# Wadeable Streams in Kansas, 2000–2001:

# Chemistry, Physical Habitat, and Fish Communities

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**by**

**Elizabeth F. Smith, Donald G. Huggins, and Debra S. Baker**

**Central Plains Center for BioAssessment**
**Kansas Biological Survey**
**University of Kansas**

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## Acknowledgements

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# Introduction

## *Background*

Water resource monitoring is often focused on exceptional sites, that is, sites of noticeably high or low quality. There may be both intentional and unintentional reasons or causes for the selection of sampling sites. One sound reason for this sampling bias is the high social and scientific priority that our society places on preservation of sites with the best conditions and remediation of those with the worst. The emphasis on impaired water monitoring was codified in the Clean Water Act requirement for 303(d) listings. More recently, relatively undisturbed "reference quality" sites have received attention for their role in setting expectations for biological criteria.

The Clean Water Act antidegradation mandate applies, however, not only to exceptional sites but to all waters. Reporting on the overall condition of aquatic resources as mandated by provision 305(b) has been supported by maintenance of a network of long-term monitoring sites. Long-term monitoring of repeat sites is a good tool for detecting trends, but may not be the best estimate of overall status. More importantly, there is no guarantee that hand-picked sites are representative of overall resource quality. For example, easy-access sites may be of relatively low quality due to their proximity to human influence, whereas resource scientists' "preferred" sites may be of unusually high quality.

Unbiased sampling can be achieved either via exhaustive census or true random sampling. Random but "even" sampling of an unevenly distributed resource presents a statistical challenge. The probabilistic site sampling methodology associated with EPA's EMAP (Environmental Monitoring and Assessment Program) project was developed as an answer to this challenge. Sites are selected from a representation of the known extent of the target population and weighted based on their proportion in the population; the sampling algorithm is spatially balanced but random. Results can be extrapolated to the target population with known confidence. In the case of this report, measurements are extrapolated to perennial wadeable stream miles in the state of Kansas.

The randomly selected sites in this study were established as part of a larger project begun in 1994-95 to evaluate the health of fisheries in USEPA Region VII. This dataset also includes a number of putative reference sites, handpicked by regional resource scientists.

# Materials & Methods

## *Data collection*

### General considerations

The findings reported here are from data collected by Kansas Department of Wildlife and Parks as part of the Regional EMAP (R-EMAP) wadeable streams project for Kansas, 2000-01 (Kansas Biological Survey, Kansas Department of Wildlife and Parks et al. September 1999). Many of the sites selected and all of the sampling methodologies are a functional follow-up to the Kansas portion of the USEPA Region VII three-state R-EMAP study of 1994-95.

Field crews of the Kansas Department of Wildlife and Parks (KDWP) collected data and samples. Chemistry specimens were processed at the USEPA Region VII chemistry laboratory in Kansas City, KS (Harry Kimball, supervisor). Fish vouchers were identified by Geff Luttrell in the Ichthyology Division of the University of Kansas Natural History Museum and Biodiversity Research Center (KUNHM-BRC). Data were assembled and analyzed at the Central Plains Center for BioAssessment (CPCB), a research unit of the Kansas Biological Survey (KBS). Analysis and reporting work done at CPCB were supported by an extension on grant USEPA X-9871820-0.

**Site selection**

Among perennial wadeable streams in Kansas, two categories of sites were selected for sampling: random and reference. For a map and list of sites, see Appendix A.

The random sites were resamples from the 1994-95 R-EMAP randomly selected sites for Kansas. The site list was originally generated by EPA Corvallis as part of a regional fisheries health project (USEPA Region VII May 1994). The sampling frame was restricted to stream segments of fourth or lower order from the RF3 stream network database. Sites were selected using a spatially random sampling regime. Sites were stratified by state but not with respect to ecoregion or stream order. For the original project there were 71 sites originally selected. Two of these (KES022, North Fork Little Sugar Creek, Linn Co., and KES037, Mill Creek, Wabaunsee Co.) were sampled at incorrect coordinates due to field error, so they were removed from the “random” population and added to the “reference” population by default. The other 69 were sampled as random sites in 1994-95. Based on their representativeness in the population, these sites represent a total stream network length of 26445.18 km. Sampling was attempted for these same sites in 2000-01.

Of the 69 random sites attempted for 2000-01, 12 were not sampled. The 12 non-sampled sites represent a stream network length of 4643.75 km. Access was denied at seven (representing 2691.76 km), and five were designated nonsampleable by field crews because they were either dry or nonwadeable, and thus did not meet physical criteria for sampling (representing 1951.99 km). The other 57 random sites were at least partially wadeable and were sampled for at least one set of parameters (physical habitat, chemistry, and/or fish community). These represent a total stream network length of 21801.43 km.

Most of the 33 putative reference sites were selected by KDHE, KDWP, and CPCB scientists and other Kansas colleagues, though the two that were added secondarily were resampled in 2000-01 (see above). Reference sites were selected by best professional judgment, based on available data regarding the integrity of biological communities, physical habitat, water chemistry, and watershed conditions. Of these sites, 32 were sampled, and one was designated nonsampleable (dry). Eleven of the 33 reference sites (including the one dry) had been sampled in 1994-95; 22 were added as new sites for the 2000-01 sampling effort.

**Field data collection and sample collection and processing**

Data and sample collection methodologies followed the 1994-95 Region VII project QAPP (USEPA Region VII May 1994) and standard EMAP guidelines (USEPA Environmental Monitoring and Assessment Program 1999); equipment and procedural particulars are detailed in the Kansas summary reports for that project (Waters 1997a; Waters 1997b).

A sample reach was laid out upstream and downstream of each x-site (the site's latitude and longitude). Standard reach length was 40× stream width, but no less than 150 m and no greater than 300 m. Eleven evenly-spaced transects were marked along the reach. Personnel then collected data and samples. Chemical and physical data measured on-site at the start of sampling included temperature, dissolved oxygen, pH, turbidity, and conductivity. Water samples were collected at this time. Sediment samples were collected during macroinvertebrate sampling (not discussed); fish tissue samples were collected during fish sampling; discharge was measured at one point after all other sampling was complete.

Physical habitat data were collected according to Lazorchek et al. (1998). Channel measurements made at each transect included a depth-substrate-embeddedness profile, as well as wetted width, bankfull width, bankfull height, bank angle, undercut, incision, and densiometer canopy cover. Between transects, crews measured water slope and compass bearing and made 10 or 15 evenly spaced thalweg measurements, recording depth, presence of fine sediment, and presence of side channels. Crews scored fish cover and tallied large woody debris. Along the banks, crews scored human disturbance (roads, row crops, pipes, etc.) and estimated riparian vegetation cover in three layers (canopy, mid-layer, and ground cover).

Fish were collected by electrofishing and/or seining. Some fish (especially T&E species or large individuals of easily identified sport species) were identified and released in the field; their identification, count, and size data were recorded on field forms. Other fish were collected and preserved as identification vouchers. A few fishes were retained for tissue sampling.

Water, fish tissue, and sediment samples were shipped to the EPA Region VII chemistry laboratory in Kansas City, Kansas, which processed the samples. Fish voucher specimens were sent to the KU Museum of Natural History for identification.

**Data entry**

Field-form data relating to locality, on-site chemistry, and physical habitat were hand-entered into KDWP's Stream Assessment Database (Microsoft Access) by KDWP personnel. Fish voucher identification data were sent to KDWP as electronic files from KU Natural History Museum and then incorporated into the same database. In July 2004, this database was released to the Central Plains Center for BioAssessment (CPCB), a research unit of the Kansas Biological Survey (KBS).

Chemistry data were quality checked and reviewed internally at EPA Region VII and then released to CPCB as electronic spreadsheet files. Conductivity measurements were discarded after questions about equipment precision. Analytes measured included nutrients, metals, and pesticides in water, sediment, and fish tissue; for the complete list see Appendix B.

### Forthcoming data

In the near future, additional data will be available that relate to these sites and collection events. Personnel from the Kansas Applied Remote Sensing program at the KBS are delineating watersheds and watershed areas for these sites using digital elevation models. Macroinvertebrates were also collected at most of these sites, and site/species/count data are available from CPCB or KDWP.

## *Data quality review, supplementation, and analysis*

### Design File

A design file (a site list master file) was constructed using KDWP site names, locations, sampling success information, reach-level data, and site weightings for randomly selected sites (which were taken from the 1994-95 dataset). Geospatial map data for Omernik Level 3 Ecoregions and HUC-8 units (current as of May 2005) were acquired from Kansas Applied Remote Sensing division of Kansas Biological Survey, matched to site coordinates in ESRI ArcMap 9.0, and appended to the design file.

### Data extraction

Raw physical habitat data, on-site chemistry data, and fish data were extracted from the April 2004 version of the KDWP Microsoft Access master database, "Stream Assessment Program Database," restructured and reformatted in MS Excel, consolidated as necessary, and imported into SAS datasets. Imported files were checked against original files for accuracy.

### Chemistry

Verified and validated chemistry data (in the form of MS Excel files) were received from USEPA Region VII chemistry laboratory. Some data were flagged. According to the laboratory's data quality manual (Kimball 2003) "The reporting limit for an analyte is the concentration represented by the lowest level in the initial calibration curve where the analyte is detected, unless otherwise specified in the RLAB Method. This concentration is typically approximately three times the method detection limit. The reporting limit is reported accompanied with a Detection ID of "U" when the analyte in question is not detected in the sample or is detected at a concentration less than the reporting limit." Some analytes in water (e.g., metals) were assessed for both total and dissolved amounts (separate samples) and reported in weight per volume. Although standards can be adjusted for application to either total or dissolved, only total amounts are compared to standards. This decision was made in part because "dissolved" (field-filtered) samples were not available for 17 sites, whereas "total" (unfiltered) samples were available for all but 2 sites. Analytes in soil are reported in weight per dry weight of soil. Analytes in fish tissue are reported in wet weight of whole fish tissue. EMAP methodology requires no special chemistry data processing. The chemistry files were restructured to one record per site and imported into SAS datasets.

New columns were added to calculate variable ALU criteria for each site (ammonia and hardness-dependent metals) and score pass/fail status for all analytes for which there are Kansas Water Quality Criteria (Kansas Department of Health and Environment Bureau of Water 2004; USEPA Office of Water 2004). Sediment quality green-area guidelines (consensus-based Probable Effect Concentrations) were extracted from the peer reviewed document, "Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines" (Ingersoll, MacDonald et al. 2000). Fish tissue chemical limits for human health were taken from EPA 823-B-00-07 (USEPA Office of Water 2000). Water, sediment, and fish tissue standards and guidelines are presented in Appendix C.

**Physical habitat**

Raw physical habitat data began as a set of seven SAS files and were quality-checked before being used to calculate site-level summary statistics. Quality-checking and calculation tools were provided by USEPA Office of Research and Development (USEPA-ORD in Corvallis, OR) in the form of a set of SAS programs, as explained and outlined in Kaufmann et al. (1999). A series of 22 programs was used to check for file structure, internal consistency, and missing, illegal, and illogical values. Some results required reference to original data sheets and subsequent manual amendment of data files; changes included recoding of variable categories and correction of typos. "Clean" raw physical habitat data were then manipulated and compressed via a series of 17 additional programs into a single file containing site-level summary statistics. From this master file, a smaller file was also extracted (Phabbest) containing a subset of these – the measures that ORD determined were most useful in pilot data exploration.

**Fish Community**

Fish community data metrics were calculated from three input files: the sample data file (species/site/count) extracted from the KDWP database, the autecology file (reproductive & feeding traits for all species) provided by US EPA Western Ecology Division, and the site info file (an abbreviated version of design file).

The sample data file was extracted from the KDWP database, compressed and restructured in MS Excel, then imported into SAS. Other preliminary work for processing fish data included: checking taxonomic names for consistency, verifying that autecology records were present for each species, compressing records for collection categories (release/voucher/tissue), and resolving data for hybrids and incomplete identifications. Incompletely identified specimens (genus only; no species) were excluded if a congener was present, and hybrids were excluded if at least one parent species was present at the site. This was done in order to avoid artificial inflation of diversity.

The three input files were manipulated via a series of 32 SAS programs into a set of individual metrics files, which in turn were compressed into a single file containing site-level summary metrics, from which IBIs were then calculated. The 8-metric IBI was developed by the US EPA

Western Ecology Division, based on data from 1994–95 collections in Kansas, Missouri, and Nebraska; details are presented in Appendix D.

The fish programs were modified to incorporate native range data for fishes. Fish distribution data to the HUC-8 level were acquired from NatureServe (NatureServe 2004), incorporated into the analysis programs, and used to score fish as native vs. introduced.

**All-data file**

Site data and chemistry data were merged with site-level summary statistics for physical habitat and fish community characteristics. The final file contains about 1000 variables comprising measured and derived parameters, flags, and comments. A small subset of these was used in analysis for the results presented here.

**Data presentation**

Cumulative distribution functions (CDFs) with 95% confidence intervals were plotted using the standard Horvitz-Thompson estimator for extensive resources (Diaz-Ramos, Stevens Jr. et al. 1996). The Horvitz-Thompson variance estimate is used to construct confidence limits. Note that there are more precise variance estimators now available in the form of local variance estimators (Stevens Jr. and Olsen 2003).

## Results

### *General Considerations*

Reference sites are a handpicked set of sites; no claim is made to representativeness, but they were selected by regional experts to represent "high-quality sites." Summary statistics are presented to describe characteristics of this population of sites.

Recall that randomly selected sites are weighted according to their representativeness in the population. Therefore they cannot be represented with traditional summary statistics or histograms. The preferred method of reporting and describing population distributions is via Cumulative Distribution Functions (CDFs). CDFs allow depiction of measured values for the entire population of sampled sites, extrapolated to the full population of sites that they represent. Data from random sites are presented as estimated Cumulative Distribution Functions, with 95% confidence intervals.

When available, the median ($50^{th}$ percentile) value from reference sites is superimposed as a vertical line on the CDF of random sites, for comparison of the two populations. Cautious inferences may be made based on the relationship of the "reference" median to the "random" median.

### *Water, Sediment, and Fish Tissue Chemistry*

Population summaries for water chemistry, sediment chemistry, and fish tissue chemistry of reference sites are given in Appendix E. Summaries of data from random sites are given in Appendix F (water chemistry), Appendix G (sediment chemistry), and Appendix H (fish tissue chemistry). For those analytes for which criteria, benchmarks, or guidelines are available, comparison of the random population to these values is given in tables in Appendix I.

**Physical Parameters and Water Chemistry**

Results are shown in Appendix E and Appendix F. At the time of sampling, reference streams had a median flow of about 1 cfs, whereas random streams had a median flow of about 0.1 cfs. The reference stream flow median about matched the $70^{th}$ percentile of the random population ( Figure 1). This is interesting for two reasons. First, it suggests that the reference stream population is probably not proportionally representative of "fifth order and lower streams" in Kansas. Second, although sampling is done at low flow, the flow value of "1 cfs" has a particular significance for Kansas. In 2001, the Kansas Legislature passed Substitute for Senate Bill 204, which declassifies all streams with a 10-year median flow under 1 cfs. There is a nontrivial possibility that many of the streams sampled would not meet that criterion and therefore fail to be subject to classification and therefore regulation.

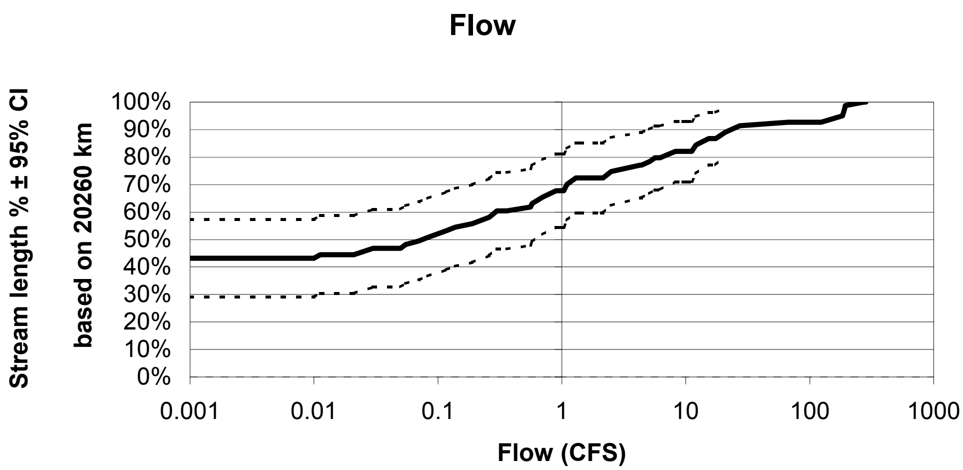


Figure 1. CDF of mean flow based on random sites, with reference-site median superimposed for comparison. Note logarithmic scale.

About three-fourths of the stream km had turbidity values of <20 NTU, which is fairly clear – a possible indicator that most samples were probably taken during normal flow periods. Differences in turbidity may be the natural result of different soil types (suspended clay particles contribute to higher turbidity) or may be caused by excessive soil erosion runoff in vulnerable watersheds. Water temperature at time of sampling ranged from about 14–28 C, with a random median of about 21 and reference median of about 24. All values met Aquatic Life Use criterion for streams (Appendix I).

As can be expected in a region with a high proportion of limestone, total alkalinity (buffering capacity) was high in all streams, and the reference and random medians were similar – around 200 mg/L bicarbonate. Reference streams had somewhat higher median pH than random streams, however (~8.3 vs. ~8.1); this could be reflective of overall greater productivity or could simply indicate that reference streams were in areas with less acidic soils. Almost all random stream km met the ALU criterion for pH. Dissolved oxygen ranged from around 1 mg/L to around 12 mg/L (Figure 2). The reference population median and random population medians were both slightly over 6 mg/L, which exceeds the ALU criterion. However, based on random samples, more than one-fourth of stream km failed the ALU criterion for dissolved oxygen (Appendix I), which is 5.0 mg/L.

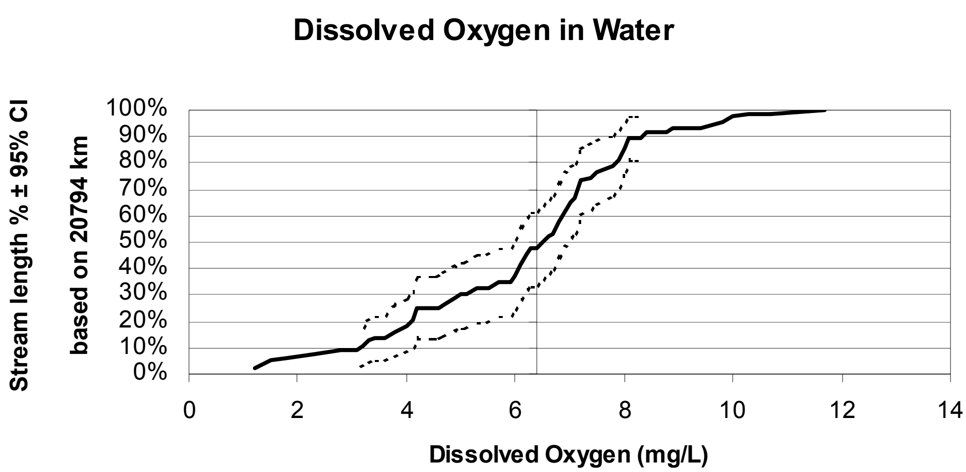


Figure 2. CDF of dissolved oxygen based on random sites, with reference-site median superimposed for comparison. The ALU criterion for DO is 5.0 mg/L.

The reference population medians for both total nitrogen and total phosphorus were slightly lower than the random-population median, with the reference median falling between the 20th and 40th percentiles for the random population. This pattern also held for sulfate and chloride, as well as a number of metals: barium, calcium, lead, magnesium, manganese, potassium, and sodium – suggesting that reference streams' chemistry may be slightly, but not dramatically, better than the general population.

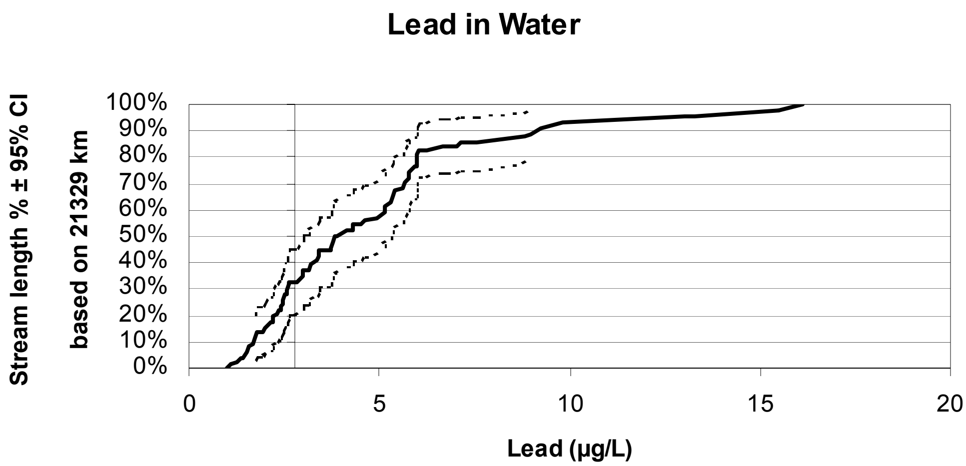


Figure 3. CDF of total lead in water based on random sites, with reference-site median superimposed for comparison. Lead was detected at all random sites. The ALU criterion for lead is hardness-dependent. No sites failed the acute ALU criterion for lead, but if measured levels were persistent, about 17% of sites would fail the chronic ALU criterion.

There were a few metals for which values were low enough to be nondetect or nearly all nondetect in all samples, reference and random: cadmium, chromium, nickel, and silver. There were also a few metals for which the reference population samples were all nondetect along with most of the random samples, but a few random samples had measurable values: arsenic, copper, iron, selenium, and zinc. Mercury was measurable at one random site and one reference site.

Some biocides were not found at measurable levels; these included diazinon, chlordane, propachlor, and trifluralin. Others were measurable only in a small fraction of samples; these include alachlor, atrazine, chlorpyrifos, and metolachlor.

None of the metal or biocide levels in random sites exceeded acute ALU criteria (Appendix I). There were a few metal and biocide analytes for which some stream km are predicted to fail the chronic ALU criterion; these were lead, selenium, mercury, atrazine, and chlorpyrifos. One ammonia criterion was also exceeded in some cases.

**Sediment Chemistry**

Sediment chemistry results are given in Appendix E (reference sites) and Appendix G (random sites). Results from random sites must be interpreted with caution. What may in some cases appear to be a range of measured values may in fact be a range of nondetect reporting limits; be sure to check the caption for information about nondetect vs. detect values.

Metals were detectable in sediment from most random sites. For some metals, reference site medians fell below the $20^{th}$ and $40^{th}$ percentile values for random sites; these include arsenic, barium, chromium, copper, lead (Figure 4), nickel, and zinc. For cadmium the two medians were about equal. Overall these results echo the pattern found in water chemistry: reference sites may have slightly, but not dramatically, less contamination than random sites.

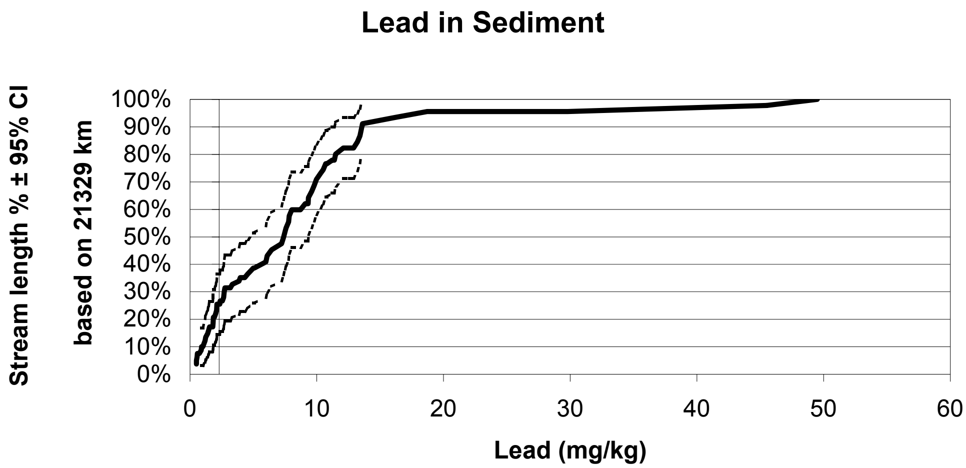


Figure 4. CDF of total lead in sediment based on random sites, with reference-site median superimposed for comparison. Values shown represent both detected levels and reporting levels for nondetects; detect = 20527 km / Nondetect = 802 km.

Three metals had notable occurrence patterns: selenium, mercury, and silver. Based on random sites, selenium was detected for only about one-third of total stream km based on random sites, and was detected at only 2 of 30 reference sites. Mercury was detected for slightly less than one-half of stream km based on random sites (Figure 5), but was detected at 22/30 reference sites (Appendix E). Silver was not detected in any sediment at random or reference sites.

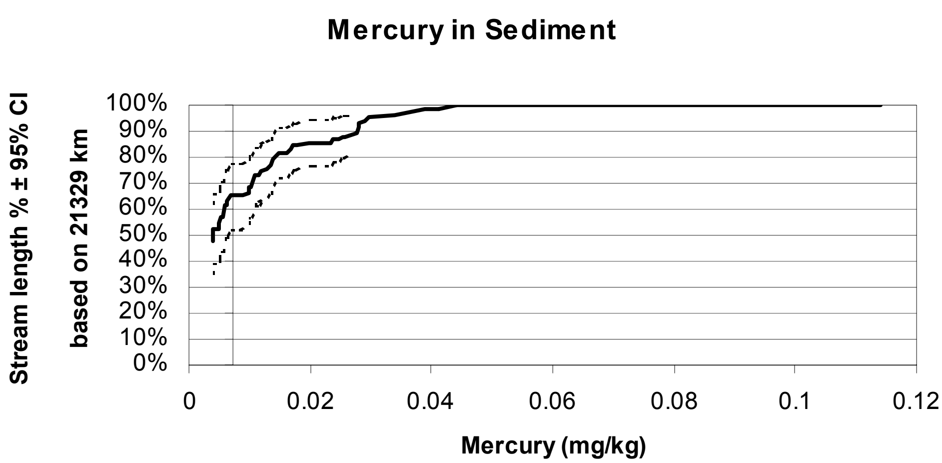


Figure 5. CDF of total mercury in sediment based on random sites, with reference-site median superimposed for comparison. Lead was not detected at all sites. Detect = 10071 km / Nondetect = 11258 km.

No biocides were detected in sediment at random sites representing more than 3% of stream km. The biocides detected at low frequency were aroclor 1254, some DDT metabolites (p,p'-DDE and p,p'-DDT), hexachlorobenzene, and some chlordane metabolites (cis-, trans-, and technical chlordane; cis- and trans- nonachlor, heptachlor epoxide, and oxychlordane). Of these, only technical chlordane occurred at a concentration high enough to exceed threshold for a sediment-toxicity guideline (Appendix I). The only biocide detected at a reference site was hexachlorobenzene (Appendix E). Biocides tested but not detected at reference or random sites include: aldrin; alachlor; aroclors 1016, 1221, 1232, 1242, 1248, and 1260; atrazine; alpha-, beta-, and gamma- BHCs; chlorpyrifos, diazinon, dieldrin, disulfoton, endrin, heptachlor, metolachlor, propachlor, and trifluralin.

## Fish Tissue Chemistry

Fish tissue samples were collected at random sites representing less than half of the total stream km and only about two-thirds of the reference sites. Furthermore, the list of fishes from which tissue samples were taken includes both bottom-dwellers and mid-water species (see Appendix A, second part). Finally, the samples were whole-fish samples, whereas human health consumption guidelines are for filet only. For these reasons, all tissue chemistry results must be interpreted with caution.

Some metals and biocides were detected neither at random sites nor at reference sites: Arsenic; aldrin; aroclors 1016, 1221, 1232, 1242, 1248, 1260; alpha-, beta-, and gamma- BHCs; chlorpyrifos; DDT; diazinon; disulfoton; and endrin. Hexachlorobenzene was detected at one reference site but no random sites.

A few analytes were detected in fish tissue at both random and reference sites: cadmium, lead, mercury, selenium, mercury (Figure 5), dieldrin, DDE, DDD, trans-nonachlor. A few biocides were detected only at random sites, among them aroclor 1254 and a number of chlordane metabolites (technical chlordane, cis- and trans- chlordane, heptachlor, heptachlor epoxide, cis-nonachlor, and oxychlordane). Because many fish species tend to immigrate and emigrate within and between streams and stream reaches, finding contaminated fish at reference sites may or may not indicate that the site is also contaminated.

