI score (60) for sites in good condition.

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