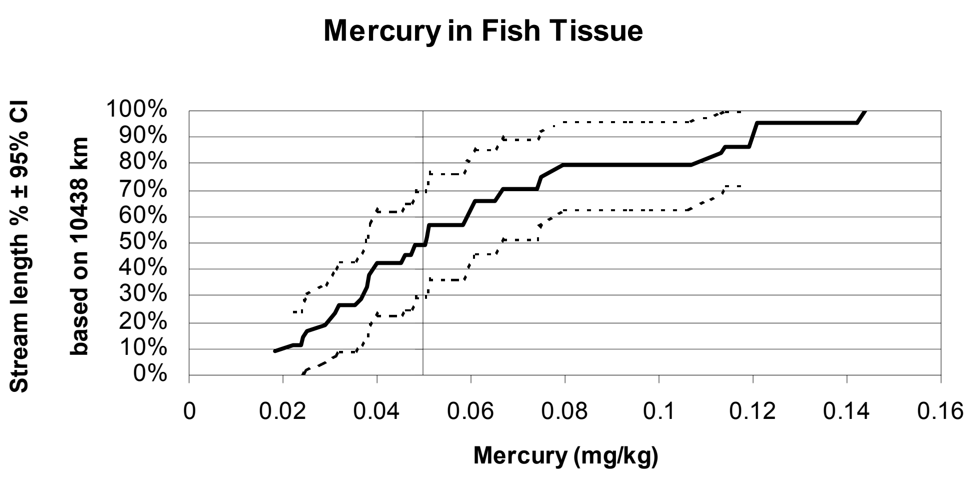


Figure 6. CDF of total mercury in fish tissue based on random sites, with reference-site median superimposed for comparison. Fish tissue samples were collected at only about half of the sites, so stream km may not be a good

representation of total Kansas stream km in the sampling frame. Mercury was not detected at all sites. Detect = 9493 km / Nondetect = 945 km.

Although metals and biocides were not found at very many of the random sites, the concentrations at which they occurred sometimes exceeded the subsistence and even recreational consumption limit guidelines recommended for "EPA green areas," which suggests that unlimited consumption is not acceptable. The problematic substances (Appendix I) are arsenic, chlordane metabolites (as a group) and heptachlor expoxide in particular, DDT metabolites (as a group), dieldrin, and gamma-BHC (lindane).

## *Physical Habitat*

Reference site summary statistics are given as tables in Appendix J; random-site results are given as CDFs in Appendix K, with reference-site medians superimposed for reference.

### Channel and reach morphology

Reference sites were, on the whole, bigger streams than random sites—whether measured by wetted width (Figure 7), bankfull width, Thalweg mean depth (Figure 8), flow (Figure 1), or reach length (see Appendix K). This may reflect a site selection bias.

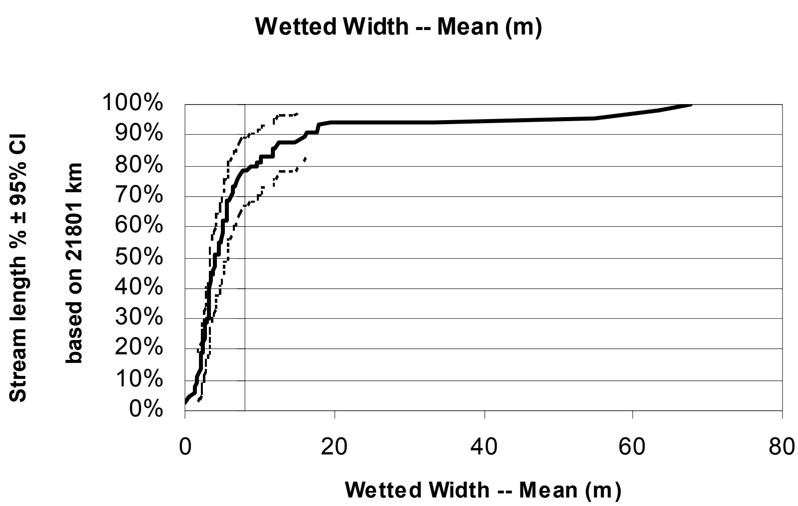


Figure 7. CDF of mean wetted width based on random sites, with reference-site median superimposed for comparison.

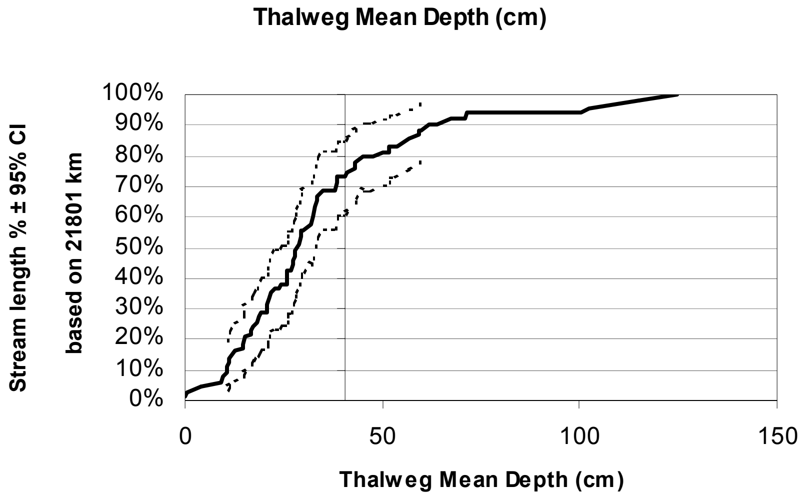


Figure 8. CDF of Thalweg mean depth based on random sites, with reference site median superimposed for comparison.

Reference sites appeared slightly more incised than random, with medians of 3 m and 2.5 m, respectively (Figure 9), which could be simply a function of size; almost all channels were incised with heights ranging from about 0.75 to 6.0 m.

Slopes were small, with 90% of stream km estimated to have a slope of 0.5% or less (Figure 9). Reference and random channel median sinuosities were similar (~1.1, see Appendix K),

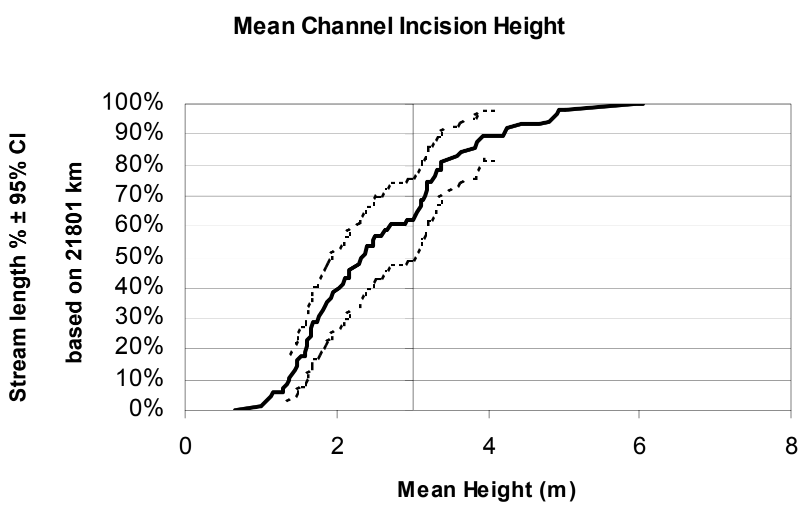


Figure 9. CDF of mean channel incision height based on random sites, with reference site median superimposed for comparison.

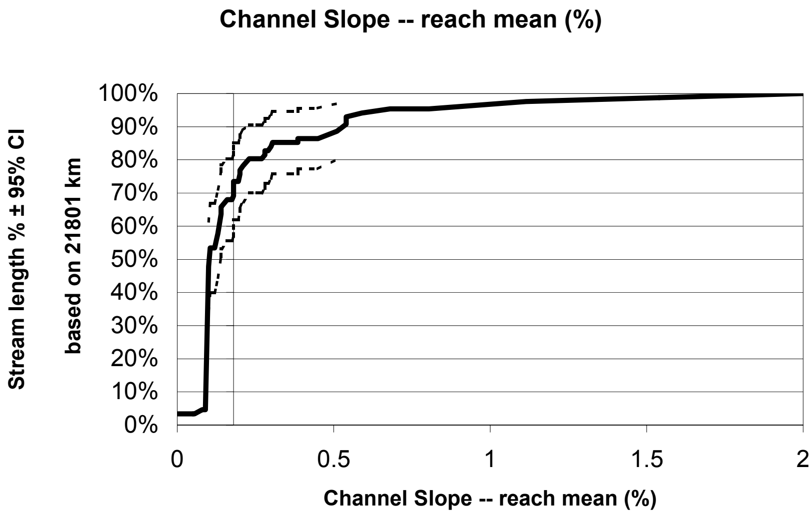


Figure 10. CDF of mean slope based on random sites, with reference site median superimposed for comparison.

What is more interesting from a biotic standpoint is the difference the reference population exhibits in measures of channel morphology variation – which translates into functional residual pool habitats during low-flow periods and variety of microhabitats year-round. This is reflected in a higher standard deviation in Thalweg depth (Figure 11) a higher mean residual depth (Figure 12), and a number of other derived metrics shown in Appendix K.

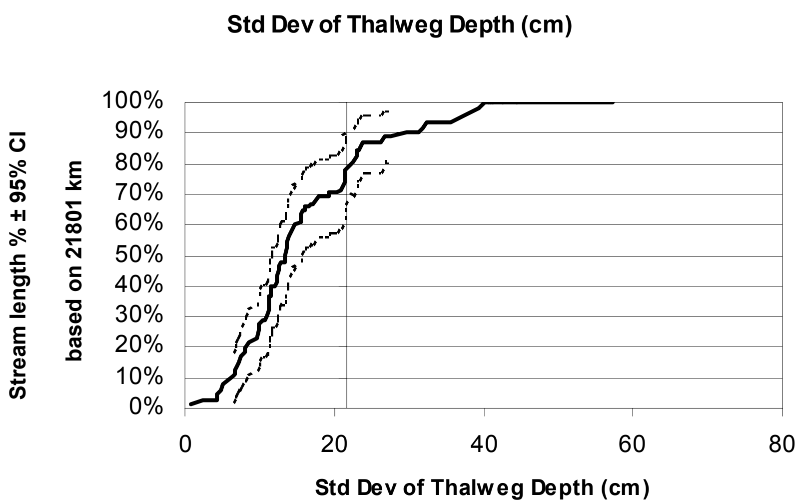


Figure 11. CDF of standard deviation of Thalweg depth based on random sites, with reference site median superimposed for comparison.

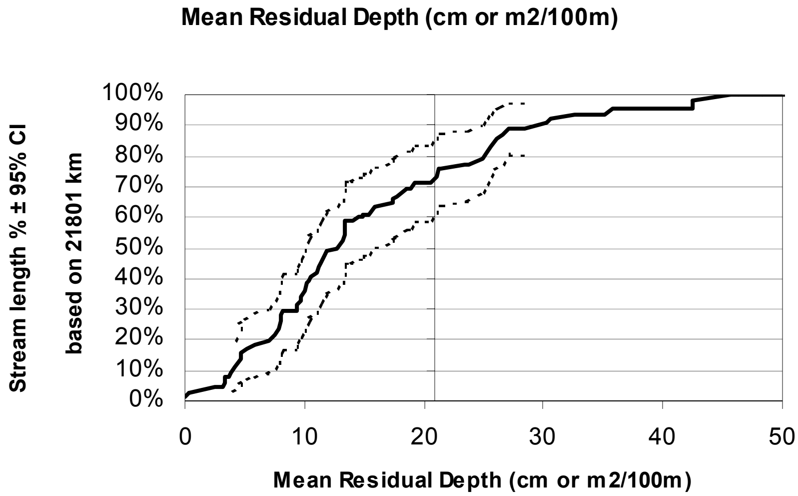


Figure 12. CDF of mean residual depth based on random sites, with reference site median superimposed for comparison.

## Substrate

Embeddedness is a reflection of sedimentation – sediment deposited in the channel fills interstitial spaces between larger substrate particles, reducing potential habitat for macroinvertebrates. By definition, sand and silt are considered "100% embedded," whereas cobble half-buried in sediment is "50% embedded." Median embeddedness for random stream km was over 90% (Figure 13), but median embeddedness value for reference streams, on the other hand, was only about 65%. The noted reduction in embeddedness within reference sites may indicate that erosion and transport of sediment from the watershed into the stream is reduced when compared to random sites and watersheds.

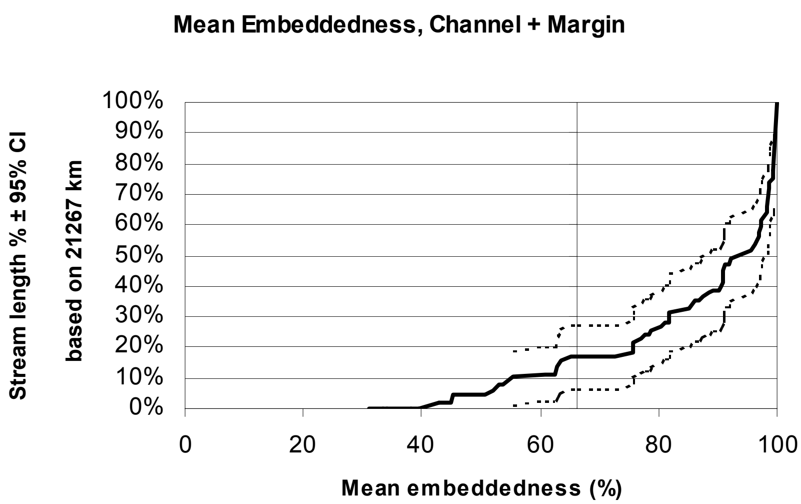


Figure 13. CDF of mean embeddedness based on random sites, with reference site median superimposed for comparison.

The substrates for randomly-selected streams were dominated by small particles. The median "percent composition" was about 90% particles under 2 mm in diameter (Figure 14). The median value of mean substrate diameter for random stream km was in fact about 0.15, which corresponds to sand or fines (Figure 15), whereas the median for reference streams was about 7.5 mm, which corresponds to coarse gravel. The absolute variation in substrate particle size (Figure 16) was also greater for the median reference stream (std dev = 5.1 mm) than it was for the median from random streams (std dev = 3.4 mm).

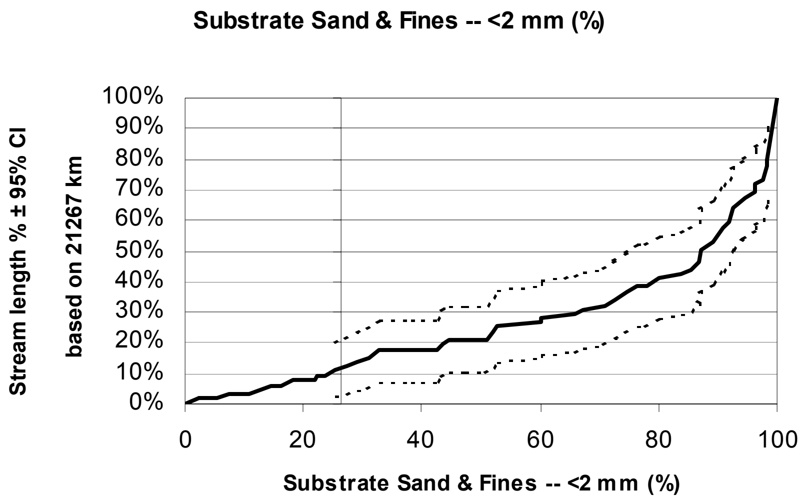


Figure 14. CDF of substrate composition based on random sites, with reference site median superimposed for comparison.

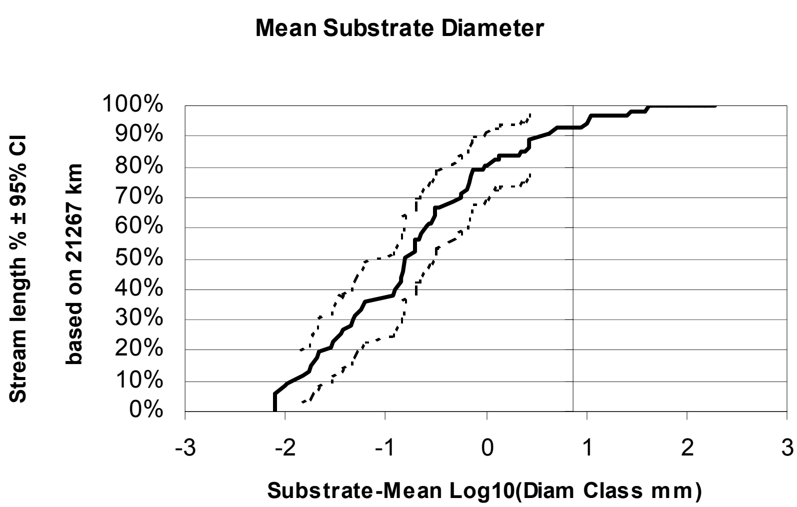


Figure 15. CDF of mean substrate diameter based on random sites, with reference site median superimposed for comparison. (Values reported as Log10(mm), calculated from class-diameter medians).

Standard Deviation of Substrate Diameter

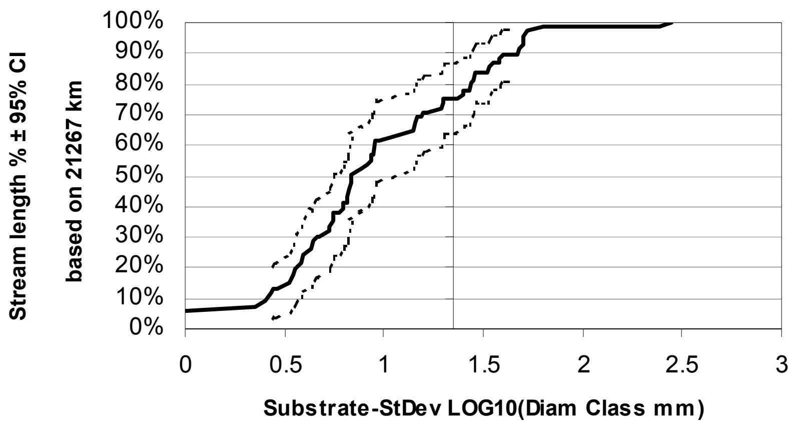


Figure 16. CDF of standard deviation of mean substrate diameter based on random sites, with reference site median superimposed for comparison. (Values reported as Log10(mm), calculated from class-diameter medians).

At first glance, these striking differences might suggest that reference streams are less affected by detrimental sediment runoff than are most streams. However, this conclusion may not be valid. Differences in substrate composition could reflect stream health. However, they could also reflect different stream types. Recall that reference streams are physically different from random streams – in width, depth, slope, and variability of channel morphology. It may be that differences in substrate composition between reference and randomly-selected streams have as much to do with representativeness as with health. Many Kansas streams, especially those in the Western High Plains and Central Great Plains, are historically probably slow-flowing, sandy-bottomed streams with minimal variation in substrate and channel morphology. The randomly-selected population probably contains streams in a number of categories. For this reason, it is difficult to draw conclusions about stream health based solely on substrate composition.

## Streambed stability

One quantitative conclusion that can be drawn from substrate composition, however, relates to the bed stability. Raw measurements of flow, channel morphology, and in-channel features are used to generate an estimate of erodible substrate diameter, i.e., the size of the largest particle that is mobile during bankfull flow (Figure 17). Estimated erodible substrate diameter for random streams ranged from about 2 to about 68 mm, with a median around 8 mm.

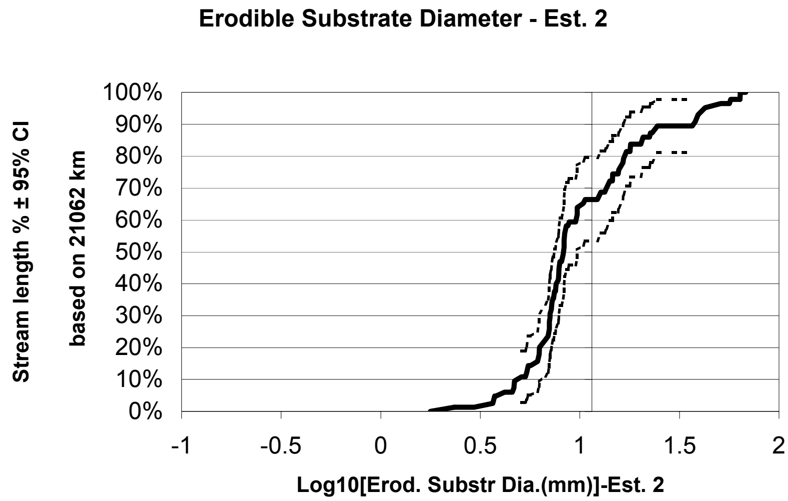


Figure 17. CDF of estimated erodible substrate diameter based on random sites, with reference site median superimposed for comparison. (Values reported as Log10(mm).

The theoretical particle size can then be compared to the actual size of particles in the streambed in order to derive a measure of "erodibility." Given the large size of erodible particles, it is no surprise that bed stability is very low. A bed stability of less than zero corresponds to erosion and one greater than zero corresponds to deposition. With respect to Log10 Relative Bed Stability (LRBS) values, Kaufmann et al. (1999, p. 50) reported that "least-disturbed EMAP streams… in the Midwest Cornbelt Great Plains generally tend to have LRBS values between –.5 and +0.5…[and] progressive intensity of human land uses is generally associated with sediment 'fining,' indicated by declining values of LRBS." The authors report that for the aforementioned region, scores to ±0.5 are "good," scores to ±2.5 are "impaired," and scores past ±2.5 are "highly impaired."

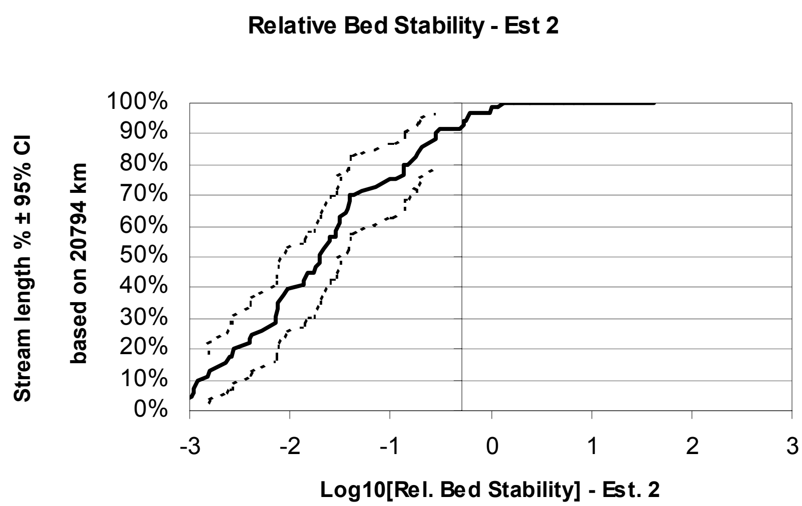


Figure 18. CDF relative bed stability based on random sites, with reference site median superimposed for comparison. Values below zero represent erosion; values above zero represent deposition. (Values reported as Log10.)

In fact, the random-streams median value for LRBS is about –1.5, whereas the reference median is –0.3 (Figure 18). This finding suggests that whatever the substrate composition, channel shape, and hydrodynamics of streams in Kansas once were, the current conditions are not conducive to maintaining stable streambeds—a finding that is supported by channel incision data (Figure 9).

## Riparian Cover

Mean canopy density at bank and at mid-channel for randomly selected reaches (as measured with a densiometer) ranged from 10 to 100%. The at-bank medians for random and reference populations were similar (around 80%), but median mid-channel density was lower for reference populations (Figure 19); this could be a reflection of wider channels rather than different vegetation patterns.

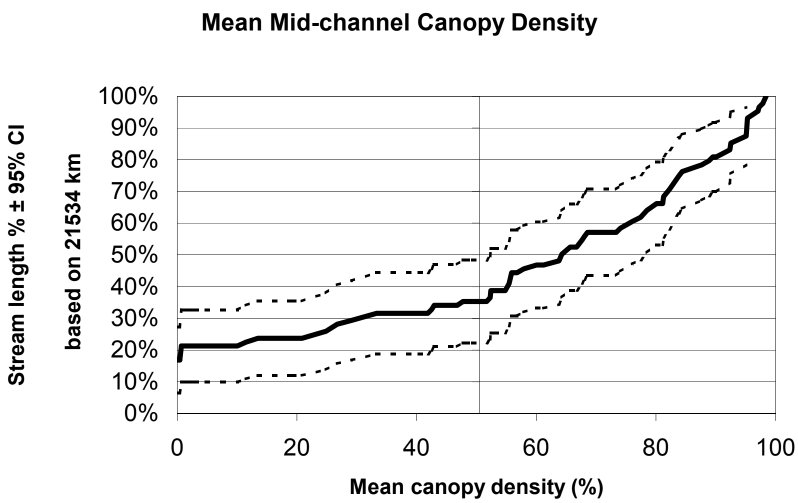


Figure 19. CDF of mean canopy density at mid-channel (measured by densiometer), as based on random sites, with reference site median superimposed for comparison.

Based on extrapolation from random sampling, 50% of stream km had three layers of riparian vegetation present for at least 90% of the reach (Figure 20), suggesting that many of our stream corridors have well developed riparian zones. The ground layer is 0 to 0.5 m; the midlayer is 0.5 to 5 m, and the canopy is over 5 m.

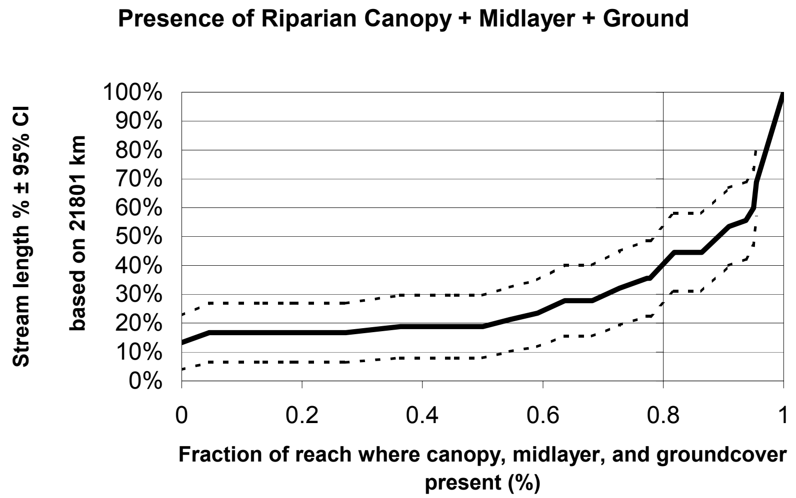


Figure 20. CDF of three-layer riparian coverage based on random sites, with reference site median superimposed for comparison.

On the other hand, the median percent cover provided by canopy (vegetation layers >5 m) is less than 10% for random sites, and about 90% of stream km are estimated to have less than 30% cover provided by canopy (Figure 21). The median canopy cover for reference sites is slightly higher, but these measures suggest that canopy cover may be sparse and that much of the channel shading provided by mid-height (0.5 to 5 m) vegetation layers.

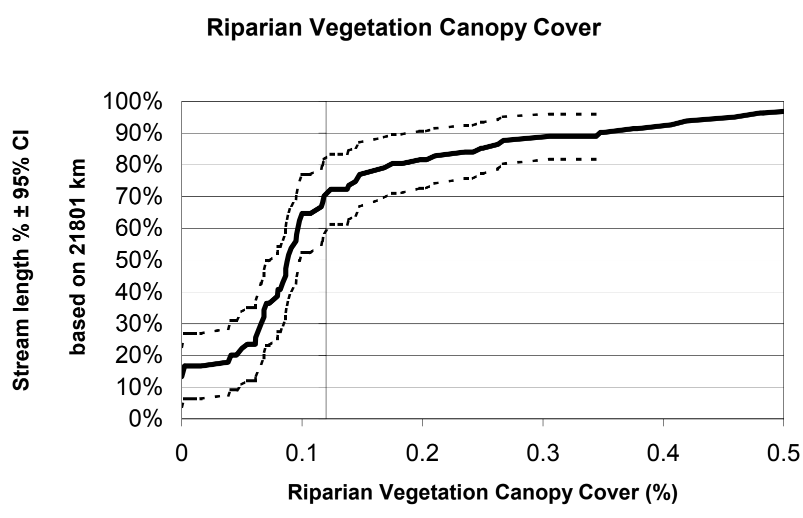


Figure 21. CDF of percent cover provided by canopy layer (>5m), as based on random sites, with reference site median superimposed for comparison. Outlier values of 0.53–0.76 (representing less than 3% of stream km) not shown.

## Riparian Disturbance

Disturbance to the riparian area is measured and reported as a proximity-weighted index of human activities. Disturbances are scored in eleven categories, two of which are considered agricultural (Row crops, Pasture/range/hay fields) and nine non-agricultural (Walls/dikes/revetments, Buildings, Pavement, Roads/railroads, Pipes, Landfills/trash, Parks/lawns, Logging operations, Mining activities).

A disturbance index is calculated based on proximity-weighted scores from both banks at all transects: (a) in channel or on channel margin, weight, wt.= 1.5 (b) within 10 m of channel, wt=1 (c) more than 10 m from channel, weight=0.67. (d) Not present = 0. The maximum score for a single category of disturbance at a given site is 1.5. The theoretical maximum for a set of n disturbances would be 1.5 x n, though in reality this would not happen.

Both the reference sites and the random sites yielded a median non-agricultural human disturbance score of only about 0.25 (Figure 22). This is the kind of score that would occur if the stream were running close to a road or lawn on one bank, and had no other disturbances. Only about 15% of wadeable stream km are estimated to have a score over 1, and about 30% of stream km are estimated to have no non-agricultural disturbance at all.

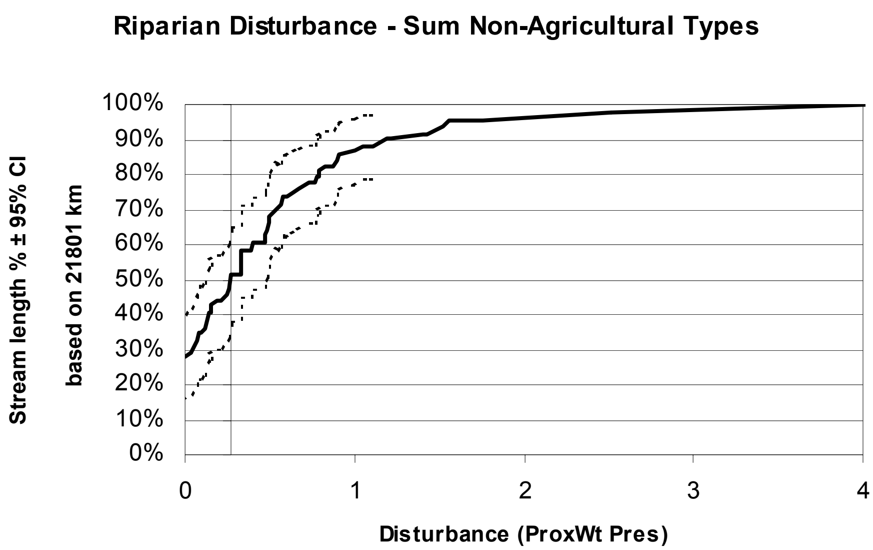


Figure 22. CDF of non-agricultural riparian disturbance (sum of nine types) as based on random sites, with reference site median superimposed for comparison. Maximum possible score is 1.5 x 9 = 13.5

Agricultural disturbance (Figure 23) was much more common than non-agricultural; the median proximity-weighted value based on randomly selected sites was near 1.0. The median for reference sites was lower at around 0.6, a value that corresponds to the 25$^{th}$ percentile value for random sites. This suggests that reference sites in fact may be found in areas with less (or at least less proximal) agricultural disturbance. In fact, local and watershed-level land use is a commonly considered factor in the selection of reference sites and watersheds.

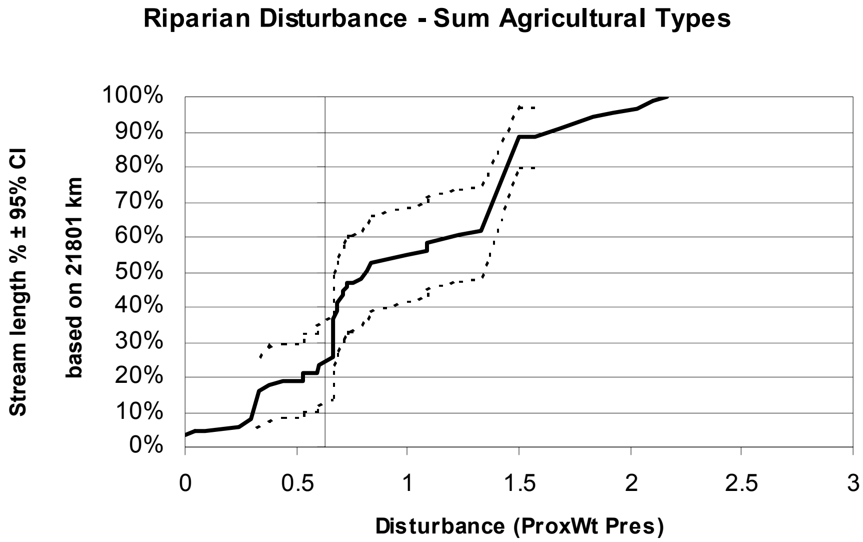


Figure 23. CDF of agricultural-type riparian disturbance (two types), as based on random sites, with reference site median superimposed for comparison. Maximum possible score is 1.5 x 2 = 3

Randomly-selected sites yield an interesting distribution pattern with respect to agricultural disturbance; there appear to be three fairly discrete classes, with breakpoints at 0.67 and 1.5, suggesting that presence of agricultural disturbance is fairly uniform along a given reach. Very few km are without agricultural disturbance. Roughly 40% of km have ag-disturbance values of 0.67 or less, roughly another 15% have values between 0.67 and 1.0, and about 45% have values over 1.0. An ag-disturbance score of 1.0 or more would correspond to the presence of row crop or pasture within 10 m of both banks at every transect.

**Fish Cover**

In both random and reference stream populations, the most ubiquitous fish cover types were Brush/small debris and Overhanging vegetation. Based on sampling of random sites, over 70% of stream km lacked boulders altogether, >70% lacked artificial cover, >50% lacked filamentous algae, >50% lacked aquatic macrophytes, >40% lacked large woody debris, and >40% lacked undercut banks. Some stream km have no fish cover whatsoever (see CDFs in Appendix K and table below).

Median percent cover for any single cover type ranged from 0–4% in random population and 0–5% in reference population. Interestingly, reference population medians were equal to or slightly higher than random medians for every type of cover except Brush/small debris (See Appendices J–K and Table 1 below).

Table 1. Fish cover descriptive statistics.

| | Random | | | Reference | | |
|---|---|---|---|---|---|---|
| **Type of fish cover** | **min** | **median** | **max** | **min** | **median** | **max** |
| Filamentous algae | 0% | 0% | 57% | 0% | 2% | 40% |
| Aquatic macrophytes | 0% | 0% | 87% | 0% | 0% | 67% |
| Large woody debris | 0% | 0.5 % | 39% | 0% | 1% | 15% |
| Undercut banks | 0% | < 0.5 % | 49% | 0% | 1% | 49% |
| Boulders/rock ledges | 0% | 1% | 48% | 0% | 1% | 38% |
| Brush/small debris | 0% | 4% | 46% | 0% | 3% | 11% |
| Overhanging vegetation | 0% | 4% | 88% | 0% | 5% | 52% |
| Artificial structures | 0% | 0% | 5% | 0% | 0% | 0% |
| *All natural types* | *0%* | *13%* | *110%* | *4%* | *23%* | *111%* |
| *All types* | *0%* | *13%* | *110%* | *4%* | *23%* | *111%* |

These medians sound quite low, but they conceal a somewhat better picture of fish habitat. In fact, some sites did have high percent cover for any single type (see "max" columns in Table 1). Therefore the overall population median values for fish cover were 13% for the random population and 23% for the reference population. In fact, the CDF above shows that about 40% of randomly selected stream km have at least 10% cover of some type. In general, sampled streams have little fish cover both in terms of extent and diversity.

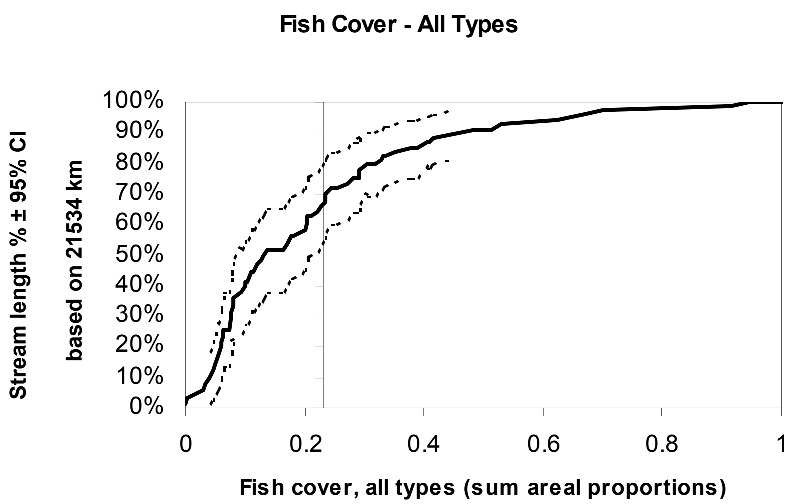


Figure 24. CDF of mean residual depth based on random sites, with reference site median superimposed for comparison. Outlier values of 0.94–1.1 (representing less than 2% of km) not shown.

## Large Woody Debris

Large woody debris (LWD) is defined as any wood at least 1.5 m long and a small end diameter of at least 0.1 m. As measured by volume, there is very little in-channel large woody debris in Kansas wadeable streams (Figure 25); about 30% of stream km apparently have no measurable volume of debris. Furthermore, the median value for reference streams is 0 $m^3/m^2$.

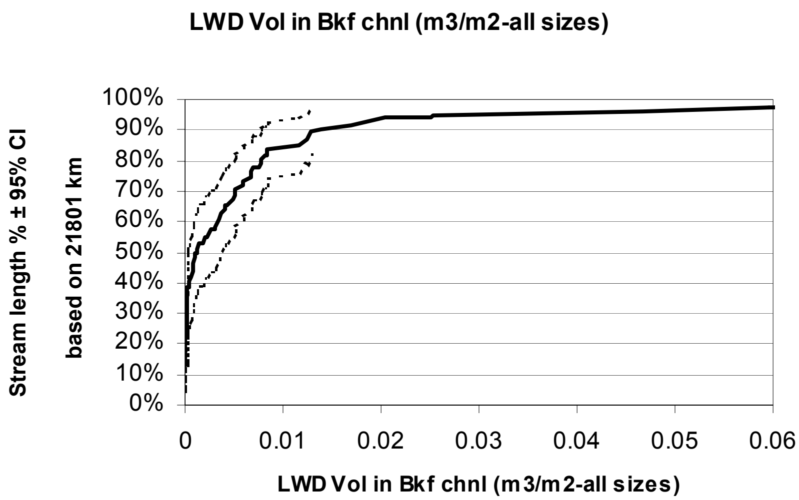


Figure 25. CDF of large woody debris volume, in the bankfull channel, as based on random sites. Outlier values of 0.08 and 0.14 (representing less than 3% of km) not shown. Reference site median value (based on 30/30 sites) = 0.

Another way to measure LWD is in "number of pieces." Figure 26 shows number of pieces per 100 m of stream reach; in this case, pieces both in the bankfull channel and above it. Note that the median for random sites is about 2 pieces per 100 m (recall that reaches ranged from 150 to 300 m), and the median for reference sites is only a little higher. Based on random sites, an estimated 80% of wadeable stream km in Kansas have fewer than 1 piece of LWD per 10 m anywhere in or above the bankfull channel.

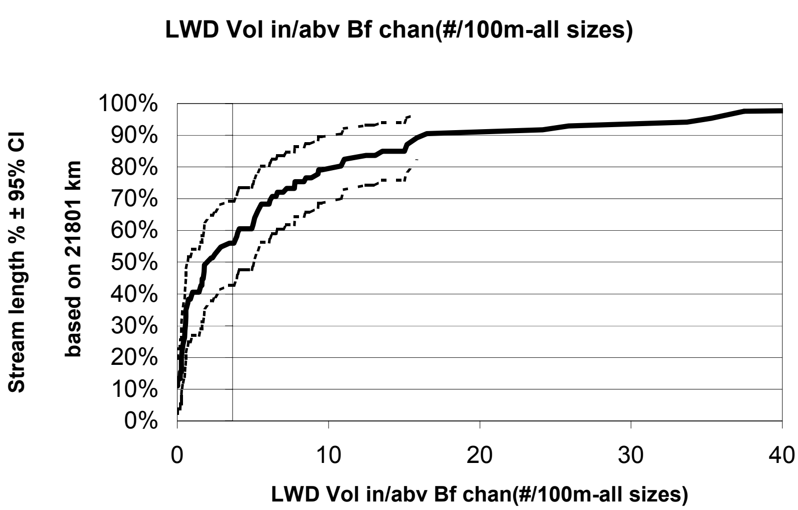


Figure 26. CDF of large woody debris pieces, in or above the bankfull channel, based on random sites, with reference site median superimposed for comparison. Outlier values of 60.0–87.4 (representing less than 2% of km) not shown.

Large woody debris may have effects where it is present (e.g., providing microhabitats or channel structure), but is evidently not a pervasive presence in Kansas wadeable streams.

### ***Fish Communities***

Seventy-eight different fish species were collected in this study; see Appendix L. The ten most commonly collected species were *Lepomis cyanellus* (green sunfish), *Cyprinella lutrensis* (red shiner), *Campostoma anomalum* (central stoneroller), *Micropterus salmoides* (largemouth bass), *Etheostoma spectabile* (orangethroat darter), *Notropis stramineus* (sand shiner), *Pimephales promelas* (fathead minnow), *Lepomis macrochirus* (bluegill), *Semotilus atromaculatus* (creek chub), and *Phenacobius mirabilis* (suckermouth minnow). These ten species accounted for 45% (509/1121) of all identifiable individual fishes collected.

The State of Kansas recognizes five Endangered fish species, 11 Threatened species, and 23 Species In Need of Conservation (SINC) (Kansas Department of Wildlife and Parks 2005; Kansas Department of Wildlife and Parks 2005). In this project, there were eight SINC captured, four Threatened Species, and one Endangered Species. Interestingly, and perhaps encouragingly, although many of these were collected only at "reference" sites, as might be expected, some of these were also found at "random" sites; see Appendix L for more information.

A recent paper by Haslouer and coauthors (Haslouer, Eberle et al. 2004) suggests that an additional six species collected in this study should merit SINC or Threatened status based on their interpretations of both historic and current distributions and known perturbations. Three darter species (*Etheostoma flabellare, E. nigrum and E. whipplei*) that are not currently listed by the state of Kansas are suggested to be either SINC or Threatened species by these authors. Haslouer *et al.* also indicated that two shiner species (*Luxilus cardinalis and L. cornutus*) and the southern redbelly dace (*Phoxinus erythrogaster*) should be candidates for listing as either Threatened or SINC species.

Fish community IBIs were calculated using the 8-metric index developed at EPA Western Ecology Division (Corvallis). Details of the IBI and its component metrics are outlined in Appendix D; the index uses a 100-point scale. Basically, lower scores of the IBI indicate impacted or disturbed fish communities, whereas higher scores are reflective of less disturbed systems. The overall range of scores varied from zero to the low nineties.

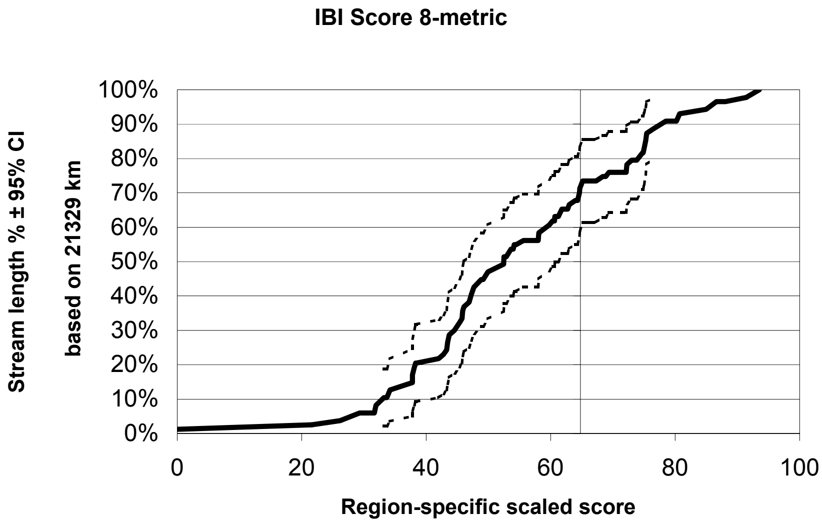


Figure 27. CDF of the Index of Biotic Integrity (IBI), based on random sites, with reference site median superimposed for comparison. The IBI is an 8-metric index based on fish community data.

The median IBI score for random sites was 52, with values ranging from 0 to 93. The random-site median of 52 was close to the 25th percentile value of the reference population (which was 54); the median score for reference sites was 71. Population summary values for the reference population are given in Appendix M, and distributions for the random population are presented in Appendix N.

Three of the metrics did not distinguish the reference from random populations; these were Native family richness, Proportion of tolerant individuals, and Proportion of individuals as carnivores. However, in five metrics, the reference population median did exceed that of the general population. These metrics were: Native species richness, Sensitive species richness, Number of native benthic species, Number of long-lived species, Proportion of individuals of introduced species. This last metric, which is the ratio of all individuals to the number specimens of introduced species scores high when there are no or few individuals of introduced species.

Notably, based on results from the randomly selected population, 70% of stream km had a sensitive-species score of zero, which suggests that sensitive species are rare or absent from a large proportion of Kansas streams. The fact that few streams appear to support pollution-sensitive species may not be surprising in view of the large extent of the Kansas landscape that has been altered to accommodate modern agricultural management. However, any interpretation of sensitive-species scores has to be based on the understanding that there are few sensitive species known to occur in Kansas.

### *Relationships among Fish and Other Factors*

Pearson correlations among fish measures and chemistry analytes, and fish and physical habitat measures (Appendix O) were examnied in the stream populations as a whole, without differentiating between random or reference. There were no significant (p<0.05) strong (r>|0.50|) correlations among fish and chemistry analytes. Since 25% of the streams had dissolved oxygen (DO) values below the state standard (Figure 2), we further explored DO (WG17) relationships with fish measures, and found little of significance, except that as DO increased, the proportion of non-native individuals (pintro) decreased (p=0.01, r=-0.28), while the proportion of native individuals (pnativ) increased (p=0.01, r=0.28).

We did not examine correlations among every fish measure and every physical habitat measure, but focused on measures suggested either by biological meaning or from state studies (NDEQ, IDNR) (Appendix O). Significant, strong relationships are reported in Table 2, and some corresponding scatter plots are presented in Figures 27 – 29, which show regression lines and Loess smoothing lines (red).

Table 2. Physical habitat variables that were significantly (p<0.05) and highly (Pearson's r>|0.50|) correlated. * denotes normal distribution. See Appendix O for codes.

| fish | measure | r |
|---|---|---|
| numnatsp* | xdepth | 0.53 |
| | ssdepth | 0.54 |
| numnatfm | xdepth | 0.50 |
| nssen | XEMBED | -0.54 |
| psen | XEMBED | -0.56 |
| nsnsen | XEMBED | -0.51 |
| pnsen | XEMBED | -0.52 |
| ptole | XEMBED | 0.62 |
| | lrbs_bw5* | -0.60 |
| | PCT_SAFN | 0.68 |
| | PCT_SFGF | 0.57 |
| | PCT_BGR | -0.59 |
| pntole | XEMBED | 0.57 |
| | lrbs_bw5* | -0.58 |
| | PCT_SAFN | 0.63 |
| | PCT_SFGF | 0.53 |
| | PCT_BGR | -0.56 |
| tolrnt | lrbs_bw5* | 0.52 |

| fish | Measure | r |
|---|---|---|
| nsnlunk | w1_hag | -0.50 |
| | rpgt75 | 0.52 |
| | Sddepth | 0.57 |
| epcarn | XEMBED | 0.59 |
| | lsubd_sd* | -0.62 |
| | PCT_SA | 0.50 |
| | PCT_SAFN | 0.64 |
| | PCT_SFGF | 0.66 |
| | PCT_BGR | -0.68 |
| epinsiv | XEMBED | -0.56 |
| | lsubd_sd* | 0.63 |
| | PCT_SAFN | -0.61 |
| | PCT_SFGF | -0.64 |
| | PCT_BGR | 0.66 |
| epmac | WF04 | -0.53 |
| ephbmic | XEMBED | -0.63 |
| | PCT_SAFN | -0.62 |
| | PCT_SFGF | -0.60 |
| | PCT_BGR | 0.63 |

### Substrate Type

In general, as percent sand and fines (PCT_SAFN) and percent fine gravel (PCT_SFGF) increased, the proportion of tolerant individuals (ptole) in a sample increased (r=0.68, r=0.57); however this proportion (ptole) decreased (r=-0.59) as percent coarse gravel increased (PCT_BIGR) (Figure 27). This is reflected in the metric of percent tolerant score (tolrnt), though only significantly and strongly with percent sand and fines (r = -0.53). Conversely, the number of sensitive species (nssen) and proportion of sensitive individuals (psen) decreased as substrate size increased (r=-0.54, r=-0.56). The metric of the sensitive species richness score (sensit) reflects this pattern, though not as strongly (vs. PCT_SAFN r=-0.45, vs. PCT_SFGF r=-0.40, vs. PCT_BIGR r=0.47).

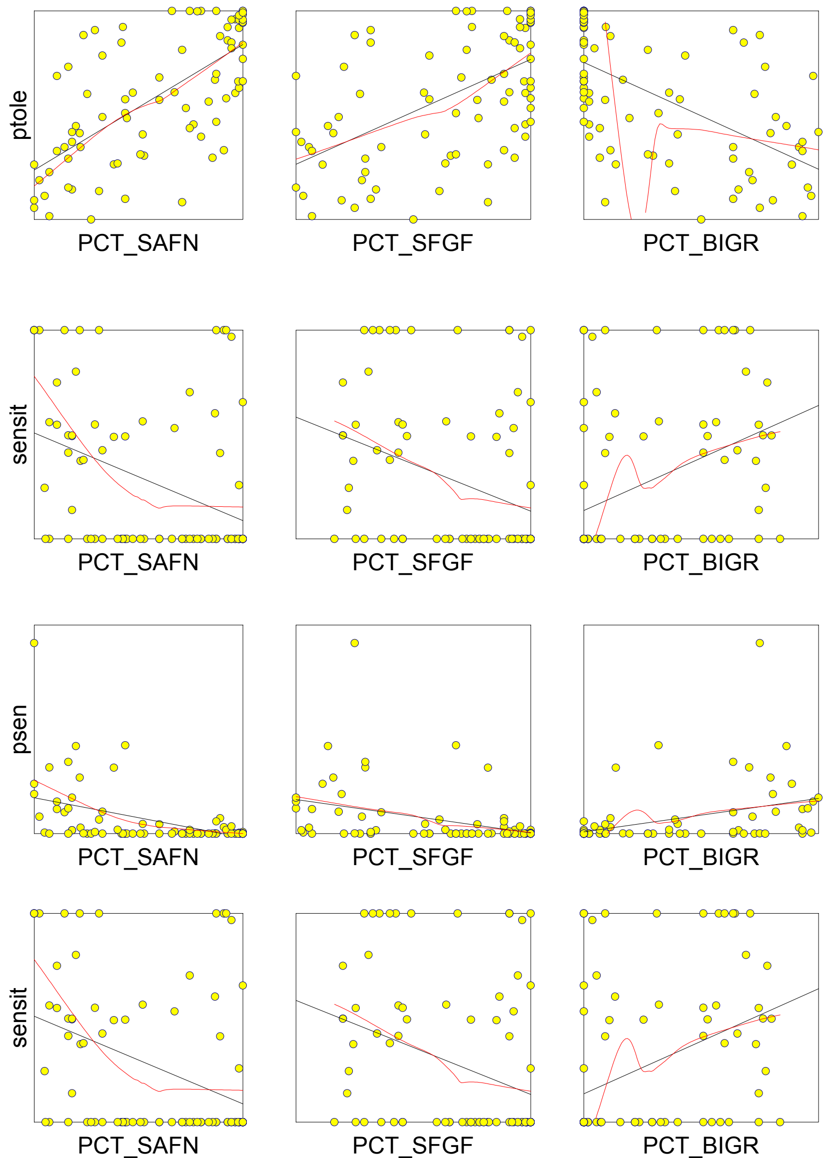


Figure 27. Matrix of the fish metrics of proportion of tolerant individuals (ptole), percent tolerant score (tolrnt), number of sensitive species (nssen) and proportion of sensitive individuals (psen) against the physical habitat variables of percent sand and fines (PCT_SAFN), percent fine gravel (PCT_SFGF), and percent coarse gravel (PCT_BIGR). From the 2000-01 Kansas REMAP dataset. Regression line in black, Loess (80%) smoothing curve in red.

Trophic guild metrics also followed similar patterns, though not necessarily strongly or significantly (Figure 28). Percent insectivores (insect) decreased with increasing percentages of sand and fines (r=-0.20, p=0.06) and percent fine gravel (r =-0.11, p=0.30), while they increased with increasing percentage of coarse gravel (r=0.16,p=0.13). This is probably due to the relationships of macroinvertebrates with substrate type. The opposite relationships were true of percent herbivores + micropahgic omnivores (herbiv) (vs. PCT_SAFN r=0.45, vs. PCT_SFGF r=0.44, vs. PCT_BIGR r=-0.36, all p=0.00).

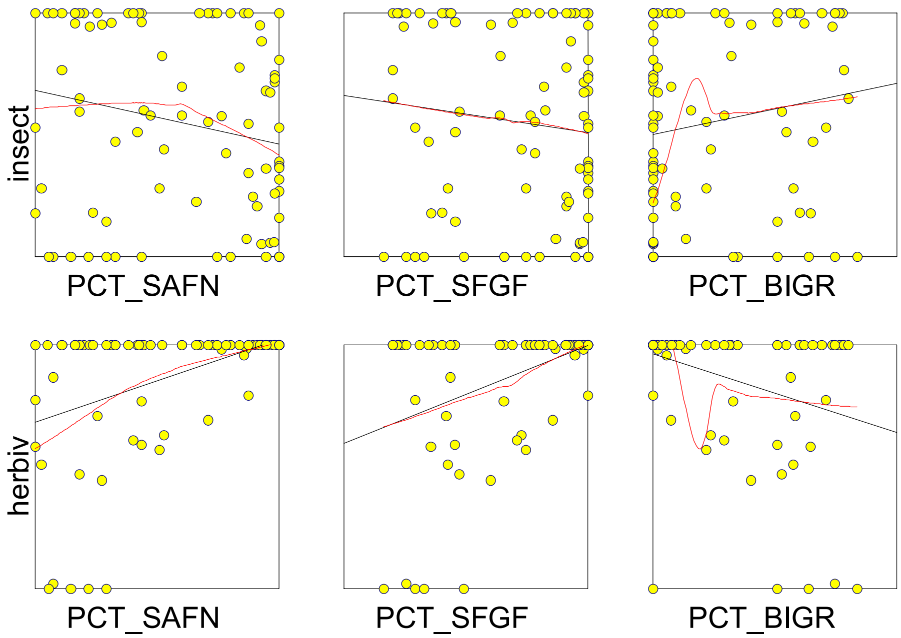


Figure 28. Matrix of the fish metrics of percent insectivores (insect) and percent herbivores + microphagious omnivores (herbiv) against the physical habitat variables of percent sand and fines (PCT_SAFN), percent fine gravel (PCT_SFGF), and percent coarse gravel (PCT_BIGR). From the 2000-01 Kansas REMAP dataset. Regression line in black, Loess (80%) smoothing curve in red.

None of the IBIs, which are based on the metrics, were significantly strongly correlated with any of the habitat measures. This may indicate a need to examine the components of the IBIs rather than the IBIs.

## Channel Morphology

Again, the proportion of sensitive individuals (psen) and tolerant individuals (ptole) followed opposite trends to each other with channel morphology (Figure 29). Sensitive individuals increased with increasing bankfull width (XBKF_W) and bed stability (lrbs_bw5), while tolerant individuals decreased. Tolerant individuals increased with increasing embeddedness (XEMBED) and proximity of agricultural riparian (w1_hag), while sensitive individuals decreased.

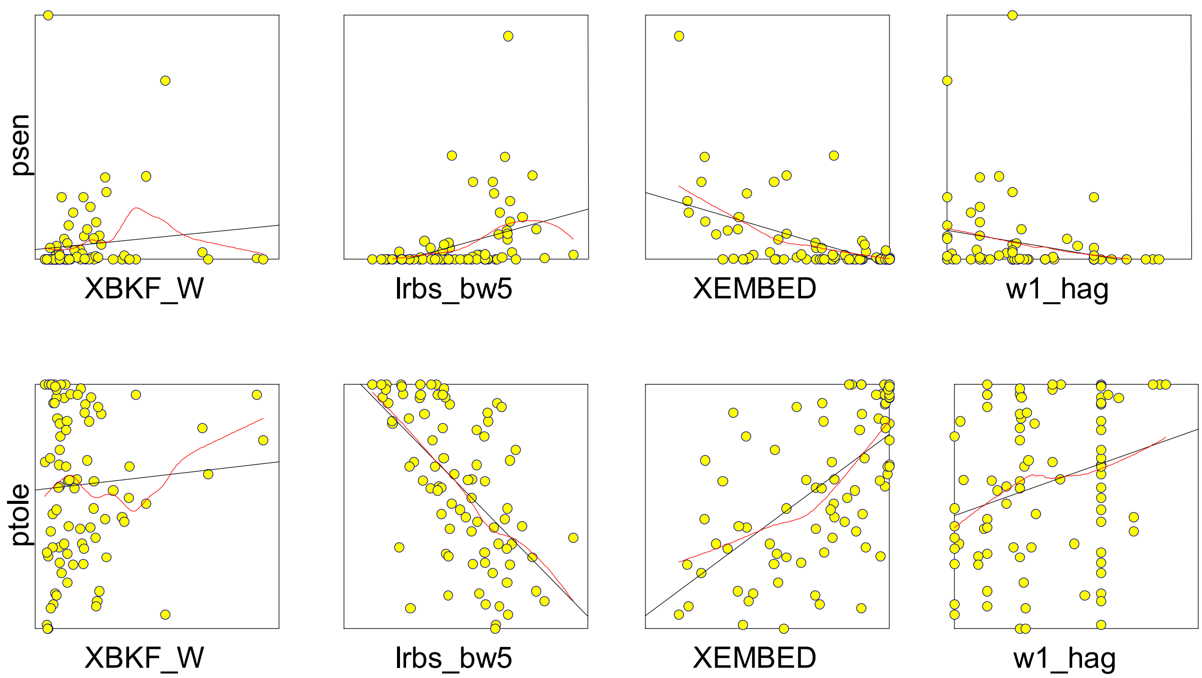


Figure 29. Matrix of the fish metrics of proportion of sensitive individuals (psen) and proportion of tolerant individuals (ptole) against the physical habitat variables of bankfull width (XBKF_W), bed stability (lrbs_bw5), embeddedness (XEMBED), and proximity of agricultural riparian (w1_hag). From the 2000-01 Kansas REMAP dataset. Regression line in black, Loess (80%) smoothing curve in red.

Flow (WF04) showed a negative significant correlation (p=0, r=-0.53) with the proportion of macrophagic omnivores (epmac). Flow correlations in the 2000-01 dataset showed low (r=0.24 to 0.34) but significant (p<0.05) positive correlations with number of species (numspec) and native species (numnatsp), number of families (numfam) and native families (numnatfam), number of sensitive species (nssen) and native sensitive species (nsnsen), number of trophic strategies (ntroph) and trophic strategies of native spp. (nntroph), proportion of herbivores and microphagic omnivores (ephbmic), % insectivores + invertivores score (insinv), % omnivores + herbivores score (omnihb), % tolerant spawners score (tolrepr), and % clinging substrate spawners score (gravel). Though the correlation coefficiant may be low, whatever part of these relationships that is explained by flow is strong. There were no significant correlations between flow and any of the IBIs.

### *Temporal comparison of 1994-95 and 2000-01 data*

Temporal changes in fish metrics and IBIs and stream flow were examined by comparing this set of 2000-01 REMAP data with the set of data collected in 1994-95 (Waters 1997a, 1997b). For comparisons, the two sets of data were coded as y1 for 1994-95 and y2 for 2000-01, and the 57 random sites that were sampled in both sets of years were examined. Sites during which one of the years was not sampled or no fish were collected were filtered out of analyses. Paired t-tests were used to examine normal data, while the Wilcoxon signed-rank test was used to examine non-normal data.

Table 3 summarizes the paired comparisons of metrics and IBIs, all IBIs were non-normal, while metrics were a mix of normal and non-normal data. Tolrnt was the only metric that increased from 1994-95 to 2000-01 (p=0.00). Natsp, natfam, nindiv, sensit, smbenth, benthic, wcolumn, wcolspcl, sunfish, minnow, longlive, troph, and repro decreased (p=0.00), while alien, carn, insinv, insect, herbiv, omni, omnihb, tolrepr, and gravel showed no difference between year sets ($p \geq 0.09$). It is interesting that troph and repro decreased, while the constituent metrics showed no difference between year sets (Figure 30 and Figure 31). This may be due to the variance around the constituent metrics being high enough to effect no difference from one year set to the next, but as a group, the variance is small enough to reveal yearly mean differences.

The Wilcoxon signed-rank test revealed that the fish IBIs based on 1994-95 surveys differed from the IBIs based on 2000-01 surveys (p=0.00) (Figure 32). IBIs of the majority of sites decreased from 1994-95 to 2000-01 (with site differences ranging from 0 to 92). Seven sites increased, with four sites having IBI differences ranging from 0.2 to 6, and three sites having large IBI differences of 20 to 37 (KES008, Medicine Cr. Tributary, Osborne Co.; KES046, Dragoon Cr. Wabanusee Co.; and KES053, Card Cr., Montgomery Co.).

Table 3. Temporal comparisons of fish metrics and IBIs, showing abbreviated variable name, variable name, data normality, significance value (p value), and changes from 1994-95 (y1) to 2000-01 (y2), and the mean and standard deviation (std. dev.) for both the y1 data and y2 data. The paired t-test was used to examine normal data, while the Wilcoxon signed-rank test was used to examine non-normal data. See Appendix O. for more completely spelled out variable names.

| | | | | change from | y1 | | y2 | |
|---|---|---|---|---|---|---|---|---|
| abbr. | variable | normality | p value | y1 to y2 | mean | std dev | mean | std dev |
| natsp | Native Species Richness Score (0-10) | y | 0.000 | decrease | 9.43 | 1.62 | 6.30 | 2.27 |
| natfam | Native Family Richness Score (0-10) | y | 0.000 | decrease | 9.75 | 1.09 | 7.16 | 2.23 |
| nindiv | No. Indiv. Score (0-10) | n | 0.000 | decrease | 10.00 | 0.00 | 6.48 | 2.79 |
| sensit | Sensit. Spp. Rich. Score (0-10) | y | 0.000 | decrease | 4.35 | 5.00 | 2.31 | 3.55 |
| tolrnt | % Tolerants Score (0-10) | y | 0.015 | increase | 3.60 | 3.53 | 4.57 | 3.59 |
| smbenth | Ntv Sm. Benth. Spp. Rich. Score (0-10) | y | 0.000 | decrease | 7.40 | 4.05 | 4.67 | 3.23 |
| benthic | Native Benth. Spp. Rich. Score (0-10) | y | 0.000 | decrease | 7.61 | 4.02 | 4.16 | 3.02 |
| wcolumn | Ntv Wtr. Col. Spp. Rich. Score (0-10) | n | 0.000 | decrease | 9.18 | 2.59 | 6.20 | 2.63 |
| wcolspcl | Ntv Wtr. Col. Spec. Spp. Score (0-10) | y | 0.000 | decrease | 7.26 | 4.50 | 3.62 | 3.86 |
| sunfish | Ntv Centrarchid Spp. Rich. Score (0-10) | n | 0.000 | decrease | 8.39 | 3.71 | 4.83 | 3.20 |
| minnow | Ntv Cyprinid Spp. Rich. Score (0-10) | y | 0.000 | decrease | 10.00 | 0.00 | 5.88 | 2.75 |
| longlive | Ntv. Long-lived Spp. Rich. Score (0-10) | n | 0.000 | decrease | 9.37 | 2.31 | 6.21 | 2.48 |
| alien | % Non-natives Score (0-10) | n | 0.739 | no difference | 9.44 | 0.89 | 9.37 | 1.18 |
| troph | No. Trophic Strat. Score (0-10) | n | 0.000 | decrease | 9.41 | 2.24 | 8.44 | 1.79 |
| carn | % Carnivores Score (0-10) | y | 0.389 | no difference | 5.97 | 4.05 | 5.49 | 4.16 |
| insinv | % Insectivores+Invertivores Score (0-10) | n | 0.451 | no difference | 6.32 | 3.71 | 6.73 | 3.69 |
| insect | % Insectivores Score (0-10) | y | 0.291 | no difference | 4.79 | 3.92 | 5.35 | 3.96 |
| herbiv | % Herbivores+Micro. Omniv. Score (0-10) | n | 0.091 | no difference | 9.30 | 2.13 | 9.21 | 2.10 |
| omni | % Macrophagic Omnivores Score (0-10) | n | 0.398 | no difference | 8.29 | 3.21 | 8.60 | 2.73 |
| omnihb | % Omniv. + Herbiv. Score (0-10) | n | 0.831 | no difference | 7.60 | 3.31 | 7.70 | 2.95 |
| repro | No. Reprod. Strat. Score (0-10) | n | 0.000 | decrease | 9.65 | 1.50 | 7.27 | 2.88 |
| tolrepr | % Tolerant Spawners Score (0-10) | y | 0.830 | no difference | 6.05 | 3.07 | 5.96 | 3.05 |
| gravel | % Cln. Subs. Spawners Score (0-10) | y | 0.838 | no difference | 6.04 | 3.06 | 5.96 | 3.05 |
| ibi1 | IBI Score (0-100)--MAHA metrics+longlive | n | 0.000 | decrease | 78.36 | 14.91 | 63.23 | 13.61 |

Table 3. Continued.

| abbr. | variable | normality | p value | change from y1 to y2 | y1 mean | y1 std dev | y2 mean | y2 std dev |
|---|---|---|---|---|---|---|---|---|
| ibi4 | IBI based on S:N and resp. (10 metrics) | n | 0.000 | decrease | 77.13 | 16.15 | 59.74 | 15.06 |
| ibi5 | IBI Score (13 metrics) | n | 0.000 | decrease | 75.91 | 15.54 | 60.48 | 13.61 |
| ibi6 | IBI score (12 metrics) | n | 0.000 | decrease | 77.20 | 16.85 | 60.55 | 14.73 |
| ibi7 | IBI score (11 metrics) | n | 0.000 | decrease | 78.47 | 16.23 | 59.94 | 15.25 |
| ibi8 | IBI score (8 metrics) | n | 0.000 | decrease | 74.41 | 17.54 | 56.95 | 16.77 |
| WG04 | Flow (CFS), REMAP Field Parameters | N | 0.005 | decrease | 20.26 | 71.54 | 16.52 | 53.25 |

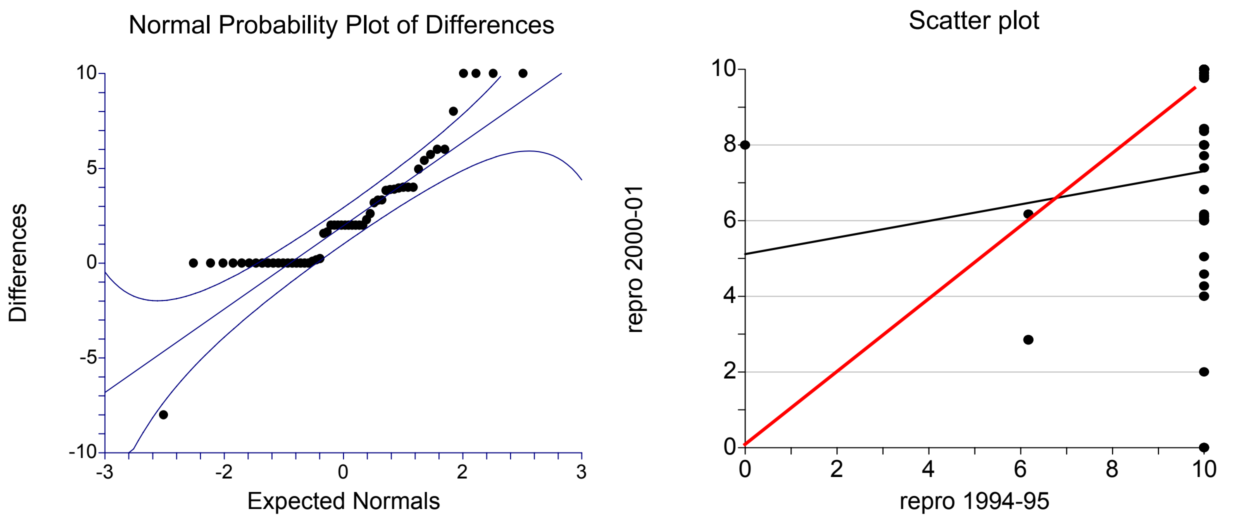


Figure 30. Plots for reproductive strategy score (repro) for 1994-95 and 2000-01. The normal probability plot of differences shows that the data were non-normal. The scatter plot shows a regression line (red) if there had been a one-to-one ratio, and hence no difference, between year sets, and also shows the actual regression line (black) which indicates a decrease from 1994-95 to 2000-01.

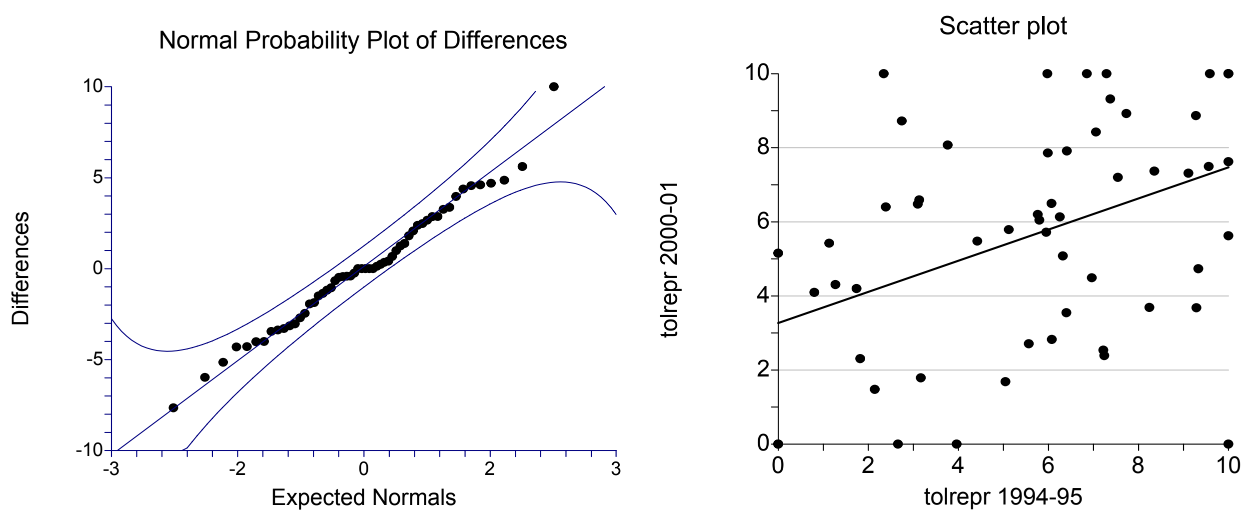


Figure 31. Plots for % tolerant spawners score (tolrepr) for 1994-95 and 2000-01. The normal probability plot of differences shows that the data were normal. Regression line in black. The extreme scatter indicates no difference between 1994-95 and 2000-01 values.

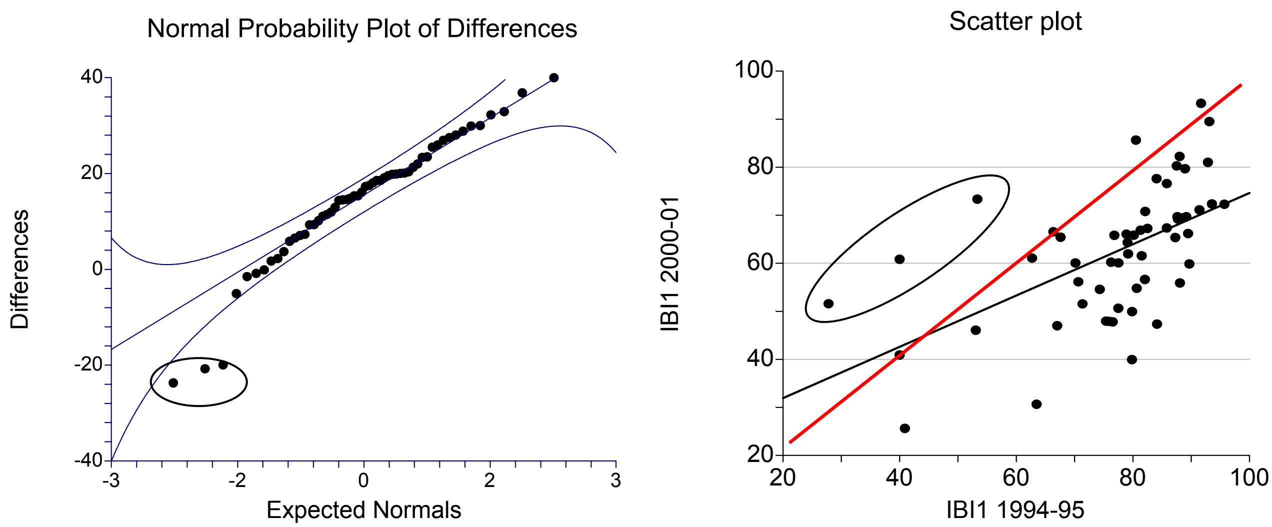


Figure 32. Plots for IBI1 for 1994-95 and 2000-01. The normal probability plot of differences shows that the data were non-normal. The scatter plot shows a regression line (red) if there had been a one-to-one ratio, and hence no difference, between year sets, and also shows the actual regression line (black) which indicates a decrease from 1994-95 to 2000-01. All IBIs followed these trends, and were significantly different (p=0.00) between year groups. Circled are sites KES008, KES046, and KES053 which greatly increased from 1994-95 to 2000-01.

Flow (WF04) was examined as a possible influence on the fish measurements (Figure 1and Figure 33). As with most of the fish measurements that showed temporal changes, flow decreased from 1994-95 to 2000-01 (p=0.00). There were large standard deviations around the flow mean in both years, due to four of the sites having very large flows (>95 CFS, sites KS030, KS035, KS047, KS057).

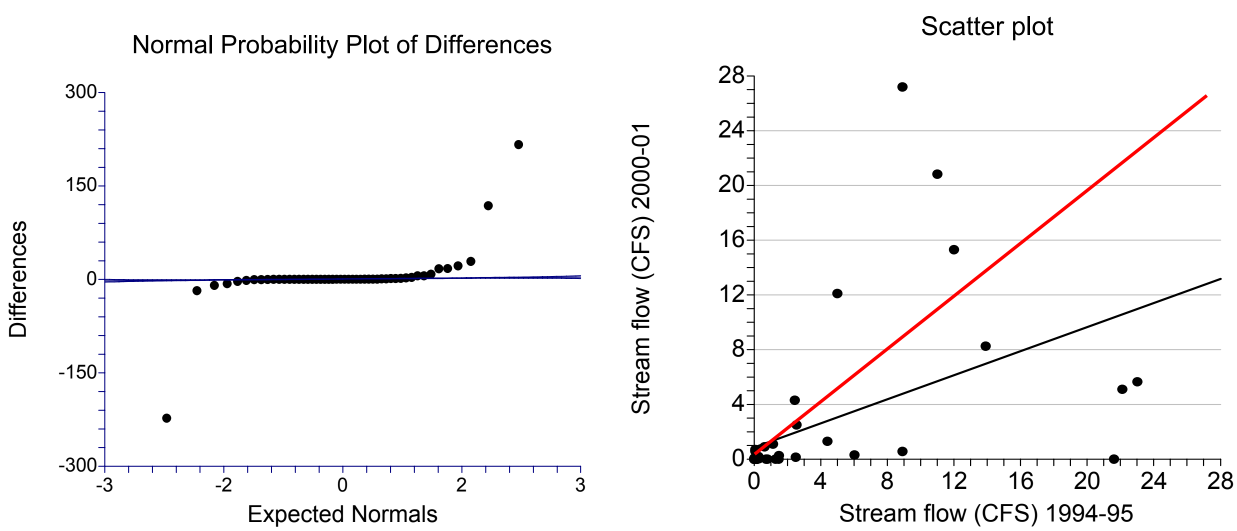


Figure 33. Plots for stream flow (CFS) for 1994-95 and 2000-01. The normal probability plot of differences shows that the data were non-normal. The scatter plot shows a regression line (red) if there had been a one-to-one ratio, and hence no difference, between year sets, and also shows the actual regression line (black) which indicates a decrease from 1994-95 to 2000-01. The four sites with flow > 95 CFS do not appear in the scatter plot.

## *Conclusion*

The EMAP program yields valuable information about the status of streams and comparisons of reference and random populations. Examining data on a regional basis can help ecologists, managers, etc. make decisions about specific parameters and specific sites. The CDFs allowed a visual comparison for each parameter of overall stream condition versus a presumed reference population. They also provided a visual comparison of each parameter to its state criteria. Overall, few statistically distinct relationships were found among the measured parameters. If fish metrics showed a change between 1994-95 to 2000-01, it tended to decrease. Managers may want to further investigate this trend, or continue sampling to examine longer-term changes. Within general changes for the streams as a population, managers can also examine changes within specific sites, such as Medicine Cr. Tributary (KES008), Dragoon Cr. (KES046), and Card Cr. (KES046), all of which showed increases in fish IBIs from 1994-95 to 2000-01.

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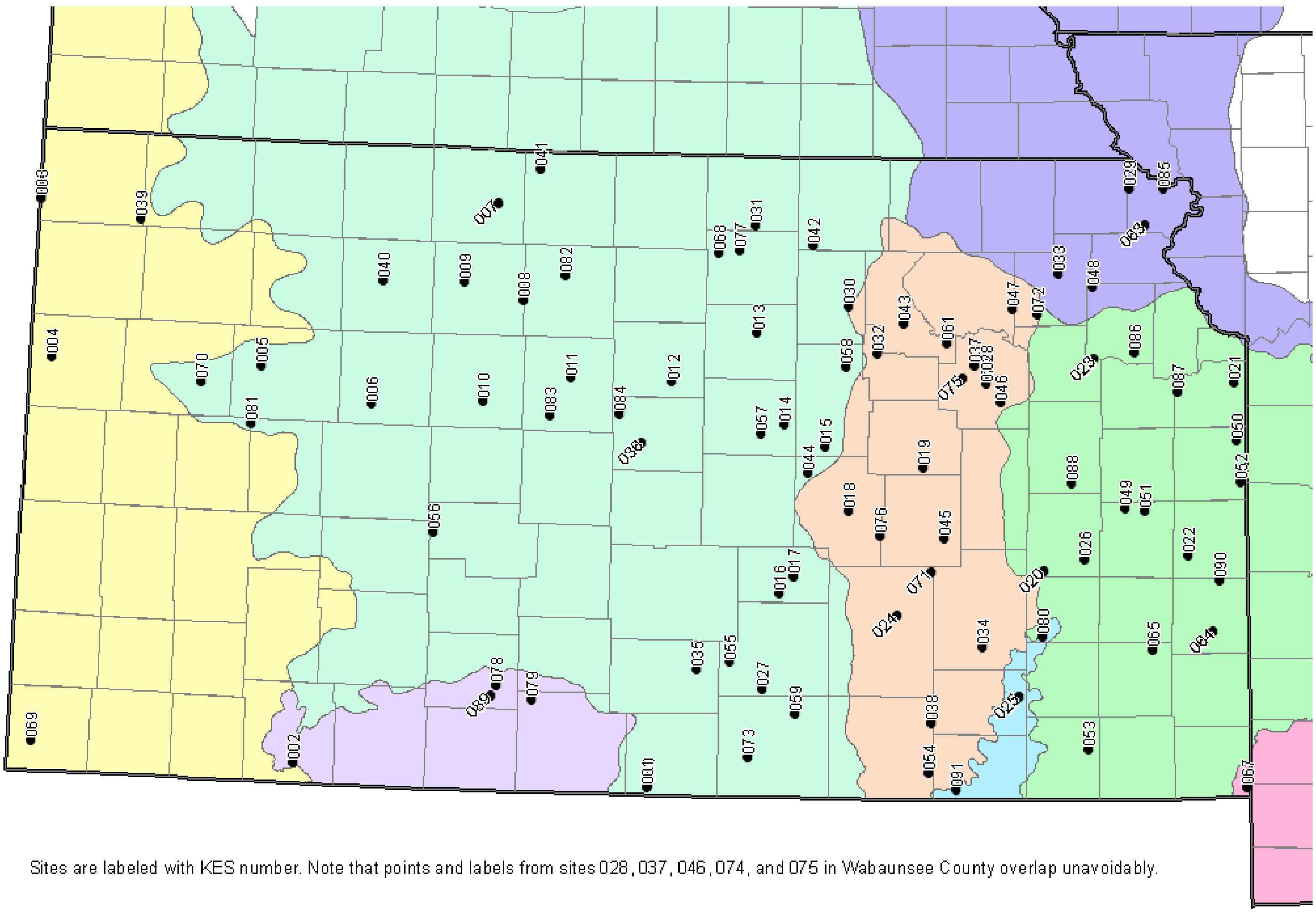
**APPENDICES**

**Appendix A.1. Map of sites sampled and attempted.**

Kansas REMAP Sites, 2000-01



Sites are labeled with KES number. Note that points and labels from sites 028, 037, 046, 074, and 075 in Wabaunsee County overlap unavoidably.

**Appendices A.2 – A.7. Localities of referencec and random sites.**

Table headers:
KES – site code used in this report
STORET – USEPA STORage and RETrival database code
YEAR – year that the site was sampled
KDWP ID – site code used by the Kansas Department of Wildlife and Parks
NAME – name of the site
COUNTY – County that the site is located in
LAT – site latitude in decimal degrees
LON – site longitude in decimal degrees
LEGAL – legal description of the site
XSTATUS – whether or not the site was sampleable
VALXSTAT – whether or not the site was wadeable
TYPE – type of site, REF = reference, RAND = random, OTH = other
WGT_R7 – weighting system used by REMAP
DRAINAGE – drainage system in which the site is found, Missouri River, Arkansas River, etc.
HUC8 – hydrologic unit code 8 in which the site is found
ER – code for the ecoregion in which the site is found
ER NAME – name of the ecoregion in which the site is found
FISHREG – fish region in which the site is found, was not assigned for sites in which no fish were collected.
HDI – habitat diversity index of the site

**Appendix A.2. Locality of reference sites sampled and attempted.**

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES022 | 009476 | 2000 | 2076 | NORTH FORK LITTLE SUGAR CREEK | LINN | 38.1350 | -94.9728 | NE4 Sec.15 T22S R22E |
| KES034 | 009494 | 2000 | KRS-005 | OTTER CREEK | GREENWOOD | 37.7064 | -96.2142 | NW4 Sec.16 R27SR11E |
| KES036 | 009495 | 2000 | KRS-003 | SOUTH FORK NINNESCAH RIVER | KINGMAN | 37.6436 | -98.2914 | NE4 Sec.3 T298S R9W |
| KES037 | 009497 | 2000 | 2097 | MILL CREEK | WABAUNSEE | 39.0267 | -96.2694 | NE4 Sec.11 T12S R10E |
| KES061 | 009641 | 2000 | KRS-006 | DEEP CREEK | RILEY | 39.1300 | -96.4392 | NW4 Sec.5 T11S R9E |
| KES063 | 009642 | 2001 | KRS-024 | NORTH BRANCH INDEPENDENCE | DONIPHAN | 39.6792 | -95.2194 | NW4 Sec.30 T4S R20E |
| KES064 | 009644 | 2001 | KRS-016 | PAWNEE CREEK | BOURBON | 37.7775 | -94.8267 | SW.4 Sec.18 T26S R24E |
| KES065 | 009645 | 2001 | KRS-017 | CANVILLE CREEK | NEOSHO | 37.6939 | -95.1942 | SW4 Sec.14 T27S R20E |
| KES067 | 009647 | 2000 | KRS-007 | SHOAL CREEK | CHEROKEE | 37.0417 | -94.6411 | NW4 Sec.35 T34SR25E |
| KES069 | 010136 | 2000 | KRS-001 | CIMARRON RIVER | MORTON | 37.1281 | -101.8947 | NW4 Sec.4 T34S R42W |
| KES070 | 010137 | 2000 | KRS-002 | SMOKY HILL RIVER | LOGAN | 38.8503 | -100.9950 | SW4 Sec.9 T14S R33W |
| KES071 | 010138 | 2000 | KRS-004 | SOUTH FORK COTTONWOOD RIVER | BUTLER | 38.0567 | -96.5303 | NW4 of NE4 Sec.16 T23S R8E |
| KES072 | 010139 | 2000 | KRS-008 | SOLDIER CREEK | JACKSON | 39.2631 | -95.8856 | SW4 Sec.17 T9S R14E |
| KES073 | 010140 | 2000 | KRS-009 | CHIKASKIA RIVER | STEVENS | 37.1800 | -97.6167 | NW4 Sec.14 T22S R3W |
| KES074 | 010141 | 2000 | KRS-010 | NEHRING CREEK | WABAUNSEE | 38.9375 | -96.1958 | NE4 Sec.9 T13S R11E |
| KES075 | 010142 | 2000 | KRS-011 | ILLINOIS CREEK | WABAUNSEE | 38.9658 | -96.3439 | NE4 Sec.31 T12S R10E |
| KES076 | 010210 | 2001 | KRS-012 | CEDAR CREEK | CHASE | 38.2267 | -96.8353 | SW4 Sec.13 T21S R5E |

Appendix A.2 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES077 | 010211 | 2001 | KRS-013 | WOLF CREEK | CLOUD | 39.5542 | -97.7161 | NW4 Sec.12 T6S R4W |
| KES078 | 010212 | 2001 | KRS-014 | THOMPSON CREEK | KIOWA | 37.4889 | -99.1322 | SW4 Sec.25 R29S R17W |
| KES079 | 010213 | 2001 | KRS-015 | TURKEY CREEK | BARBER | 37.4286 | -98.9192 | SW4 Sec.13 T30S R15W |
| KES080 | 010214 | 2001 | KRS-018 | SANDY CREEK | WOODSON | 37.7575 | -95.8531 | S2 of NE4 Sec.27 T26S R14E |
| KES081 | 010215 | 2001 | KRS-019 | WEST SALT CREEK | LANE | 38.6669 | -100.6725 | NE4 Sec.18 T16S R30W |
| KES082 | 010216 | 2001 | KRS-020 | KILL CREEK | OSBORNE | 39.4200 | -98.7867 | NW4 Sec.28 T7S R13W |
| KES083 | 010217 | 2001 | KRS-021 | LANDON CREEK | RUSSELL | 38.7600 | -98.8572 | E2 Sec.10 T15S R14W |
| KES084 | 010218 | 2001 | KRS-022 | SPRING CREEK | ELLSWORTH | 38.7764 | -98.4375 | SE4 Sec.4 T15S R10W |
| KES085 | 010219 | 2001 | KRS-028 | MOSQUITO CREEK | DONIPHAN | 39.8492 | -95.1008 | NE4 Sec.30 T2S R21E |
| KES086 | 010220 | 2001 | KRS-025 | BUCK CREEK | JEFFERSON | 39.0858 | -95.2900 | NW4 Sec.22 T11S R19E |
| KES087 | 010221 | 2001 | KRS-026 | CAPTAIN CREEK | JOHNSON | 38.8997 | -95.0300 | SE4 of SW4 Sec.24 T13S R21E |
| KES088 | 010222 | 2001 | KRS-029 | LONG CREEK | OSAGE | 38.4714 | -95.6767 | SE4 of NE4 Sec.19 T18S R16E |
| KES089 | 010223 | 2001 | KRS-030 | MEDICINE LODGE RIVER | KIOWA | 37.4383 | -99.1592 | SW4 Sec.14 T30S R17W |
| KES090 | 010224 | 2001 | KRS-031 | LITTLE OSAGE RIVER | BOURBON | 38.0139 | -94.7833 | SW4 Sec.28 T23S R24E |
| KES091 | 010225 | 2001 | KRS-023 | CANEY RIVER | CHATAUQUA | 37.0361 | -96.3744 | SE4 Sec.1 T35S R9E |

**Appendix A.3. Locality of random sites sampled and attempted.**

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES001 | 009451 | 2000 | 2051 | SANDY CREEK | HARPER | 37.0278 | -98.2147 | SW4 Sec.5 T35S R8W |
| KES002 | 009453 | 2000 | 2053 | CROOKED CREEK | MEADE | 37.0919 | -100.3292 | NE4 Sec.14 T34S R28W |
| KES003 | 009454 | 2000 | 2054 | SOUTH FORK REPUBLICAN RIVER | CHEYENNE | 39.6667 | -102.0339 | NE4 Sec.33 T4S R42W |
| KES004 | 009455 | 2000 | 2055 | WILLOW CREEK | WALLACE | 38.9297 | -101.9153 | NW4 Sec.18 T13S R41W |
| KES005 | 009456 | 2000 | 2056 | SOUTH BRANCH HACKBERRY CREEK | GOVE | 38.9397 | -100.6258 | NW4 Sec.11 T13S R30W |
| KES006 | 009457 | 2000 | 2057 | SMOKY HILL RIVER | TREGO | 38.7828 | -99.9481 | NW4 Sec.1 T15S R24W |
| KES007 | 009458 | 2000 | 2058 | BIG CREEK | PHILLIPS | 39.7471 | -99.2148 | SW4 Sec.35 T3S R17W |
| KES008 | (none) | 2000 | 2059 | MEDICINE CREEK TRIBUTARY | OSBORNE | 39.2966 | -99.0417 | SW4 Sec.6 T9S R15W |
| KES009 | 009460 | 2000 | 2060 | LOST CREEK | ROOKS | 39.3717 | -99.4081 | SW4 Sec.11 T8S R19W |
| KES010 | 009461 | 2000 | 2061 | BIG CREEK | ELLIS | 38.8183 | -99.2667 | SE4 Sec.24 T14S R18W |
| KES011 | 009462 | 2000 | 2062 | TRIB. TO CEDAR CREEK | RUSSELL | 38.9383 | -98.7375 | NW4 Sec.11 T13S R13W |
| KES012 | 009463 | 2000 | 2063 | WEST ELKHORN CREEK | LINCOLN | 38.9319 | -98.1158 | SE4 Sec.8 T13S R7W |
| KES013 | 009465 | 2000 | 2065 | LINDSEY CREEK | OTTAWA | 39.1686 | -97.6003 | NE4 Sec.24 T10S R3W |
| KES014 | 009466 | 2000 | 2066 | GYPSUM CREEK | SALINE | 38.7428 | -97.4286 | SE4 Sec.16 T15S R1W |
| KES015 | 009467 | 2000 | 2067 | WEST TURKEY CREEK | DICKINSON | 38.6425 | -97.1814 | SW4 Sec.23 T16S R2E |
| KES016 | 009468 | 2000 | 2068 | EMMA CREEK | HARVEY | 37.9483 | -97.4447 | NW4 Sec.21 T24S R1W |
| KES017 | 009469 | 2000 | 2069 | SAND CREEK | HARVEY | 38.0300 | -97.3592 | SE4 Sec.19 T23 R1E |

Appendix A.3 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES018 | 009640 | 2000 | 2070 | COTTONWOOD RIVER | MARION | 38.3436 | -97.0292 | NE4 Sec.6 T20S R4E |
| KES019 | 009471 | 2000 | 2071 | EAST CREEK | MORRISS | 38.5489 | -96.5781 | NW4 Sec.30 T17S R8E |
| KES020 | 009472 | 2000 | 2072 | SOUTH BIG CREEK | COFFEY | 38.0631 | -95.8478 | NW4 Sec.11 T23S R14E |
| KES021 | 009473 | 2000 | 2073 | INDIAN CREEK TRIB. | JOHNSON | 38.9386 | -94.6847 | NW4 Sec.7 T13S R25E |
| KES023 | 009480 | 2000 | 2080 | WHETSTONE CREEK | SHAWNEE | 39.0578 | -95.5364 | NW4 Sec.33 T11S R17E |
| KES024 | 009481 | 2000 | 2081 | BEMIS CREEK | BUTLER | 37.8525 | -96.7322 | NE4 Sec.26 T25S R6E |
| KES025 | 009482 | 2000 | 2082 | EAST PAINTERHOOD CREEK | ELK | 37.4761 | -95.9950 | SW4 Sec.33 T29S R13E |
| KES026 | 009483 | 2000 | 2083 | CROOKED CREEK | COFFEY | 38.1192 | -95.6042 | NW4 Sec.24 T22S R16E |
| KES027 | 009484 | 2000 | 2084 | NINNESCAH RIVER | SEDGWICK | 37.5028 | -97.5364 | NE4 Sec.28 T29S R2W |
| KES028 | 009485 | 2000 | 2085 | KUENZLI CREEK | WABAUNSEE | 38.9878 | -96.1944 | SE4 Sec.21 T12S R11E |
| KES029 | 009486 | 2000 | 2086 | CEDAR CREEK | DONIPHAN | 39.8556 | -95.3158 | NW4 Sec.29 T2S R19E |
| KES030 | 009487 | 2000 | 2087 | REPUBLICAN RIVER | CLAY | 39.2994 | -97.0397 | E2 Sec.1 T9S R3E |
| KES031 | 009488 | 2000 | 2088 | WEST CREEK | REPUBLIC | 39.6708 | -97.6233 | SW4 Sec.26 T4S R3W |
| KES032 | 009489 | 2000 | 2089 | FOUR MILE CREEK | GEARY | 39.0772 | -96.8653 | SW4 Sec.22 T11S R5E |
| KES033 | 009492 | 2000 | 2092 | BANNER CREEK | JACKSON | 39.4542 | -95.7536 | SW4 Sec.9 T7S R15E |
| KES035 | 009495 | 2001 | 2124 | SOUTH FORK NINNESCAH RIVER | KINGMAN | 37.5869 | -97.9331 | NW4 Sec.25 T28S R6W |
| KES038 | 009601 | 2001 | 2101 | SPRING CREEK | COWLEY | 37.3514 | -96.5256 | SE4 Sec.16 T31S R8E |

Appendix A.3 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES039 | 009605 | 2001 | 2105 | BEAVER CREEK | CHEYENNE | 39.5989 | -101.4181 | NE4 Sec.25 T5S R37W & SE4 Sec.24 T5 |
| KES040 | 009607 | 2001 | 2107 | SAND CREEK | GRAHAM | 39.3661 | -99.9089 | SE4 Sec.8 T8S R23W |
| KES041 | 009608 | 2001 | 2108 | WEST BEAVER CREEK | SMITH | 39.9111 | -98.9614 | NE4 Sec.1 T2S R15W |
| KES042 | 009610 | 2001 | 2110 | PARSONS CREEK | WASHINGTON | 39.5819 | -97.2644 | SE4 Sec.25 T5S R1E |
| KES043 | 009611 | 2001 | 2111 | KITTEN CREEK | RILEY | 39.2203 | -96.7058 | SE4 Sec.36 T9S R6E |
| KES044 | 009612 | 2001 | 2112 | TRIB. TO NORTH COTTONWOOD | MARION | 38.5161 | -97.2767 | NW4 Sec.1 T18S R1E |
| KES045 | 009613 | 2001 | 2113 | EAST BRANCH SHARPES CREEK | CHASE | 38.2153 | -96.4514 | NE4 Sec.19 T21S R9E |
| KES046 | 009614 | 2001 | 2114 | DRAGOON CREEK | WABAUNSEE | 38.8519 | -96.1083 | NW4 Sec.8 T14S R12E |
| KES047 | 009615 | 2001 | 2115 | CROSS CREEK | POTTAWATOMIE/JACKSON | 39.2881 | -96.0350 | NW4 Sec.12 T9S R12E |
| KES048 | 009616 | 2001 | 2116 | DELAWARE RIVER TRIB. | JEFFERSON | 39.3911 | -95.5450 | SE4 Sec.32 T8S R17E |
| KES049 | 009618 | 2001 | 2118 | IANTHA CREEK | ANDERSON | 38.3586 | -95.3561 | NW4 Sec.31 T19S R19E |
| KES050 | 009619 | 2001 | 2119 | NORTH WEA CREEK TRIB. | MIAMI | 38.6667 | -94.6703 | SW4 Sec.8 T16S R25E |
| KES051 | 009620 | 2001 | 2120 | POTTAWATOMIE CREEK TRIB. | ANDERSON | 38.3450 | -95.2336 | NE4 Sec.6 T20S R20E |
| KES052 | 009621 | 2001 | 2121 | ELM CREEK | MIAMI | 38.4725 | -94.6542 | NW4 Sec.21 T18S R25E |
| KES053 | 009622 | 2001 | 2122 | CARD CREEK | MONTGOMERY | 37.2275 | -95.5850 | SE4 Sec.30 T32S R14E |
| KES054 | 009623 | 2001 | 2123 | TRIB. TO NORTH CEDAR CREEK | COWLEY | 37.1164 | -96.5392 | SW4 Sec.4 T34S R8E |
| KES055 | 009625 | 2001 | 2125 | NORTH FORK NINNESCAH RIVER | SEDGWICK | 37.6244 | -97.7378 | SE4 Sec.10 T28S R4W |

Appendix A.3 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES056 | 009626 | 2001 | 2126 | PAWNEE RIVER | PAWNEE | 38.1950 | -99.5436 | SW4 Sec.29 T21S R20W |
| KES057 | 009627 | 2001 | 2127 | SMOKY HILL RIVER | SALINE | 38.7003 | -97.5700 | SW4 Sec.32 T15S R2W |
| KES058 | 009628 | 2001 | 2128 | CHAPMAN CREEK TRIB. | DICKINSON | 39.0164 | -97.0586 | NE4 Sec.14 T12S R3E |
| KES059 | 009630 | 2001 | 2130 | NINNESCAH RIVER TRIB. | SUMNER | 37.3872 | -97.3356 | NE4 Sec.5 T31S R1E |
| KES060 | 009633 | 2001 | 2133 | SANDY CREEK | HARPER | 37.0336 | -98.2072 | NE4 Sec.5 T35S R8W |
| KES068 | 009648 | 2001 | 2148 | WHITES CREEK | CLOUD | 39.5392 | -97.8444 | NW4 Sec.14 T6S R5W |

**Appendix A.4. Locality of sites not sampled.**

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | LAT | LON | LEGAL |
|---|---|---|---|---|---|---|---|---|
| KES092 | 9452 | 2000 | KS002S | MULE CREEK | COMANCHE | 37.2582 | -99.0351 | |
| KES093 | 9464 | 2000 | KS014S | UNNAMED TRIB., BLOOD CREEK | BARTON | 38.5619 | -99.0204 | |
| KES094 | 9474 | 2000 | KS024S | KANSAS RIVER | DOUGLAS | 39.0193 | -95.2811 | |
| KES095 | 9475 | 2000 | KS025S | POTTAWATOMIE CREEK | MIAMI | 38.4853 | -94.9407 | |
| KES096 | 9477 | 2000 | KS026S | DRAGOON CREEK (A) | OSAGE | 38.7083 | -95.8037 | |
| KES097 | 9478 | 2000 | KS027S | STRANGER CREEK | LEAVENWORTH | 39.1292 | -95.0171 | |
| KES098 | 9479 | 2000 | KS028S | FISH POND CREEK | JEFFERSON | 39.2806 | -95.3681 | |
| KES099 | 9602 | 2000 | KS040S | UNNAMED TRIB., S. BR., VERDIGRIS RIVER | GREENWOOD | 38.1469 | -96.3070 | |
| KES100 | 9606 | 2000 | KS044S | DRY CREEK | HODGEMAN | 38.1790 | -99.8000 | |
| KES101 | 9609 | 2000 | KS047S | ELM CREEK (A) | CLOUD | 39.5192 | -97.5011 | |
| KES102 | (none) | 2001 | 2117 | TRIB. TO ROCK CREEK | COFFEY | 38.3753 | -95.5808 | |
| KES103 | 9629 | 2000 | KS067S | NEOSHO RIVER | MORRIS | 38.5744 | -96.3881 | |
| KES107 | (none) | 2001 | KRS-027 | WOLF CREEK | RICE | 38.5153 | -97.9561 | |

Appendix A.5. Status of reference sites sampled and attempted.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES022 | SAMPLEABLE | WADEABLE | OTH | 0 | Missouri | 10290102 | 40 | Central Irregular Plains | LOWLAND | 21 |
| KES034 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070102 | 28 | Flint Hills | LOWLAND | 26 |
| KES036 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260006 | 27 | Central Great Plains | PLAINS | 19 |
| KES037 | SAMPLEABLE | WADEABLE | OTH | 0 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 34 |
| KES061 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 28 |
| KES063 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10240011 | 47 | Western Corn Belt Plains | LOWLAND | 23 |
| KES064 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10290104 | 40 | Central Irregular Plains | LOWLAND | 8 |
| KES065 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070205 | 40 | Central Irregular Plains | LOWLAND | 7 |
| KES067 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070207 | 39 | Ozark Highlands | UPLAND | 33 |
| KES069 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11040002 | 25 | Western High Plains | PLAINS | 28 |
| KES070 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260003 | 27 | Central Great Plains | PLAINS | 8 |
| KES071 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070203 | 28 | Flint Hills | LOWLAND | 25 |
| KES072 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 22 |
| KES073 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11060005 | 27 | Central Great Plains | PLAINS | 31 |
| KES074 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 12 |
| KES075 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 16 |
| KES076 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070202 | 28 | Flint Hills | LOWLAND | 20 |

Appendix A.5 continued.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES077 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10250017 | 27 | Central Great Plains | PLAINS | 23 |
| KES078 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11060003 | 26 | Southwestern Tablelands | PLAINS | 15 |
| KES079 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11060003 | 26 | Southwestern Tablelands | PLAINS | 25 |
| KES080 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070101 | 29 | Central Oklahoma/Texas Plains | | 23 |
| KES081 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260003 | 27 | Central Great Plains | PLAINS | 8 |
| KES082 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260014 | 27 | Central Great Plains | PLAINS | 7 |
| KES083 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260006 | 27 | Central Great Plains | PLAINS | 23 |
| KES084 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10260006 | 27 | Central Great Plains | PLAINS | 22 |
| KES085 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10240005 | 47 | Western Corn Belt Plains | LOWLAND | 23 |
| KES086 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270104 | 40 | Central Irregular Plains | LOWLAND | 20 |
| KES087 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10270104 | 40 | Central Irregular Plains | LOWLAND | 18 |
| KES088 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | 13 |
| KES089 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11060003 | 26 | Southwestern Tablelands | PLAINS | 22 |
| KES090 | SAMPLEABLE | WADEABLE | REF | 0 | Missouri | 10290103 | 40 | Central Irregular Plains | LOWLAND | 31 |
| KES091 | SAMPLEABLE | WADEABLE | REF | 0 | Arkansas | 11070106 | 29 | Central Oklahoma/Texas Plains | | 18 |

## Appendix A.6. Status of random sites sampled and attempted.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER # | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES001 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11060004 | 27 | Central Great Plains | PLAINS | 15 |
| KES002 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11040007 | 26 | Southwestern Tablelands | PLAINS | 30 |
| KES003 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10250003 | 25 | Western High Plains | PLAINS | 28 |
| KES004 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260001 | 25 | Western High Plains | PLAINS | 10 |
| KES005 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260005 | 27 | Central Great Plains | PLAINS | 10 |
| KES006 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260003 | 27 | Central Great Plains | PLAINS | 21 |
| KES007 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260012 | 27 | Central Great Plains | PLAINS | 27 |
| KES008 | SAMPLEABLE | INTWADE | RAND | 472.44812 | Missouri | 10260014 | 27 | Central Great Plains | PLAINS | 10 |
| KES009 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260014 | 27 | Central Great Plains | PLAINS | 24 |
| KES010 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260007 | 27 | Central Great Plains | PLAINS | 24 |
| KES011 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260009 |  | Central Great Plains |  | 19 |
| KES012 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260010 | 27 | Central Great Plains | PLAINS | 19 |
| KES013 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260015 | 27 | Central Great Plains | PLAINS | 27 |
| KES014 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260008 | 27 | Central Great Plains | PLAINS | 25 |
| KES015 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10260008 | 27 | Central Great Plains | PLAINS | 26 |
| KES016 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11030012 | 27 | Central Great Plains | PLAINS | 9 |
| KES017 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11030012 | 27 | Central Great Plains | PLAINS | 14 |
| KES018 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11070202 | 28 | Flint Hills | LOWLAND | 27 |

Appendix A.6 continued.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER # | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES019 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11070201 | 28 | Flint Hills | LOWLAND | 28 |
| KES020 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11070204 | 40 | Central Irregular Plains | LOWLAND | 9 |
| KES021 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10300101 | 40 | Central Irregular Plains | LOWLAND | 29 |
| KES023 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10270102 | 40 | Central Irregular Plains | LOWLAND | 7 |
| KES024 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11030017 | 28 | Flint Hills | LOWLAND | 18 |
| KES025 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11070104 | 29 | Central Oklahoma/Texas Plains | | 18 |
| KES026 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11070204 | 40 | Central Irregular Plains | LOWLAND | 7 |
| KES027 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Arkansas | 11030016 | 27 | Central Great Plains | PLAINS | 10 |
| KES028 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 8 |
| KES029 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10240005 | 47 | Western Corn Belt Plains | LOWLAND | 11 |
| KES030 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10250017 | 28 | Flint Hills | LOWLAND | 15 |
| KES031 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10250017 | 27 | Central Great Plains | PLAINS | 7 |
| KES032 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10250017 | 28 | Flint Hills | LOWLAND | 23 |
| KES033 | SAMPLEABLE | WADEABLE | RAND | 472.44812 | Missouri | 10270103 | 47 | Western Corn Belt Plains | LOWLAND | 25 |
| KES035 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11030015 | 27 | Central Great Plains | PLAINS | 14 |
| KES038 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11070106 | 28 | Flint Hills | LOWLAND | 16 |
| KES039 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10250012 | 25 | Western High Plains | PLAINS | 9 |
| KES040 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10260013 | 27 | Central Great Plains | PLAINS | 25 |

Appendix A.6 continued.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER # | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES041 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10260012 | 27 | Central Great Plains | PLAINS | 22 |
| KES042 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10250017 | 27 | Central Great Plains | PLAINS | 13 |
| KES043 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10270101 | 28 | Flint Hills | LOWLAND | 8 |
| KES044 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11070202 | 27 | Central Great Plains | PLAINS | 13 |
| KES045 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11070203 | 28 | Flint Hills | LOWLAND | 21 |
| KES046 | SAMPLEABLE | INTWADE | RAND | 267.32359 | Missouri | 10290101 | 28 | Flint Hills | LOWLAND | 5 |
| KES047 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10270102 | 28 | Flint Hills | LOWLAND | 25 |
| KES048 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10270103 | 47 | Western Corn Belt Plains | LOWLAND | 19 |
| KES049 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | 9 |
| KES050 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10290102 | 40 | Central Irregular Plains | LOWLAND | 19 |
| KES051 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | 21 |
| KES052 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10290102 | 40 | Central Irregular Plains | LOWLAND | 8 |
| KES053 | SAMPLEABLE | INTWADE | RAND | 267.32359 | Arkansas | 11070103 | 40 | Central Irregular Plains | LOWLAND | 7 |
| KES054 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11070106 | 28 | Flint Hills | LOWLAND | 21 |
| KES055 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11030014 | 27 | Central Great Plains | PLAINS | 17 |
| KES056 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11030005 | 27 | Central Great Plains | PLAINS | 7 |
| KES057 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10260008 | 27 | Central Great Plains | PLAINS | 15 |
| KES058 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10260008 | 27 | Central Great Plains | PLAINS | 16 |

Appendix A.6 continued.

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER # | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES059 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11030016 | 27 | Central Great Plains | PLAINS | 3 |
| KES060 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Arkansas | 11060004 | 27 | Central Great Plains | PLAINS | 19 |
| KES068 | SAMPLEABLE | WADEABLE | RAND | 267.32359 | Missouri | 10250017 | 27 | Central Great Plains | PLAINS | 7 |

**Appendix A.7. Status of sites not sampled.**

| KES | XSTATUS | VALXSTAT | TYPE | WGT_R7 | DRAINAGE | HUC8 | ER | ER NAME | FISHREG | HDI |
|---|---|---|---|---|---|---|---|---|---|---|
| KES092 | NOACCESS | ACCDENIED | PER | 472.44812 | Arkansas | 11060002 | 26 | Southwestern Tablelands | PLAINS | |
| KES093 | NOACCESS | ACCDENIED | PER | 472.44812 | Arkansas | 11030011 | 27 | Central Great Plains | PLAINS | |
| KES094 | NONSAMPERM | NOTWADE | PER | 472.44812 | Missouri | 10270104 | 40 | Central Irregular Plains | LOWLAND | |
| KES095 | NONSAMPERM | NOTWADE | PER | 472.44812 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | |
| KES096 | NOACCESS | ACCDENIED | PER | 472.44812 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | |
| KES097 | NONSAMPERM | NOTWADE | PER | 472.44812 | Missouri | 10270104 | 40 | Central Irregular Plains | LOWLAND | |
| KES098 | NOACCESS | ACCDENIED | PER | 472.44812 | Missouri | 10270103 | 40 | Central Irregular Plains | LOWLAND | |
| KES099 | NOACCESS | ACCDENIED | PER | 267.32359 | Arkansas | 11070101 | 28 | Flint Hills | LOWLAND | |
| KES100 | NOACCESS | ACCDENIED | PER | 267.32359 | Arkansas | 11030006 | 27 | Central Great Plains | PLAINS | |
| KES101 | NOACCESS | ACCDENIED | PER | 267.32359 | Missouri | 10250017 | 27 | Central Great Plains | PLAINS | |
| KES102 | NONSAMPERM | DRYVISIT | RAND | 267.32359 | Missouri | 10290101 | 40 | Central Irregular Plains | LOWLAND | |
| KES103 | NONSAMPERM | NOTWADE | PER | 267.32359 | Arkansas | 11070201 | 28 | Flint Hills | LOWLAND | |
| KES107 | NONSAMPERM | DRYVISIT | REF | 0 | Missouri | 10260008 | 27 | Central Great Plains | PLAINS | |

**Appendix A.8. Sites from which fish samples were collected.**

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | No. | Latin Name | Common Name |
|---|---|---|---|---|---|---|---|---|
| KES001 | 9451 | 2000 | 2051 | SANDY CREEK | HARPER | 2 | Cyprinus carpio | common carp |
| KES003 | 9454 | 2000 | 2054 | SOUTH FORK REPUBLICAN RIVER | CHEYENNE | 3 | Ameiurus melas | black bullhead |
| KES004 | 9455 | 2000 | 2055 | WILLOW CREEK | WALLACE | 3 | Ameiurus melas | black bullhead |
| KES005 | 9456 | 2000 | 2056 | SOUTH BRANCH HACKBERRY CREEK | GOVE | 4 | Cyprinus carpio | common carp |
| KES007 | 9458 | 2000 | 2058 | BIG CREEK | PHILLIPS | 3 | Ameiurus melas | black bullhead |
| KES009 | 9460 | 2000 | 2060 | LOST CREEK | ROOKS | 1 | Cyprinus carpio | common carp |
| KES010 | 9461 | 2000 | 2061 | BIG CREEK | ELLIS | 3 | Cyprinus carpio | common carp |
| KES012 | 9463 | 2000 | 2063 | WEST ELKHORN CREEK | LINCOLN | 9 | Semotilus atromaculatus | creek chub |
| KES015 | 9467 | 2000 | 2067 | WEST TURKEY CREEK | DICKINSON | 2 | Catostomus commersoni | white sucker |
| KES017 | 9469 | 2000 | 2069 | SAND CREEK | HARVEY | 2 | Cyprinus carpio | common carp |
| KES022 | 9476 | 2000 | 2076 | NORTH FORK LITTLE SUGAR CREEK | LINN | 2 | Ameiurus natalis | yellow bullhead |
| KES024 | 9481 | 2000 | 2081 | BEMIS CREEK | BUTLER | 1 | Cyprinus carpio | common carp |
| KES026 | 9483 | 2000 | 2083 | CROOKED CREEK | COFFEY | 2 | Ameiurus melas | black bullhead |
| KES027 | 9484 | 2000 | 2084 | NINNESCAH RIVER | SEDGWICK | 3 | Cyprinus carpio | common carp |
| KES029 | 9486 | 2000 | 2086 | CEDAR CREEK | DONIPHAN | 2 | Ameiurus melas | black bullhead |
| KES030 | 9487 | 2000 | 2087 | REPUBLICAN RIVER | CLAY | 2 | Cyprinus carpio | common carp |
| KES031 | 9488 | 2000 | 2088 | WEST CREEK | REPUBLIC | 3 | Cyprinus carpio | common carp |
| KES033 | 9492 | 2000 | 2092 | BANNER CREEK | JACKSON | 4 | Ameiurus natalis | yellow bullhead |

Appendix A.8 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | No. | Latin Name | Common Name |
|---|---|---|---|---|---|---|---|---|
| KES034 | 9494 | 2000 | KRS-005 | OTTER CREEK | GREENWOOD | 1 | Pylodictis olivaris | flathead catfish |
| KES035 | 9495 | 2001 | 2124 | SOUTH FORK NINNESCAH RIVER | KINGMAN | 1 | Cyprinus carpio | common carp |
| KES036 | 9495 | 2000 | KRS-003 | SOUTH FORK NINNESCAH RIVER | KINGMAN | 1 | Cyprinus carpio | common carp |
| KES043 | 9611 | 2001 | 2111 | KITTEN CREEK | RILEY | 2 | Ameiurus melas | black bullhead |
| KES049 | 9618 | 2001 | 2118 | IANTHA CREEK | ANDERSON | 1 | Cyprinus carpio | common carp |
| KES055 | 9625 | 2001 | 2125 | NORTH FORK NINNESCAH RIVER | SEDGWICK | 1 | Moxostoma erythrurum | golden redhorse |
| KES056 | 9626 | 2001 | 2126 | PAWNEE RIVER | PAWNEE | 2 | Ameiurus melas | black bullhead |
| KES057 | 9627 | 2001 | 2127 | SMOKY HILL RIVER | SALINE | 1 | Ictalurus punctatus | channel catfish |
| KES058 | 9628 | 2001 | 2128 | CHAPMAN CREEK TRIB. | DICKINSON | 6 | Semotilus atromaculatus | creek chub |
| KES061 | 9641 | 2000 | KRS-006 | DEEP CREEK | RILEY | 2, 1 | Cyprinus carpio, Moxostoma macrolepidotum | common carp, shorthead redhorse |
| KES065 | 9645 | 2001 | KRS-017 | CANVILLE CREEK | NEOSHO | 2 | Ameiurus natalis | yellow bullhead |
| KES068 | 9648 | 2001 | 2148 | WHITES CREEK | CLOUD | 1 | Ameiurus melas | black bullhead |
| KES069 | 10136 | 2000 | KRS-001 | CIMARRON RIVER | MORTON | 20 | Cyprinus carpio | common carp |
| KES070 | 10137 | 2000 | KRS-002 | SMOKY HILL RIVER | LOGAN | 3 | Cyprinus carpio | common carp |
| KES071 | 10138 | 2000 | KRS-004 | SOUTH FORK COTTONWOOD RIVER | BUTLER | 2 | Ameiurus natalis | yellow bullhead |
| KES072 | 10139 | 2000 | KRS-008 | SOLDIER CREEK | JACKSON | 1 | Cyprinus carpio | common carp |
| KES073 | 10140 | 2000 | KRS-009 | CHIKASKIA RIVER | STEVENS | 1 | Cyprinus carpio | common carp |

Appendix A.8 continued.

| KES | STORET | YEAR | KDWP ID | NAME | COUNTY | No. | Latin Name | Common Name |
|---|---|---|---|---|---|---|---|---|
| KES076 | 10210 | 2001 | KRS-012 | CEDAR CREEK | CHASE | 2 | Moxostoma erythrurum | golden redhorse |
| KES077 | 10211 | 2001 | KRS-013 | WOLF CREEK | CLOUD | 7 | Semotilus atromaculatus | creek chub |
| KES078 | 10212 | 2001 | KRS-014 | THOMPSON CREEK | KIOWA | 1 | Moxostoma erythrurum | golden redhorse |
| KES079 | 10213 | 2001 | KRS-015 | TURKEY CREEK | BARBER | 2 | Ameiurus natalis | yellow bullhead |
| KES080 | 10214 | 2001 | KRS-018 | SANDY CREEK | WOODSON | 1 | Cyprinus carpio | common carp |
| KES081 | 10215 | 2001 | KRS-019 | WEST SALT CREEK | LANE | 1 | Cyprinus carpio | common carp |
| KES083 | 10217 | 2001 | KRS-021 | LANDON CREEK | RUSSELL | 2 | Ameiurus natalis | yellow bullhead |
| KES084 | 10218 | 2001 | KRS-022 | SPRING CREEK | ELLSWORTH | 3 | Ameiurus melas | black bullhead |
| KES088 | 10222 | 2001 | KRS-029 | LONG CREEK | OSAGE | 1 | Micropterus salmoides | largemouth bass |
| KES090 | 10224 | 2001 | KRS-031 | LITTLE OSAGE RIVER | BOURBON | 1 | Cyprinus carpio | common carp |
| KES091 | 10225 | 2001 | KRS-023 | CANEY RIVER | CHATAUQUA | 3 | Moxostoma macrolepidotum | shorthead redhorse |

## Appendix B. Physical and chemical parameters measured/analyzed.

**Field measurements of water chemistry and physical parameters:**

Conductivity (umhos/cm), REMAP Field Parameters
Temperature (Deg C), REMAP Field Parameters
Flow (CFS), REMAP Field Parameters
pH (SU), REMAP Field Parameters
Dissolved Oxygen (mg/L), REMAP Field Parameters

**Analytes measured in water samples:**

Organic Nitrogen (mg/L), by Calculation
Diazinon (ug/L), in Water by GC/EC
Alkalinity (bicarbonate, mg/L), in Water
Total Nitrogen (mg/L), by Calculation
Chloride (mg/L), in Water
Turbidity (NTU)
Hardness (as CaCO3, mg/L), in Water by Calculation
Silver (ug/L), Metals in Water by ICP for REMAP
Barium (ug/L), Metals in Water by ICP for REMAP
Chromium (ug/L), Metals in Water by ICP for REMAP
Copper (ug/L), Metals in Water by ICP for REMAP
Nickel (ug/L), Metals in Water by ICP for REMAP
Zinc (ug/L), Metals in Water by ICP for REMAP
Calcium (mg/L), Metals in Water by ICP for REMAP
Magnesium (mg/L), Metals in Water by ICP for REMAP
Sodium (mg/L), Metals in Water by ICP for REMAP
Potassium (mg/L), Metals in Water by ICP for REMAP
Arsenic (ug/L), in Water by AA
Cadmium (ug/L), in Water by AA
Lead in Water by AA (Lead, ug/L)
Selenium (ug/L), in Water by AA
Mercury (ug/L), in Water
Barium, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Chromium, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Copper, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Iron, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Manganese, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Nickel, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Selenium, Dissolved (ug/L), in Water by AA
Zinc, Dissolved (ug/L), Dissolved Metals in Water by ICAP for REMAP
Calcium, Dissolved (mg/L), Dissolved Metals in Water by ICAP for REMAP
Magnesium, Dissolved (mg/L), Dissolved Metals in Water by ICAP for REMAP
Arsenic, Dissolved (ug/L), in Water by AA
Cadmium, Dissolved (ug/L), in Water by AA
Lead, Dissolved (ug/L), in Water by AA
Silver, Dissolved (ug/L), in Water by AA
Mercury, Dissolved (ug/L), in Water by AA
Chlordane, technical (ug/L), REMAP Pesticides in Water by GC/EC
Alachlor (ug/L), REMAP Pesticides in Water by GC/EC

**Appendix B continued. Analytes measured in water samples:**

Propachlor (ug/L), REMAP Pesticides in Water by GC/EC
Atrazine (ug/L), REMAP Pesticides in Water by GC/EC
Trifluralin (ug/L), REMAP Pesticides in Water by GC/EC
Metolachlor (ug/L), REMAP Pesticides in Water by GC/EC
Chlorpyrifos (ug/L), REMAP Pesticides in Water by GC/EC
Ammonia, as Nitrogen (mg/L), in Water by Automated Distillation
Nitrate+Nitrite, as Nitrogen (mg/L), in Water
Total Kjeldahl Nitrogen (mg/L), in Water, Colorimetric
Total Phosphorus(mg/L), in Water, Colorimetric
Sulfate (mg/L), in Water

**Analytes measured in sediment samples:**

Decachlorobiphenyl (% Rec), REMAP Pesticides in Soil by GC/EC
Disulfoton (ug/kg), REMAP Pesticides in Soil by GC/EC
Percent Solids (%)
Total Organic Carbon (%), in Soil
Silver (mg/kg), Metals in Solids by ICP for REMAP
Barium (mg/kg), Metals in Solids by ICP for REMAP
Chromium (mg/kg), Metals in Solids by ICP for REMAP
Copper (mg/kg), Metals in Solids by ICP for REMAP
Nickel (mg/kg), Metals in Solids by ICP for REMAP
Zinc (mg/kg), Metals in Solids by ICP for REMAP
Arsenic (mg/kg), in Soil by AA
Lead (mg/kg), in Soil by AA
Selenium (mg/kg), in Solids by AA
Mercury (mg/kg), in Soil or Sediment
Cadmium (mg/kg), in Soil by AA
A-BHC (ug/kg), REMAP Pesticides in Soil by GC/EC
B-BHC (ug/kg), REMAP Pesticides in Soil by GC/EC
G-BHC (ug/kg), REMAP Pesticides in Soil by GC/EC
Aldrin (ug/kg), REMAP Pesticides in Soil by GC/EC
Dieldrin (ug/kg), REMAP Pesticides in Soil by GC/EC
Endrin (ug/kg), REMAP Pesticides in Soil by GC/EC
p,p'-DDE (ug/kg), REMAP Pesticides in Soil by GC/EC
p,p'-DDD (ug/kg), REMAP Pesticides in Soil by GC/EC
p,p'-DDT (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1016 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1221 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1232 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1242 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1248 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1254 (ug/kg), REMAP Pesticides in Soil by GC/EC
Aroclor 1260 (ug/kg), REMAP Pesticides in Soil by GC/EC
Chlordane, technical (ug/kg), REMAP Pesticides in Soil by GC/EC
Heptachlor (ug/kg), REMAP Pesticides in Soil by GC/EC
Heptachlor Epoxide (ug/kg), REMAP Pesticides in Soil by GC/EC
cis-Chlordane (ug/kg), REMAP Pesticides in Soil by GC/EC

| **Appendix B continued.  Analytes measured in sediment samples:** |
| --- |
| trans-Chlordane (ug/kg), REMAP Pesticides in Soil by GC/EC |
| cis-Nonachlor (ug/kg), REMAP Pesticides in Soil by GC/EC |
| trans-Nonachlor (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Oxychlordane (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Atrazine (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Diazinon (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Metolachlor (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Alachlor (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Chlorpyrifos (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Trifluralin (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Propachlor (ug/kg), REMAP Pesticides in Soil by GC/EC |
| Hexachlorobenzene (ug/kg), REMAP Pesticides in Soil by GC/EC |
| **Analytes measured in fish tissue samples:** |
| Arsenic (mg/kg), Metals in Fish Tissue by ICAP for REMAP |
| Cadmium (mg/kg), Metals in Fish Tissue by ICAP for REMAP |
| Lead (mg/kg), Metals in Fish Tissue by ICAP for REMAP |
| Selenium (mg/kg), Metals in Fish Tissue by ICAP for REMAP |
| Mercury (mg/kg), Mercury in Whole Fish |
| A-BHC (mg/kg), REMAP Pesticides in Fish by GC/EC |
| B-BHC (mg/kg), REMAP Pesticides in Fish by GC/EC |
| G-BHC (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aldrin (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Dieldrin (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Endrin (mg/kg), REMAP Pesticides in Fish by GC/EC |
| p,p'-DDE (mg/kg), REMAP Pesticides in Fish by GC/EC |
| p,p'-DDD (mg/kg), REMAP Pesticides in Fish by GC/EC |
| p,p'-DDT (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1016 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1221 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1232 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1242 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1248 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1254 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Aroclor 1260 (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Chlordane, technical (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Heptachlor (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Heptachlor Epoxide (mg/kg), REMAP Pesticides in Fish by GC/EC |
| cis-Chlordane (mg/kg), REMAP Pesticides in Fish by GC/EC |
| trans-Chlordane (mg/kg), REMAP Pesticides in Fish by GC/EC |
| cis-Nonachlor (mg/kg), REMAP Pesticides in Fish by GC/EC |
| trans-Nonachlor (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Oxychlordane (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Diazinon (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Disulfoton (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Chlorpyrifos (mg/kg), REMAP Pesticides in Fish by GC/EC |
| Hexachlorobenzene (mg/kg), REMAP Pesticides in Fish by GC/EC |

**Appendix C. Water, sediment, and fish tissue criteria, guidelines, and screening values.**

**Water.** Water quality standards for total recoverable analytes for Acute and Chronic Aquatic Life Use are taken from the current Kansas Surface Water Quality Standards (KDHE Bureau of Water 2004), which for most analytes reported here are identical to the National Recommended Water Quality Criteria (USEPA Office of Water 2004).

For some analytes, absolute standards apply:

| Analyte | KS ALU, Acute | KS ALUChronic |
|---|---|---|
| Diazinon (ug/L) | -- | 0.08 |
| Chloride (mg/L) | 860,000 | -- |
| Chromium (ug/L) | -- | 40 |
| Arsenic (ug/L) | 340 | 150 |
| Selenium (ug/L) | 20 | 5 |
| Mercury (ug/L) | 1.4 | 0.77 |
| Chlordane, technical (ug/L) | 2.4 | 0.0043 |
| Alachlor (ug/L) | 760 | 76 |
| Propachlor (ug/L) | -- | 8 |
| Atrazine (ug/L) | 170 | 3 |
| Chlorpyrifos (ug/L) | 0.083 | 0.041 |

For hardness-dependent metals, criteria are calculated using the following equation:

CMC or CCC = EXP[(M(LN(hardness)))-B],

where M and B are as listed in the following table:

| Analyte | Acute: M | Acute: B | Chronic: M | Chronic: B |
|---|---|---|---|---|
| Cadmium | 1.0166 | -3.924 | 0.7409 | -4.719 |
| Chromium III | .8190 | 3.7256 | 0.8190 | 0.6848 |
| Copper | 0.9422 | -1.700 | 0.8545 | -1.702 |
| Lead | 1.273 | -1.460 | 1.273 | -4.705 |
| Nickel | 0.8460 | 2.255 | 0.8460 | 0.0584 |
| Silver | 1.72 | -6.59 | -- | -- |
| Zinc | 0.8473 | 0.884 | 0.8473 | 0.884 |

The usable range for hardness is 25 to 250. At the recommendation of Ann Jacobs at EPA Region VII (pers. comm.), values below 25 were set to 25 and values over 250 set to 250 for these calculations.

For ammonia in water, the criteria are dependent on pH and Temperature:

The acute critereion or CMC (one-hour average in mg/L), where salmonid fish are not present, is:

CMC = (0.411/(10^(7.204–pH) +1)) + (58.4/(10^(pH–7.204) +1))

The chronic criterion or CCC (thirty-day average in mg/L), when fish early life stages are present, is:

CCC = [ (0.0577/(10^(7.688–pH)+1)) + (2.847/(10^(pH-7.688)+1))) ] *
[min (2.85 | (1.45*10^(0.028*(25–T))) ]

**Sediment.** Sediment quality guidelines that reflect probable effect concentrations (PECs; i.e., above which harmful effects are likely to be observed; MacDonald et al. 2000a). An asterisk (*) designates a reliable PEC (>20 samples and >75% correct classification as toxic).

| Substance | Consensus-Based PEC | |
|---|---|---|
| *Metals (in mg/kg DW)* | | |
| Arsenic | 33 | * |
| Cadmium | 4.98 | * |
| Chromium | 111 | * |
| Copper | 149 | * |
| Lead | 128 | * |
| Mercury | 1.06 | |
| Nickel | 48.6 | * |
| Zinc | 459 | * |
| *Polycyclic Aromatic Hydrocarbons (in µg/kg DW)* | | |
| Anthracene | 845 | |
| Fluorene | 536 | |
| Naphthalene | 561 | * |
| Phenanthrene | 1170 | * |
| Benz[a]anthracene | 1050 | * |
| Benzo(a)pyrene | 1450 | * |
| Chrysene | 1290 | * |
| Fluoranthene | 2230 | |
| Pyrene | 1520 | * |
| Total PAHs | 22800 | * |
| *Polychlorinated Biphenyls (in µg/kg DW)* | | * |
| Total PCBs | 676 | * |
| *Organochlorine Pesticides (in µg/kg DW)* | | * |
| Chlordane | 17.6 | |
| Dieldrin | 61.8 | |
| Sum DDD | 28 | |
| Sum DDE | 31.3 | * |
| Sum DDT | 62.90 | |
| Total DDTs | 572 | |
| Endrin | 207 | |
| Heptachlor Epoxide | 16 | |
| Lindane (gamma-BHC) | 4.99 | |

**Fish Tissue.** Values for Recreational and Subsistence fish consumption for human health are taken from the National Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories, EPA 823-B-00-07 (USEPA Office of Water 2000). The values presented are not standards or benchmarks, but rather Screening Values for Defining Green Areas, where a Green Area is defined as one in which fish may be safely consumed at unrestricted levels. These values apply to fish tissue; note that the samples collected were analyzed for whole-fish.

| ANALYTE | RECREATIONAL (in ppm) | SUBSISTENCE (in ppm) |
|---|---|---|
| Arsenic | 0.26 | 0.00387 |
| Cadmium | 4.3 | 0.58 |
| Selenium | 4.0 | 2.9 |
| Mercury | 0.4 | 0.058 |
| Lindane (Gamma-BHC) | 0.0307 | 0.00378 |
| Dieldrin | 0.0025 | 0.000307 |
| Endrin | 1.2 | 0.147 |
| Heptachlor Epoxide | 0.00439 | 0.00054 |
| Disulfoton | 0.16 | 0.019 |
| Chlorpyrifos | 1.2 | 1.147 |
| Hexachlorobenzene | 0.025 | 0.00307 |
| DDT Metabolites Sum * | *0.117* | 0.017 |
| Aroclors Sum ** | 0.02 | 0.00245 |
| Chlordane Metabolites Sum *** | 0.114 | 0.016 |

*Analytes summed for comparison to guidance:*

* p,p'-DDT + p,p'-DDE + p,p'-DDD
** Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260
*** Chlordane, technical + Heptachlor + Heptachlor Epoxide + cis-Chlordane + trans-Chlordane + cis-Nonachlor + trans-Nonachlor + Oxychlordane

**Appendix D. Description, development, and modifications of the fish IBI.**

**I. Description.** *Description of the Fish Metrics and the original 12-metric Index of Biotic Integrity, modified from a program description written by Dave Peck, Corvallis OR.*

The multimetric index of biotic integrity being developed and evaluated for use in the Region 7 R-EMAP studies currently consists of 12 metrics. Expectations for each metric were developed for three separate subregions within Region 7: The eastern lowlands (including the Flint Hills of Kansas), the western plains (including the Sand Hills of Nebraska), and the Ozark Plateau. For metrics based on the number of species, expectations are calibrated for stream size by using the $\log_{10}$ of the mean wetted stream width as a surrogate measure of size. For trophic-related metrics, expectations were based on the mean proportion from a set of hand-picked "reference" sites to provide for internal consistency in values and allow the final index to achieve the maximum possible value. For other proportional metrics, expectations were developed based on a specified percentile (generally the 90th) of the distribution of responses across all sites in a subregion.

For each metric, a score between 0 and 10 is assigned based on comparison to expectations. The final index is calculated as the sum of individual scores rescaled to range between 0 and 100.

Metrics and expectations are presented below:

1. Native Species Richness
   - Lowland: expected no. spp.= -0.0253 + 27.3492(log(mean width))
   - Plains: expected no. spp.= 6.9545 + 9.4775(log(mean width))
   - Ozarks: expected no. spp.= -2.4385 + 23.6795(log(mean width))
2. Native Family Richness
   - Lowland: expected no. families= 0.7091 + 8.0361(log(mean width))
   - Plains: expected no. families= 2.4368 + 4.4586(log(mean width))
   - Ozarks: expected no. families=-0.5131 + 7.6850(log(mean width))
3. Number of Individuals Collected
   - Lowland: expected sq. root (abundance)= -3.1424 + 49.8472(log(mean width))
   - Plains: expected sq. root (abundance)= 6.2001 + 60.7819(log(mean width))
   - Ozarks: expected sq. root (abundance)=-13.2154 + 41.2932(log(mean width))
4. Sensitive Species Richness
   - Lowland: expected no. spp.= -1.9554 + 7.3959(log(mean width))
   - Plains: expected no. spp.= 0.7894 + 1.6925(log(mean width))
   - Ozarks: expected no. spp.=-6.2363 + 13.2891(log(mean width))
5. Proportion of Tolerant Individuals
   - Lowland: <=15%
   - Plains: <=20%
   - Ozarks: 0%
6. Number of Native Benthic Species (including round bodied suckers)
   - Lowland: expected no. spp.= -0.6077 + 9.2836(log(mean width))
   - Plains: expected no. spp.= 1.2953 + 4.0517(log(mean width))
   - Ozarks: expected no. spp.= -1.3343 + 8.8601(log(mean width))

7. Number of Native Water Column Species
   - Lowland: expected no. spp.= -1.4780 + 13.9873(log(mean width))
   - Plains: expected no. spp.= 2.0215 + 3.9725(log(mean width))
   - Ozarks: expected no. spp.=-8.8290 + 18.6853(log(mean width))
8. Number of [Native] Long-lived species (expected life span of at least 4 years)
   - Lowland: expected no. spp.= -1.9364 + 18.8643(log(mean width))
   - Plains: expected no. spp.= 2.7958 + 5.5702(log(mean width))
   - Ozarks: expected no. spp.=-7.3159 + 18.5809(log(mean width))
9. Proportion of Individuals of Introduced Species
   - All Subregions: 0%
10. Proportion of Individuals as Carnivores
    - Lowland: >=15%
    - Plains: >=25%
    - Ozarks: >=20%
11. Proportion of Individuals as Insectivores and Invertivores
    - Lowland: >=55%
    - Plains: >=50%
    - Ozarks: >=50%
12. Proportion of Individuals as Omnivores and Herbivores
    - Lowland: <=25%
    - Plains: <=25%
    - Ozarks: <=30%

**II. Development of the IBI.** *Description of the Fish IBI Development – summarized from electronic correspondence received from Dave Peck, Corvallis OR.*

The fish regions were developed for Region VII (Kansas, Iowa, Nebraska, Missouri) based on knowledge of fish zoogeography and ancestral drainages in this part of the country, coupled with existing ecoregion boundaries. The Kansas Flint Hills and Nebraska Sand Hills presented some difficulty with their unique characteristics, but there were not enough sites to treat them as independent regions. The Missouri Ozarks also had a small number of sites, but were treated as an independent region based on the high number of endemics.

The reference sites did not play a direct role in selection criteria for IBI scores, but they were included along with the random sites in the metric evaluation process. Each possible metric was subjected to a series of tests:

- Range test (dropped metrics with a small range, or with a large range but a high proportion of “zero” scores)
- Signal:noise test comparing among-site variance to repeat-site variance. (dropped metrics that could not distinguish between sites)
- Spearman rank correlations with scatterplots of metric vs. known stressors such as nutrients, substrate, riparian cover, etc. (dropped metrics that showed no linear correlations or other visible relationships to any stressors)

Consideration was also given to including a number of different types of metrics, i.e., taxon richness, tolerance, feeding guilds, etc. Most metrics were scored on a linear scale using combined data from all sites (both random and reference) in a given region. The 90th percentile was the cutoff for scoring a 10; the 80th for scoring a 9, and so on. For negative metrics the relationship was reversed. An exception was for trophic metrics. In this case, reference sites were used to provide an "expected" proportion (=mean) of piscivores, invertivores, etc, since these are internally consistent and must sum to 100%. So a "reference" stream might have the following trophic composition: 15% piscivores, 50% invertivores, and 30% omnivores. With this approach, the metrics do not presume that "more is better," but addresses more of a "trophic balance" (or lack thereof). Each metric is identified in parentheses as “positive” (+) or “negative” (–).

1. Native Species Richness (+)
2. Native Family Richness (+)
3. Number of Individuals Collected (+)
4. Sensitive Species Richness (+)
5. Proportion of Tolerant Individuals (–)
6. Number of Native Benthic Species (including round bodied suckers) (+)
7. Number of Native Water Column Species (+)
8. Number of Long-lived species (expected life span of at least 4 years) (+)
9. Proportion of Individuals of Introduced Species (–)
10. Proportion of Individuals as Carnivores (+)
11. Proportion of Individuals as Insectivores and Invertivores (+)
12. Proportion of Individuals as Omnivores and Herbivores (–)

**III. Modifications of the IBI.** *Peck has produced two derivative versions of the original 12-metric IBI. One has 11 metrics and one has 8. In each case, the metrics (each scaled 0–10) are summed, multiplied by 10, and divided by the number of metrics used so that the final scale ranges from 0 to 100. The eight-metric IBI is the one used in this report.*

| Metric | 12-m IBI | 11-m IBI | 8-m IBI |
|---|---|---|---|
| 1. Native Species Richness | X | X | X |
| 2. Native Family Richness | X | X | X |
| 3. Number of Individuals Collected | X | X | – |
| 4. Sensitive Species Richness | X | X | X |
| 5. Proportion of Tolerant Individuals | X | X | X |
| 6. Number of Native Benthic Species | X | X | X |
| 7. Number of Native Water Column Species | X | X | – |
| 8. Number of Long-lived species | X | X | X |
| 9. Proportion of Individuals of Introduced Species | X | X | X |
| 10. Proportion of Individuals as Carnivores | X | X | X |
| 11. Proportion of Individuals as Insectivores and Invertivores | X | – | – |
| 12. Proportion of Individuals as Omnivores and Herbivores | X | X | – |

**Appendix E. Water chemistry, sediment chemistry, and fish tissue chemistry summary from reference sites.**

There were 30 reference sites in all, but not every site was analyzed for every parameter. The first column after the analyte name shows how many samples were analyzed. Nondetects are “truly” low values, known to be somewhere between zero (analyte not present in sample) and the reporting limit. The values assigned to nondetects here are the reporting limits, but reporting limits were not necessarily uniform from one sample to the next – especially for sediment chemistry. This can lead to difficulties in interpretation of results, and in this dataset, it does. For a given analyte, the range of “reporting limit” values assigned to nondetects in a number of cases overlapped with the range of “real” measured values. The table below shows summary statistics for the “whole” population (including nondetects); this is an estimate of the analyte levels in the reference population as a whole. The table also shows summary statistics for the “measured” population (excluding nondetects); this more certain number represents the analyte levels ONLY for that subset of the population in which the analyte was measurably present. Note that if all data were nondetect or all were detect, there are values only in one half of the row. Note also that data for analyte HF02 (Conductivity) were discarded.

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WA10 | Organic Nitrogen (mg/L), by Calculation | 30 | 0.08 | 0.22 | 0.56 | 0.76 | 1.55 | 0.57 | 0.40 | 24 | 0.10 | 0.48 | 0.63 | 0.83 | 1.55 | 0.68 | 0.36 | 6 |
| WC33 | Diazinon (ug/L), in Water | 29 | 0.03 | 0.03 | 0.40 | 0.40 | 0.40 | 0.29 | 0.17 | 0 | | | | | | | | 29 |
| WF01 | Temperature (Deg C), REMAP Field Parameters | 30 | | | | | | | | 30 | 13.60 | 22.00 | 24.00 | 25.50 | 28.00 | 23.41 | 3.34 | 0 |
| WF04 | Flow (CFS), REMAP Field Parameters | 29 | | | | | | | | 29 | 0.00 | 0.00 | 0.98 | 6.20 | 284.30 | 17.37 | 56.31 | 0 |
| WF05 | pH (SU), REMAP Field Parameters | 30 | | | | | | | | 30 | 7.80 | 8.10 | 8.35 | 8.50 | 8.80 | 8.31 | 0.26 | 0 |
| WG03 | Alkalinity (bicarbonate, mg/L), in Water | 30 | | | | | | | | 30 | 75.90 | 175.00 | 206.00 | 269.00 | 466.00 | 224.43 | 80.20 | 0 |
| WG11 | Total Nitrogen (mg/L), by Calculation | 30 | | | | | | | | 30 | 0.09 | 0.60 | 0.75 | 1.96 | 8.28 | 1.55 | 1.74 | 0 |
| WG12 | Chloride (mg/L), in Water | 30 | | | | | | | | 30 | 3.70 | 6.80 | 15.55 | 48.70 | 364.00 | 55.74 | 91.28 | 0 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WG17 | Dissolved Oxygen (mg/L), REMAP Field Parameters | 30 | | | | | | | | 30 | 3.10 | 4.70 | 6.40 | 8.10 | 10.70 | 6.32 | 1.92 | 0 |
| WG30 | Turbidity (NTU) | 30 | 0.60 | 1.00 | 4.95 | 10.90 | 41.50 | 7.50 | 8.28 | 26 | 0.60 | 2.70 | 6.95 | 11.40 | 41.50 | 8.50 | 8.47 | 4 |
| WG31 | Hardness (as CaCO3, mg/L), in Water by Calculation | 30 | | | | | | | | 30 | 81.60 | 186.00 | 250.50 | 359.00 | 1040.00 | 312.32 | 205.21 | 0 |
| WM01 | Silver (ug/L), in Water | 30 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 | 0.00 | 0 | | | | | | | | 30 |
| WM04 | Barium (ug/L), in Water | 30 | | | | 168.00 | | | | 30 | 56.10 | 99.30 | 126.00 | 168.00 | 309.00 | 146.05 | 71.73 | 0 |
| WM08 | Chromium (ug/L), in Water | 30 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 15.00 | 0.00 | 0 | | | | | | | | 30 |
| WM09 | Copper (ug/L), in Water | 30 | 5.00 | 5.00 | 5.00 | 5.00 | 6.28 | 5.20 | 0.42 | 6 | 5.66 | 5.85 | 6.02 | 6.25 | 6.28 | 6.01 | 0.24 | 24 |
| WM13 | Nickel (ug/L), in Water | 30 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 0.00 | 0 | | | | | | | | 30 |
| WM20 | Zinc (ug/L), in Water | 30 | 25.00 | 25.00 | 25.00 | 46.50 | 172.00 | 42.09 | 31.96 | 13 | 28.40 | 42.30 | 51.90 | 75.80 | 172.00 | 64.45 | 38.90 | 17 |
| WM21 | Calcium (mg/L), in Water | 30 | | | | | | | | 30 | 26.00 | 62.60 | 74.15 | 101.00 | 300.00 | 90.95 | 57.17 | 0 |
| WM22 | Magnesium (mg/L), in Water | 30 | | | | | | | | 30 | 3.00 | 8.91 | 13.85 | 22.40 | 86.50 | 20.75 | 20.71 | 0 |
| WM23 | Sodium (mg/L), in Water | 30 | | | | | | | | 30 | 7.50 | 10.00 | 16.45 | 54.40 | 271.00 | 50.71 | 68.64 | 0 |
| WM24 | Potassium (mg/L), in Water | 30 | 2.00 | 2.47 | 3.38 | 6.64 | 23.60 | 5.28 | 4.84 | 27 | 2.21 | 2.59 | 3.56 | 7.87 | 23.60 | 5.64 | 4.97 | 3 |
| WM27 | Arsenic (ug/L), in Water | 30 | 2.00 | 2.00 | 2.00 | 3.54 | 14.80 | 3.53 | 3.01 | 12 | 2.18 | 3.23 | 4.53 | 7.57 | 14.80 | 5.84 | 3.78 | 18 |
| WM28 | Cadmium (ug/L), in Water | 30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0 | | | | | | | | 30 |
| WM30 | Lead in Water (Lead, ug/L) | 30 | 1.00 | 1.93 | 2.77 | 4.61 | 13.30 | 3.71 | 2.60 | 28 | 1.44 | 2.11 | 2.93 | 5.11 | 13.30 | 3.90 | 2.59 | 2 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM32 | Selenium (ug/L), in Water | 30 | 2.00 | 2.00 | 2.00 | 2.00 | 3.14 | 2.12 | 0.30 | 5 | 2.38 | 2.51 | 2.69 | 2.96 | 3.14 | 2.74 | 0.31 | 25 |
| WM34 | Mercury (ug/L), in Water | 30 | 0.10 | 0.10 | 0.20 | 0.20 | 0.58 | 0.18 | 0.09 | 1 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | | 29 |
| WM38 | Barium, Dissolved (ug/L), in Water | 28 | | | | . | | | | 28 | 47.90 | 98.80 | 129.00 | 162.00 | 316.00 | 141.32 | 65.55 | 0 |
| WM42 | Chromium, Dissolved (ug/L), in Water | 28 | 4.00 | 4.00 | 4.00 | 4.00 | 13.50 | 4.36 | 1.79 | 2 | 4.47 | 4.47 | 8.99 | 13.50 | 13.50 | 8.99 | 6.39 | 26 |
| WM43 | Copper, Dissolved (ug/L), in Water | 28 | 2.00 | 2.00 | 2.00 | 2.00 | 4.71 | 2.10 | 0.51 | 2 | 2.19 | 2.19 | 3.45 | 4.71 | 4.71 | 3.45 | 1.78 | 26 |
| WM44 | Iron, Dissolved (ug/L), in Water | 28 | 29.00 | 29.00 | 29.00 | 29.00 | 51.80 | 30.30 | 4.66 | 3 | 32.60 | 32.60 | 39.10 | 51.80 | 51.80 | 41.17 | 9.77 | 25 |
| WM45 | Manganese, Dissolved (ug/L), in Water | 28 | 2.00 | 10.70 | 39.10 | 71.45 | 266.00 | 57.59 | 66.98 | 27 | 2.31 | 10.70 | 41.30 | 72.60 | 266.00 | 59.64 | 67.35 | 1 |
| WM47 | Nickel, Dissolved (ug/L), in Water | 28 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 0.00 | 0 | | | | | | | | 28 |
| WM50 | Selenium, Dissolved (ug/L), in Water | 28 | 2.00 | 2.00 | 2.00 | 2.00 | 18.80 | 2.65 | 3.17 | 4 | 2.37 | 2.41 | 2.48 | 10.66 | 18.80 | 6.53 | 8.18 | 24 |
| WM54 | Zinc, Dissolved (ug/L), in Water | 28 | 4.00 | 4.00 | 7.49 | 17.80 | 58.20 | 13.19 | 13.33 | 16 | 5.86 | 10.57 | 14.65 | 27.05 | 58.20 | 20.08 | 14.21 | 12 |
| WM55 | Calcium, Dissolved (mg/L), in Water | 28 | | | | | | | | 28 | 25.90 | 54.65 | 71.15 | 88.15 | 215.00 | 82.14 | 43.20 | 0 |
| WM56 | Magnesium, Dissolved (mg/L), in Water | 28 | | | | | | | | 28 | 3.09 | 6.58 | 14.05 | 19.90 | 67.90 | 16.74 | 14.03 | 0 |
| WM60 | Arsenic, Dissolved (ug/L), in Water | 28 | 2.00 | 2.00 | 2.00 | 2.45 | 9.02 | 2.82 | 1.87 | 8 | 2.07 | 3.12 | 3.96 | 6.92 | 9.02 | 4.89 | 2.58 | 20 |
| WM61 | Cadmium, Dissolved (ug/L), in Water | 28 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0 | | | | | | | | 28 |
| WM63 | Lead, Dissolved (ug/L), in Water | 28 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0 | | | | | | | | 28 |
| WM65 | Silver, Dissolved (ug/L), in Water | 28 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0 | | | | | | | | 28 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WM68 | Mercury, Dissolved (ug/L), in Water | 28 | 0.10 | 0.10 | 0.20 | 0.20 | 7.29 | 0.42 | 1.35 | 1 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | 7.29 | | 27 |
| WP24 | Chlordane, technical (ug/L), Pesticides in Water | 29 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0 | | | | | | | | 29 |
| WP27 | Alachlor (ug/L), Pesticides in Water | 29 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0 | | | | | | | | 29 |
| WP28 | Propachlor (ug/L), Pesticides in Water | 29 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0 | | | | | | | | 29 |
| WP31 | Atrazine (ug/L), Pesticides in Water | 29 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 0.00 | 0 | | | | | | | | 29 |
| WP32 | Trifluralin (ug/L), Pesticides in Water | 29 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0 | | | | | | | | 29 |
| WP43 | Metolachlor (ug/L), Pesticides in Water | 29 | 0.05 | 0.05 | 0.50 | 0.50 | 0.50 | 0.36 | 0.21 | 0 | | | | | | | | 29 |
| WQ02 | Chlorpyrifos (ug/L), Pesticides in Water | 29 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.00 | 0 | | | | | | | | 29 |
| WT01 | Ammonia, as Nitrogen (mg/L), in Water | 30 | 0.06 | 0.06 | 0.10 | 0.10 | 0.65 | 0.18 | 0.22 | 3 | 0.08 | 0.08 | 0.08 | 0.13 | 0.13 | 0.10 | 0.03 | 27 |
| WT02 | Nitrate+Nitrite, as Nitrogen (mg/L), in Water | 30 | 0.03 | 0.03 | 0.10 | 1.73 | 7.93 | 0.99 | 1.76 | 21 | 0.03 | 0.09 | 0.38 | 2.34 | 7.93 | 1.41 | 1.97 | 9 |
| WT03 | Total Kjeldahl Nitrogen (mg/L), in Water | 30 | 0.08 | 0.22 | 0.56 | 0.76 | 1.55 | 0.58 | 0.41 | 25 | 0.10 | 0.48 | 0.63 | 0.78 | 1.55 | 0.67 | 0.38 | 5 |
| WT04 | Total Phosphorus (mg/L), in Water | 30 | 0.02 | 0.10 | 0.10 | 0.14 | 0.33 | 0.13 | 0.08 | 11 | 0.03 | 0.08 | 0.12 | 0.28 | 0.33 | 0.16 | 0.11 | 19 |
| WT12 | Sulfate (mg/L), in Water | 30 | | | | | | | | 30 | 8.60 | 21.20 | 40.60 | 72.30 | 840.00 | 131.06 | 217.97 | 0 |
| HP39 | Decachlorobiphenyl (% Rec), Pesticides in Sediment | 2 | | | | | | | | 2 | 82.10 | 82.10 | 97.05 | 112.00 | 112.00 | 97.05 | 21.14 | 0 |
| SC30 | Disulfoton (ug/kg), Pesticides in | 30 | 12.00 | 14.00 | 19.00 | 88.00 | 400.00 | 67.89 | 89.14 | 0 | | | | | | | | 30 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment | | | | | | | | | | | | | | | | | |
| SG07 | Percent Solids (%) | 30 | | | | | | | | 30 | 34.10 | 58.50 | 68.25 | 73.10 | 83.60 | 65.73 | 11.09 | 0 |
| SG31 | Total Organic Carbon (%), in Sediment | 30 | 0.09 | 0.12 | 0.57 | 1.30 | 3.30 | 0.90 | 0.90 | 23 | 0.11 | 0.51 | 0.77 | 1.70 | 3.30 | 1.14 | 0.90 | 7 |
| SM01 | Silver (mg/kg), Metals in Sediment | 30 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 0.00 | 0 | | | | | | | | 30 |
| SM04 | Barium (mg/kg), Metals in Sediment | 30 | | | | | | | | 30 | 18.30 | 76.70 | 100.50 | 140.00 | 347.00 | 114.19 | 67.61 | 0 |
| SM08 | Chromium (mg/kg), Metals in Sediment | 30 | 1.75 | 6.05 | 9.70 | 14.70 | 20.50 | 10.02 | 5.82 | 28 | 1.75 | 6.57 | 10.05 | 15.35 | 20.50 | 10.60 | 5.60 | 2 |
| SM09 | Copper (mg/kg), Metals in Sediment | 30 | 1.00 | 4.57 | 6.56 | 9.16 | 13.10 | 6.66 | 3.30 | 27 | 1.82 | 5.29 | 6.88 | 9.69 | 13.10 | 7.22 | 2.98 | 3 |
| SM13 | Nickel (mg/kg), Metals in Sediment | 30 | 2.00 | 9.03 | 10.25 | 16.00 | 22.10 | 11.55 | 5.59 | 28 | 2.26 | 9.20 | 10.70 | 16.15 | 22.10 | 12.23 | 5.13 | 2 |
| SM20 | Zinc (mg/kg), Metals in Sediment | 30 | 5.00 | 24.30 | 31.95 | 45.10 | 437.00 | 45.46 | 75.20 | 28 | 5.55 | 26.10 | 33.70 | 45.45 | 437.00 | 48.34 | 77.10 | 2 |
| SM27 | Arsenic (mg/kg), in Sediment | 30 | 0.50 | 2.51 | 3.45 | 7.07 | 11.10 | 4.68 | 2.87 | 27 | 0.67 | 2.81 | 4.59 | 7.30 | 11.10 | 5.03 | 2.79 | 3 |
| SM30 | Lead (mg/kg), in Sediment | 30 | 0.50 | 0.71 | 2.30 | 5.08 | 29.80 | 4.62 | 6.24 | 25 | 0.52 | 1.80 | 2.55 | 9.33 | 29.80 | 5.45 | 6.54 | 5 |
| SM32 | Selenium (mg/kg), in Sediment | 30 | 0.50 | 0.50 | 0.50 | 0.50 | 0.82 | 0.52 | 0.07 | 2 | 0.75 | 0.75 | 0.78 | 0.82 | 0.82 | 0.78 | 0.05 | 28 |
| SM34 | Mercury (mg/kg), in Sediment | 30 | 0.00 | 0.00 | 0.01 | 0.02 | 0.04 | 0.01 | 0.01 | 22 | 0.00 | 0.01 | 0.01 | 0.02 | 0.04 | 0.01 | 0.01 | 8 |
| SM57 | Cadmium (mg/kg), in Sediment | 30 | 0.05 | 0.13 | 0.26 | 0.51 | 500.00 | 17.08 | 91.21 | 24 | 0.06 | 0.20 | 0.32 | 0.58 | 3.51 | 0.51 | 0.69 | 6 |
| SP01 | A-BHC (ug/kg), Pesticides in Sediment | 30 | 0.60 | 0.81 | 0.88 | 1.10 | 5.30 | 1.17 | 0.92 | 0 | | | | | | | | 30 |
| SP02 | B-BHC (ug/kg), Pesticides in Sediment | 30 | 2.00 | 2.70 | 2.95 | 3.50 | 18.00 | 3.92 | 3.13 | 0 | | | | | | | | 30 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP04 | G-BHC (ug/kg), Pesticides in Sediment | 30 | 0.80 | 0.99 | 1.10 | 1.30 | 6.30 | 1.46 | 1.13 | 0 | | | | | | | | 30 |
| SP05 | Aldrin (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.60 | 1.75 | 2.10 | 11.00 | 2.35 | 1.91 | 0 | | | | | | | | 30 |
| SP06 | Dieldrin (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.60 | 1.75 | 2.10 | 11.00 | 2.35 | 1.91 | 0 | | | | | | | | 30 |
| SP10 | Endrin (ug/kg), Pesticides in Sediment | 30 | 1.60 | 2.10 | 2.35 | 2.80 | 14.00 | 3.11 | 2.44 | 0 | | | | | | | | 30 |
| SP13 | p,p-DDE (ug/kg), Pesticides in Sediment | 30 | 2.00 | 2.70 | 2.95 | 3.50 | 18.00 | 3.92 | 3.13 | 0 | | | | | | | | 30 |
| SP14 | p,p-DDD (ug/kg), Pesticides in Sediment | 30 | 1.60 | 2.10 | 2.35 | 2.80 | 14.00 | 3.11 | 2.44 | 0 | | | | | | | | 30 |
| SP15 | p,p-DDT (ug/kg), Pesticides in Sediment | 30 | 2.00 | 2.70 | 2.95 | 3.50 | 18.00 | 3.92 | 3.13 | 0 | | | | | | | | 30 |
| SP17 | Aroclor 1016 (ug/kg), Pesticides in Sediment | 30 | 40.00 | 54.00 | 58.50 | 70.00 | 350.00 | 77.92 | 61.08 | 0 | | | | | | | | 30 |
| SP18 | Aroclor 1221 (ug/kg), Pesticides in Sediment | 30 | 40.00 | 60.00 | 71.00 | 88.00 | 440.00 | 90.39 | 74.06 | 0 | | | | | | | | 30 |
| SP19 | Aroclor 1232 (ug/kg), Pesticides in Sediment | 30 | 24.00 | 29.00 | 37.00 | 54.60 | 200.00 | 52.99 | 44.35 | 0 | | | | | | | | 30 |
| SP20 | Aroclor 1242 (ug/kg), Pesticides in Sediment | 30 | 24.00 | 29.00 | 37.00 | 54.60 | 200.00 | 52.99 | 44.35 | 0 | | | | | | | | 30 |
| SP21 | Aroclor 1248 (ug/kg), Pesticides in Sediment | 30 | 40.00 | 54.00 | 58.50 | 70.00 | 350.00 | 78.05 | 61.17 | 0 | | | | | | | | 30 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP22 | Aroclor 1254 (ug/kg), Pesticides in Sediment | 30 | 20.00 | 27.00 | 29.50 | 35.00 | 180.00 | 39.16 | 31.29 | 0 | | | | | | | | 30 |
| SP23 | Aroclor 1260 (ug/kg), Pesticides in Sediment | 30 | 20.00 | 27.00 | 29.50 | 35.00 | 180.00 | 39.16 | 31.29 | 0 | | | | | | | | 30 |
| SP24 | Chlordane, technical (ug/kg), Pesticides in Sediment | 30 | 7.20 | 8.10 | 9.55 | 12.00 | 53.00 | 13.09 | 10.17 | 0 | | | | | | | | 30 |
| SP25 | Heptachlor (ug/kg), Pesticides in Sediment | 30 | 0.95 | 1.10 | 1.30 | 1.64 | 7.00 | 1.83 | 1.44 | 0 | | | | | | | | 30 |
| SP26 | Heptachlor Epoxide (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.60 | 1.75 | 2.10 | 11.00 | 2.35 | 1.91 | 0 | | | | | | | | 30 |
| SP27 | cis-Chlordane (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 3.40 | 4.00 | 21.00 | 3.84 | 3.53 | 0 | | | | | | | | 30 |
| SP28 | trans-Chlordane (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 3.40 | 4.00 | 21.00 | 3.84 | 3.53 | 0 | | | | | | | | 30 |
| SP29 | cis-Nonachlor (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 3.40 | 4.00 | 21.00 | 3.84 | 3.53 | 0 | | | | | | | | 30 |
| SP30 | trans-Nonachlor (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 3.40 | 4.00 | 21.00 | 3.84 | 3.53 | 0 | | | | | | | | 30 |
| SP31 | Oxychlordane (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 3.40 | 4.00 | 21.00 | 3.84 | 3.53 | 0 | | | | | | | | 30 |
| SP45 | Atrazine (ug/kg), Pesticides in Sediment | 30 | 72.00 | 86.00 | 115.00 | 164.00 | 600.00 | 158.57 | 132.07 | 0 | | | | | | | | 30 |
| SP52 | Diazinon (ug/kg), Pesticides in Sediment | 30 | 16.00 | 25.70 | 55.00 | 67.00 | 350.00 | 61.46 | 59.62 | 0 | | | | | | | | 30 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP67 | Metolachlor (ug/kg), Pesticides in Sediment | 30 | 20.00 | 27.00 | 29.50 | 35.00 | 180.00 | 39.16 | 31.29 | 0 | | | | | | | | 30 |
| SP68 | Alachlor (ug/kg), Pesticides in Sediment | 30 | 6.00 | 8.19 | 9.35 | 11.00 | 63.00 | 15.12 | 15.43 | 0 | | | | | | | | 30 |
| SP86 | Chlorpyrifos (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.40 | 1.90 | 2.73 | 10.00 | 2.65 | 2.20 | 0 | | | | | | | | 30 |
| SQ16 | Trifluralin (ug/kg), Pesticides in Sediment | 30 | 1.20 | 1.93 | 4.10 | 5.00 | 26.00 | 4.59 | 4.42 | 0 | | | | | | | | 30 |
| SQ19 | Propachlor (ug/kg), Pesticides in Sediment | 30 | 8.00 | 10.90 | 11.60 | 14.00 | 70.00 | 15.54 | 12.22 | 0 | | | | | | | | 30 |
| SS48 | Hexachlorobenzene (ug/kg), Pesticides in Sediment | 30 | 0.40 | 0.64 | 1.40 | 1.70 | 8.80 | 1.54 | 1.50 | 1 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | | 29 |
| TM03 | Arsenic (mg/kg), Metals in Fish Tissue | 23 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.00 | 0 | | | | | | | | 23 |
| TM06 | Cadmium (mg/kg), Metals in Fish Tissue | 23 | 0.06 | 0.06 | 0.06 | 0.07 | 0.16 | 0.07 | 0.03 | 6 | 0.07 | 0.07 | 0.10 | 0.15 | 0.16 | 0.11 | 0.04 | 17 |
| TM14 | Lead (mg/kg), Metals in Fish Tissue | 23 | 0.17 | 0.17 | 0.17 | 0.17 | 0.21 | 0.17 | 0.01 | 1 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | | 22 |
| TM16 | Selenium (mg/kg), Metals in Fish Tissue | 23 | 0.54 | 0.82 | 1.17 | 1.35 | 2.58 | 1.24 | 0.51 | 23 | 0.54 | 0.82 | 1.17 | 1.35 | 2.58 | 1.24 | 0.51 | 0 |
| TM34 | Mercury (mg/kg), Mercury in Whole Fish | 23 | 0.02 | 0.04 | 0.05 | 0.07 | 0.12 | 0.06 | 0.03 | 20 | 0.02 | 0.05 | 0.06 | 0.08 | 0.12 | 0.06 | 0.03 | 3 |
| TP01 | A-BHC (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | | | | | | | | 23 |
| TP02 | B-BHC (mg/kg), Pesticides in Fish | 23 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP04 | G-BHC (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | | | | | | | | 23 |

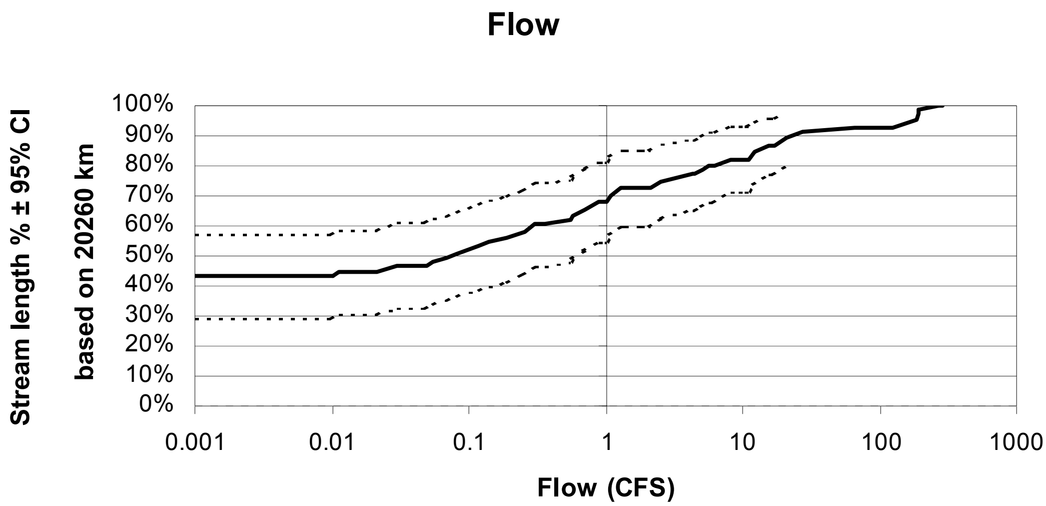
| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP05 | Aldrin (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP06 | Dieldrin (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 2 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 21 |
| TP10 | Endrin (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP13 | p,p-DDE (ug/kg), Pesticides in Fish | 23 | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 2 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.03 | 0.02 | 21 |
| TP14 | p,p-DDD (ug/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 22 |
| TP15 | p,p-DDT (ug/kg), Pesticides in FIsh | 23 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP17 | Aroclor 1016 (mg/kg), Pesticides in Fish | 23 | 0.10 | 0.10 | 0.10 | 0.20 | 0.20 | 0.14 | 0.05 | 0 | | | | | | | | 23 |
| TP18 | Aroclor 1221 (mg/kg), Pesticides in Fish | 23 | 0.05 | 0.05 | 0.05 | 0.25 | 0.25 | 0.12 | 0.10 | 0 | | | | | | | | 23 |
| TP19 | Aroclor 1232 (mg/kg), Pesticides in Fish | 23 | 0.08 | 0.08 | 0.08 | 0.10 | 0.16 | 0.09 | 0.02 | 0 | | | | | | | | 23 |
| TP20 | Aroclor 1242 (mg/kg), Pesticides in Fish | 23 | 0.04 | 0.04 | 0.04 | 0.10 | 0.10 | 0.06 | 0.03 | 0 | | | | | | | | 23 |
| TP21 | Aroclor 1248 (mg/kg), Pesticides in Fish | 23 | 0.04 | 0.04 | 0.04 | 0.20 | 0.20 | 0.10 | 0.08 | 0 | | | | | | | | 23 |
| TP22 | Aroclor 1254 (mg/kg), Pesticides in Fish | 23 | 0.03 | 0.03 | 0.03 | 0.10 | 0.16 | 0.07 | 0.05 | 0 | | | | | | | | 23 |
| TP23 | Aroclor 1260 (mg/kg), Pesticides in Fish | 23 | 0.02 | 0.02 | 0.02 | 0.10 | 0.10 | 0.05 | 0.04 | 0 | | | | | | | | 23 |
| TP24 | Chlordane, technical (mg/kg), Pesticides in Fish | 23 | 0.03 | 0.03 | 0.03 | 0.03 | 0.06 | 0.03 | 0.01 | 0 | | | | | | | | 23 |
| TP25 | Heptachlor (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0 | | | | | | | | 23 |
| TP26 | Heptachlor Epoxide (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0 | | | | | | | | 23 |

| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all | n-detect | min-detect | p25-detect | p50-detect | p75-detect | max-detect | mean-detect | stdev-detect | n-nondetects |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP27 | cis-Chlordane (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP28 | trans-Chlordane (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP29 | cis-Nonachlor (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0 | | | | | | | | 23 |
| TP30 | trans-Nonachlor (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21 |
| TP32 | Oxychlordane (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0 | | | | | | | | 23 |
| TP35 | Diazinon (mg/kg), Pesticides in Fish | 8 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 | 0 | | | | | | | | 8 |
| TP36 | Disulfoton (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.10 | 0.10 | 0.20 | 0.07 | 0.06 | 0 | | | | | | | | 23 |
| TP47 | Chlorpyrifos (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | | | | | | | | 23 |
| TP76 | Hexachlorobenzene (mg/kg), Pesticides in Fish | 23 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 22 |

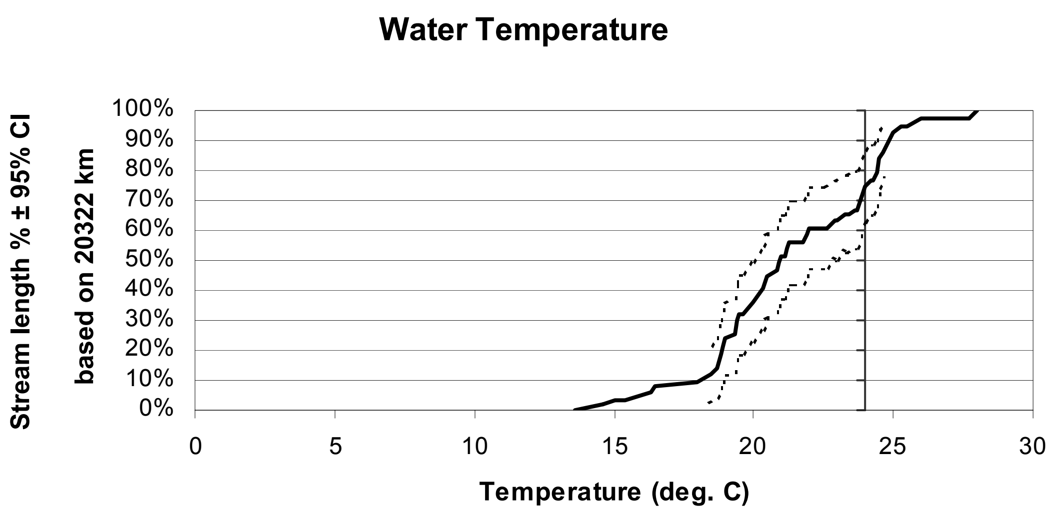
**Appendix F. Analytes in water: physical parameters, general chemistry, metals, and biocides.**

Two populations are represented in the following graphs and summaries: reference sites, and randomly selected sites. Nondetects are included as their reporting limit for both random and reference datasets. For each analyte, the Cumulative Distribution Function (CDF) graph represents the expected distribution of values in Kansas wadeable streams, as derived from random sites. The vertical bar superimposed on the CDF represents the median value from the reference population. The CDF is represented by a solid line, with dotted lines showing its 95% confidence limits. Not every analyte was measured for every site; a value on the y-axis shows the number of Kansas wadeable stream kilometers to which the CDF estimate applies, and a note below indicates the number of km represented by detect (measured) versus nondetect (reporting-limit) values. For reference-site medians, a solid bar indicates that more than half of the values were *measured reported* values, whereas a dotted bar indicates that at least half of the values are reporting limits derived from *nondetects*. This gives some indication of the "trustworthiness" of the measure. In cases for which there are two or fewer distinct values in the random population, a CDF is not plotted, and only the maximum value is reported (as text).

## ANALYTES IN WATER:
## PHYSICAL PARAMETERS AND GENERAL CHEMISTRY

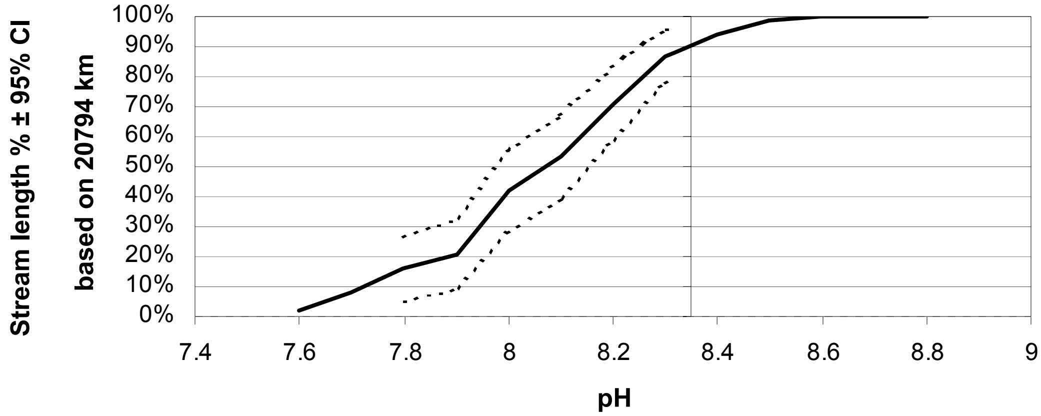



Flow (Random): Detect = 20260 km / Nondetect = 0 km.
Note logarithmic scale for Flow.



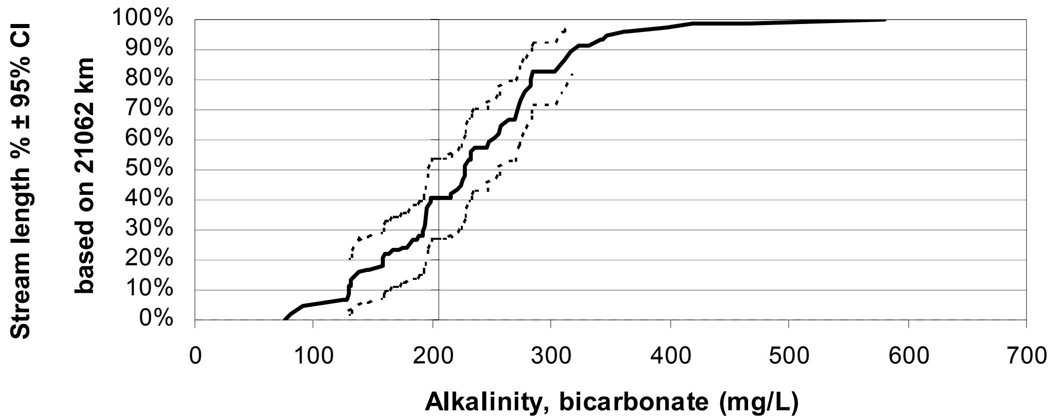

Water Temperature (Random): Detect = 20322 km / Nondetect = 0 km

## Water pH



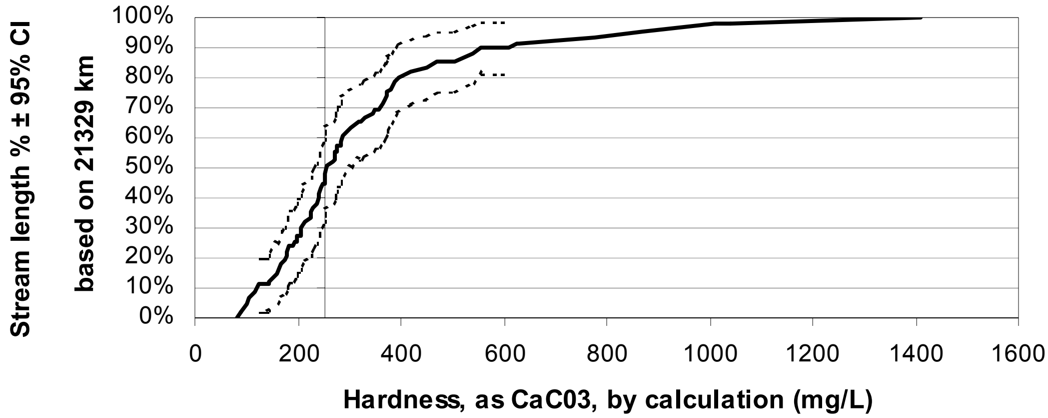

Water pH (Random): Detect = 20794 km / Nondetect = 0 km

## Alkalinity in water



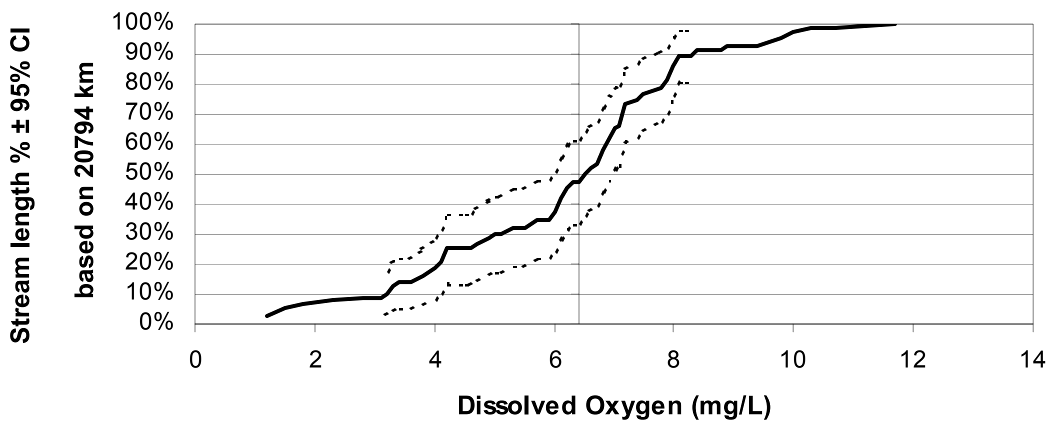

Alkalinity in water (Random): Detect = 21062 km / Nondetect = 0 km

## Hardness in Water



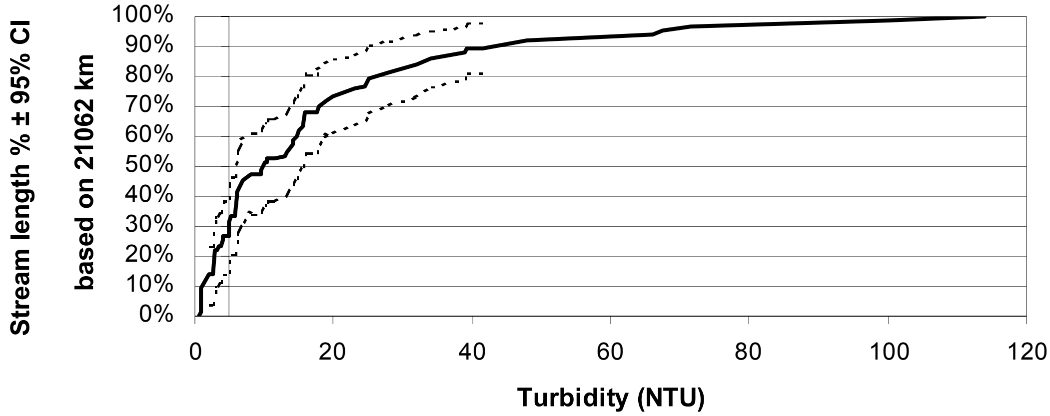

Hardness in Water (Random): Detect = 21329 km / Nondetect = 0 km

## Dissolved Oxygen in Water



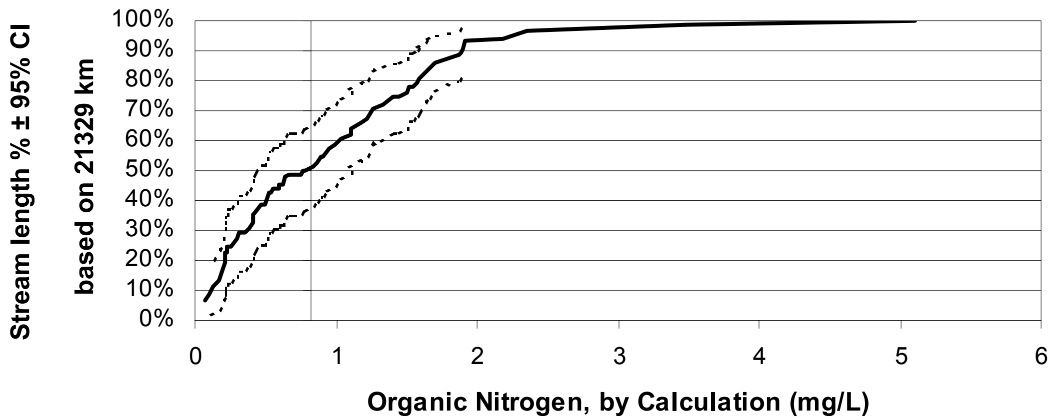

Dissolved Oxygen in Water (Random): Detect = 20794 km / Nondetect = 0 km

## Water Turbidity



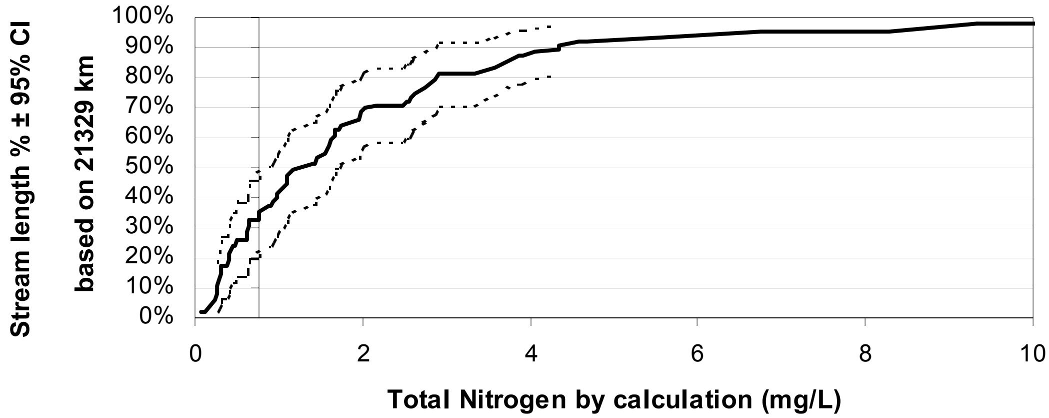

Water Turbidity (Random): Detect = 20117 km / Nondetect = 945 km

## Organic Nitrogen in Water



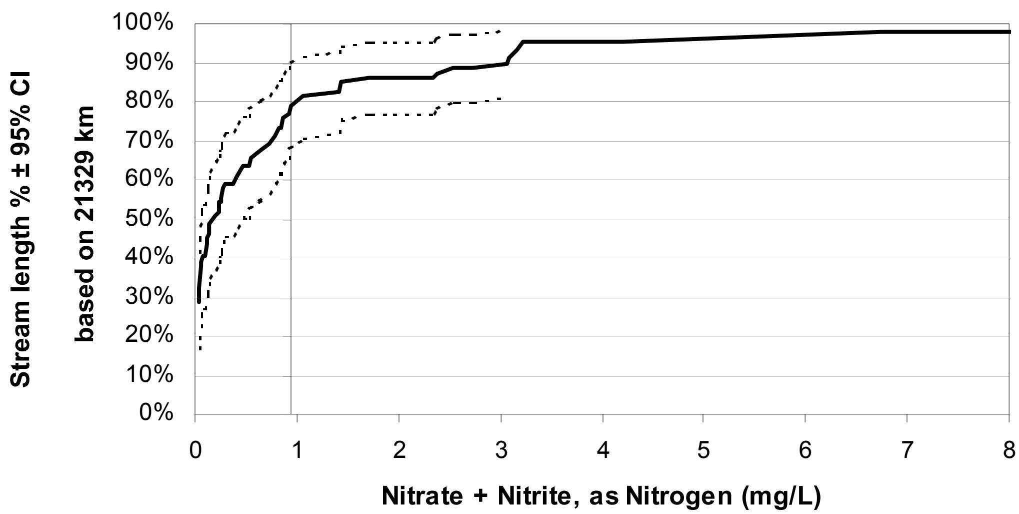

Organic Nitrogen in Water (Random): Detect = 19110 km / Nondetect = 2219 km

## Total Nitrogen in Water



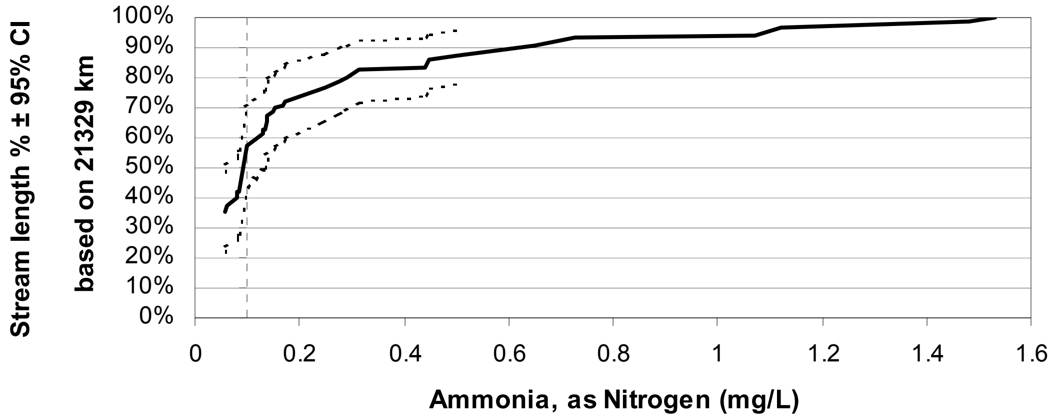

Total Nitrogen in Water (Random): Detect = 20322 km / Nondetect = 1007 km
Scale for Total Nitrogen does not show one outlier value of 293.

## Nitrate + Nitrite in Water



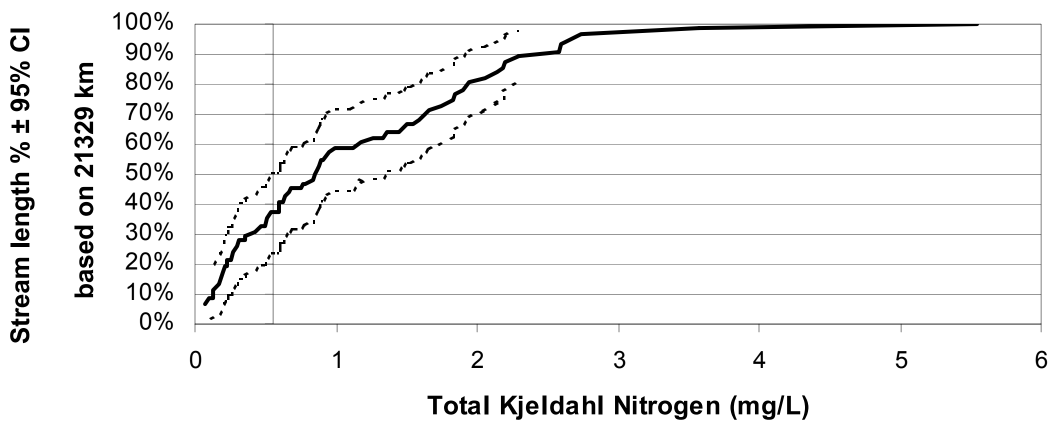

Nitrate+Nitrite in Water (Random): Detect = 15678 km / Nondetect = 5651 km
Scale for Nitrate + Nitrite does not show outlier value of 291.

## Ammonia (as Nitrogen) in Water



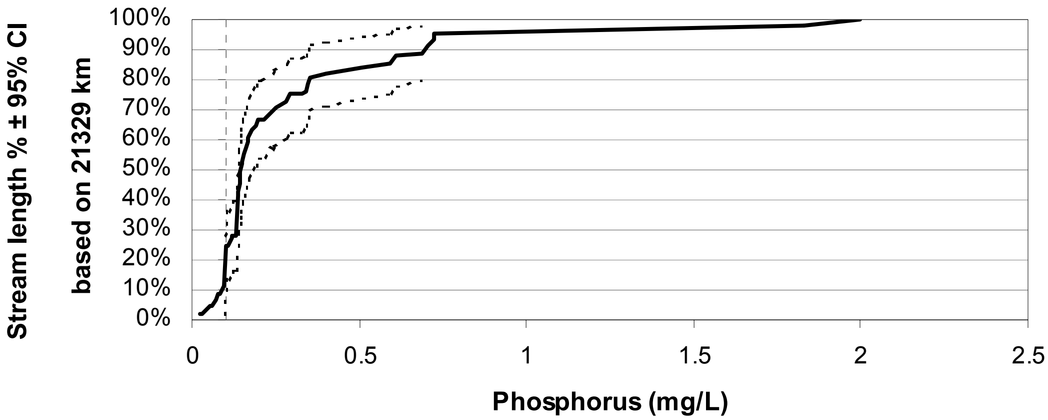

Ammonia (as Nitrogen) in Water (Random): Detect = 9760 km / Nondetect = 11569 km

## Total Kjeldahl Nitrogen in Water



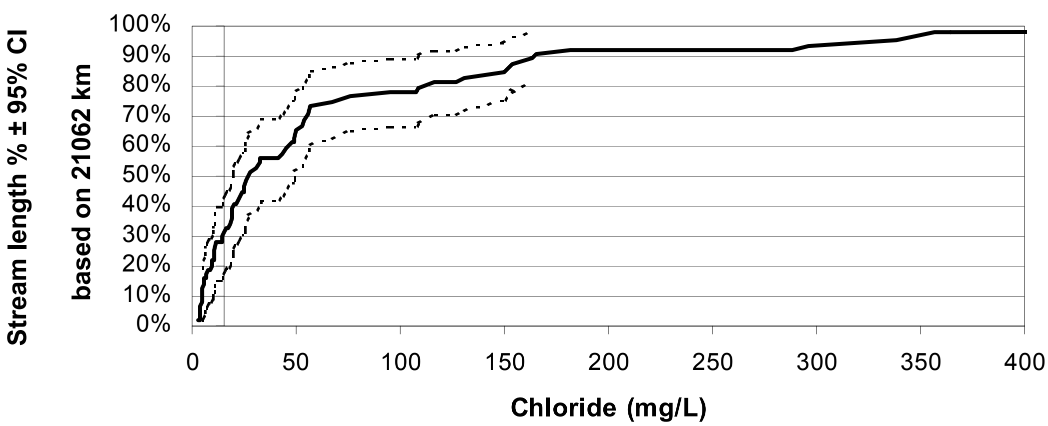

Total Kjeldahl Nitrogen in Water (Random): Detect = 19110 km / Nondetect = 2219 km

## Total Phosphorus in Water



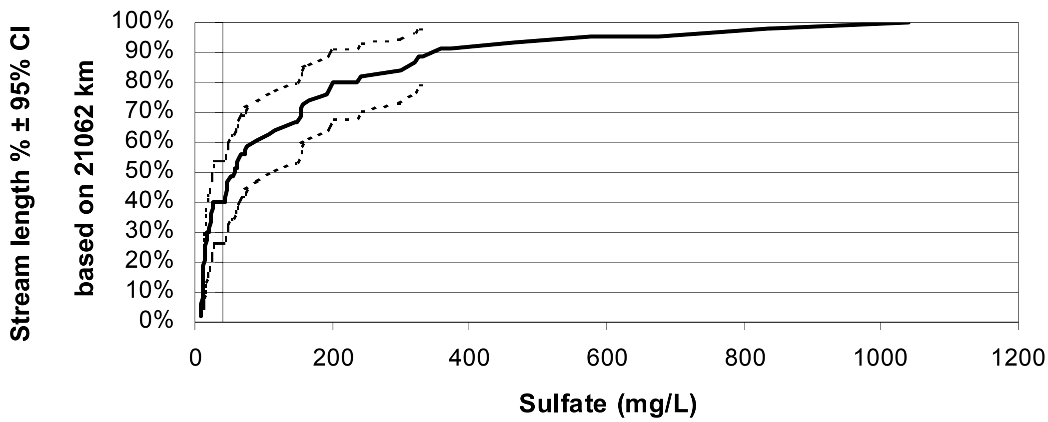

Total Phosphorus in Water (Random): Detect = 10624 km / Nondetect = 10705 km

## Chloride in Water




Chloride in Water (Random): Detect = 21062 km / Nondetect = 0 km
Scale for Chloride does not show one outlier value of 1730.

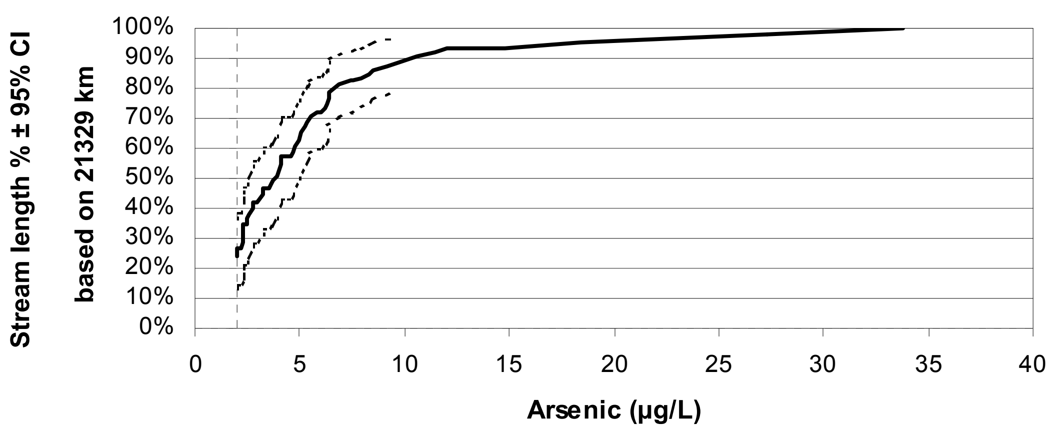
## Sulfate in Water



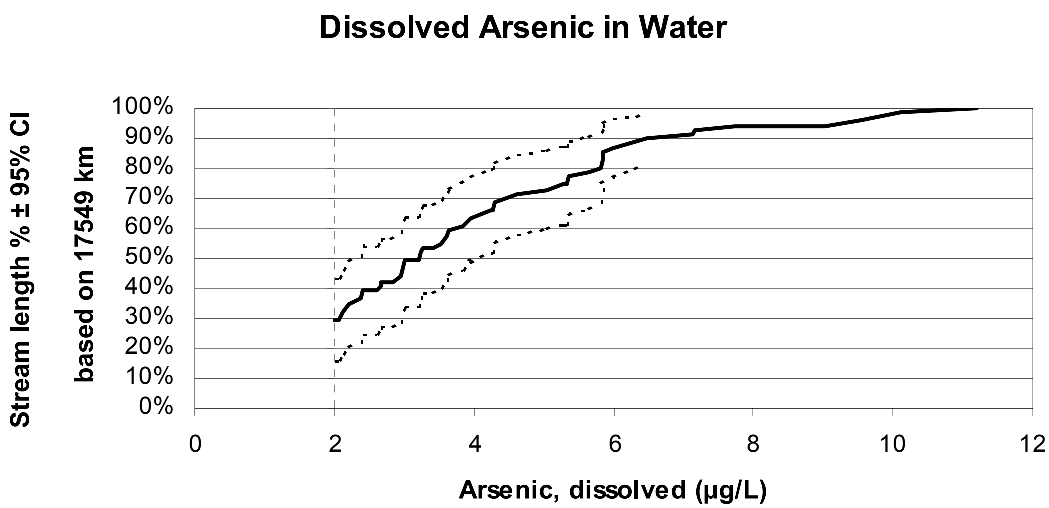

Sulfate in Water (Random): Detect = 21062 km / Nondetect = 0 km

## ANALYTES IN WATER: METALS

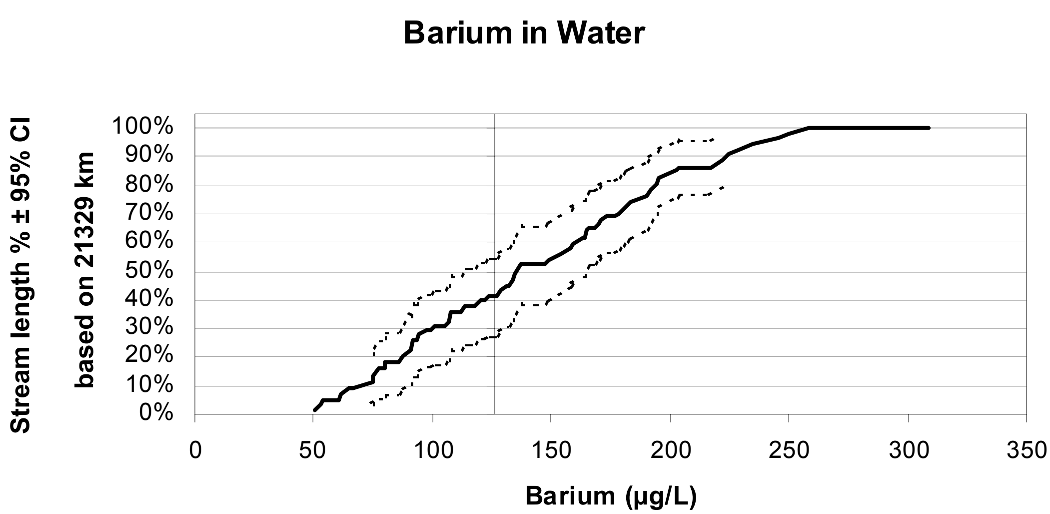
## Arsenic in Water




Arsenic in Water (Random): Detect = 16151 km / Nondetect = 5178 km

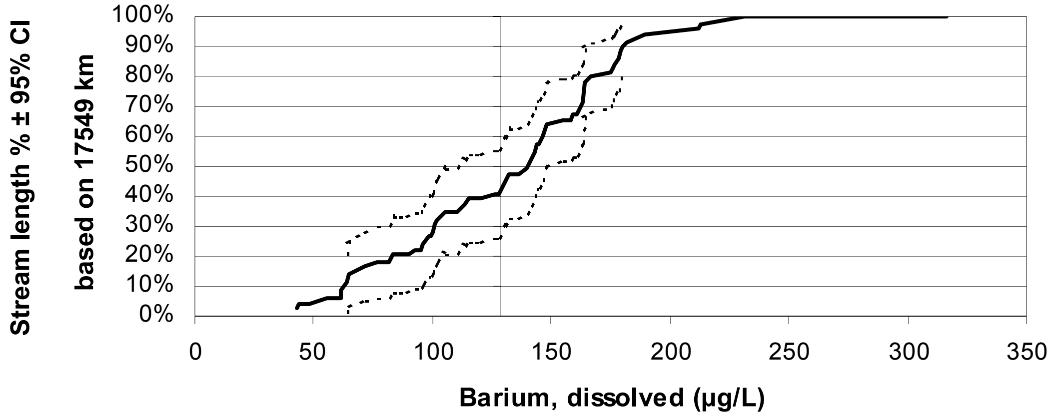



Dissolved Arsenic in Water (Random): Detect = 12371 km / Nondetect = 5178 km




Barium in Water (Random): Detect = 21329 km / Nondetect = 0 km

## Dissolved Barium in Water




Dissolved Barium in Water (Random): Detect = 17549 km / Nondetect = 0 km

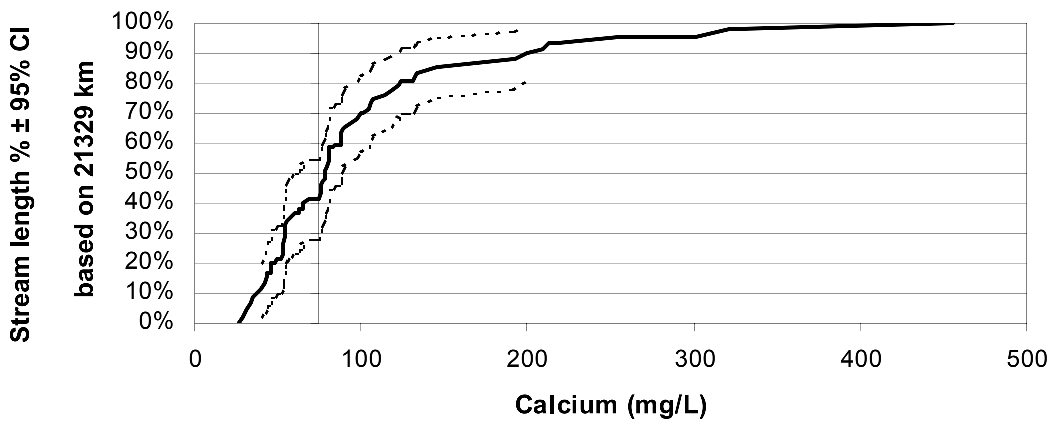
## Cadmium in Water

**Random** **21329 km** **all values ≤1 ug/L**
**Reference** **30/30 nd** **median = 1 ug/L**
Cadmium in Water (Random): Detect = 0 km / Nondetect = 21329 km

## Dissolved Cadmium in Water

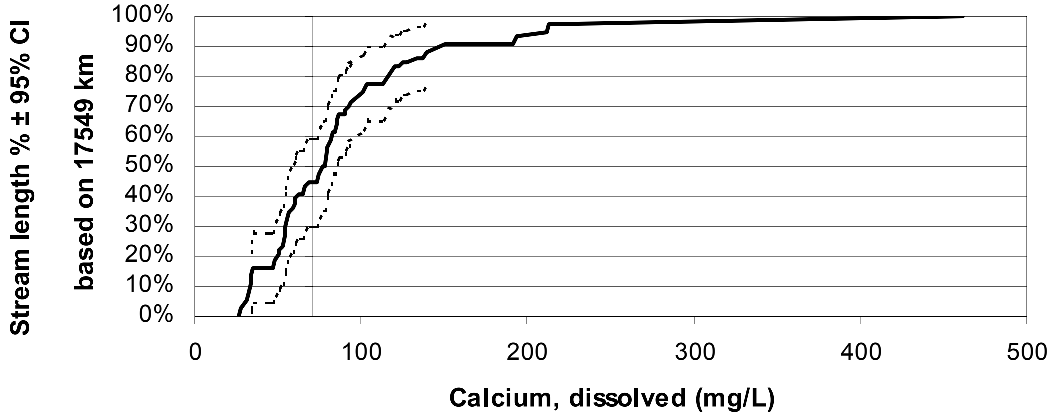
**Random** **17282 km** **all values ≤1 ug/L**
**Reference** **28/30 nd** **median = 1 ug/L**
Dissolved Cadmium in Water (Random): Detect = 0 km / Nondetect = 17282 km

## Calcium in Water




Calcium in Water (Random): Detect = 21329 km / Nondetect = 0 km

## Dissolved Calcium in Water

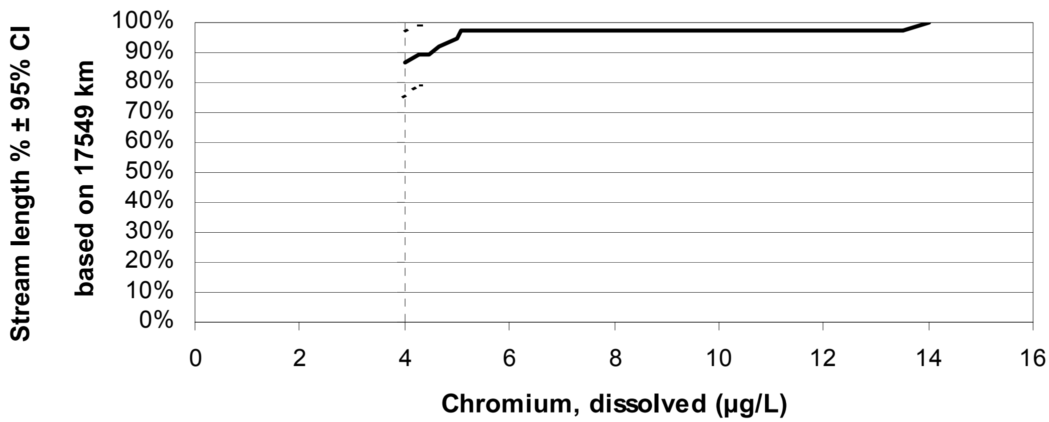



Dissolved Calcium in Water (Random): Detect = 17549 km / Nondetect = 0 km

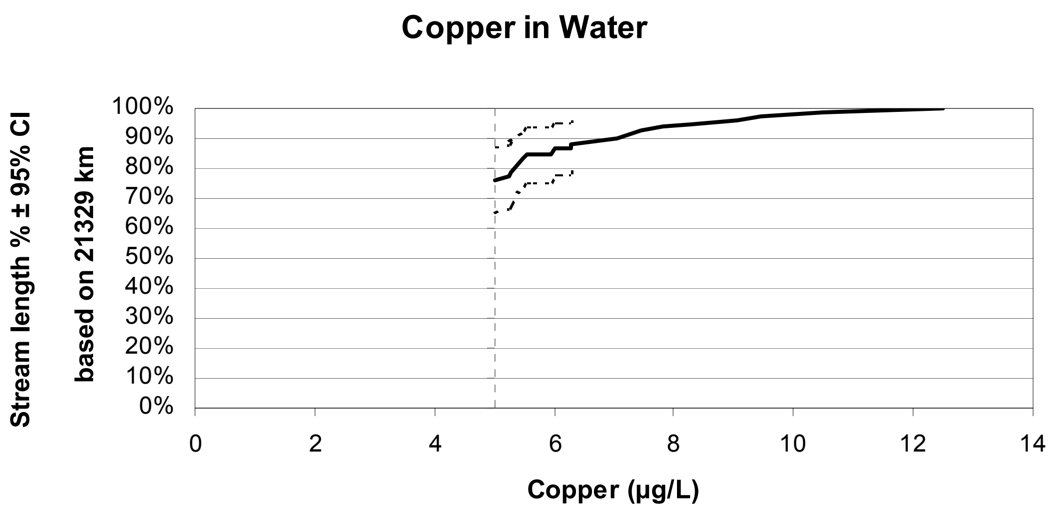
## Chromium in Water

**Random** **21329 km** **all values ≤ 20.5 ug/L**
**Reference** **30/30 nd** **median = 15**
Chromium in Water (Random): Detect = 472 km / Nondetect = 20857 km

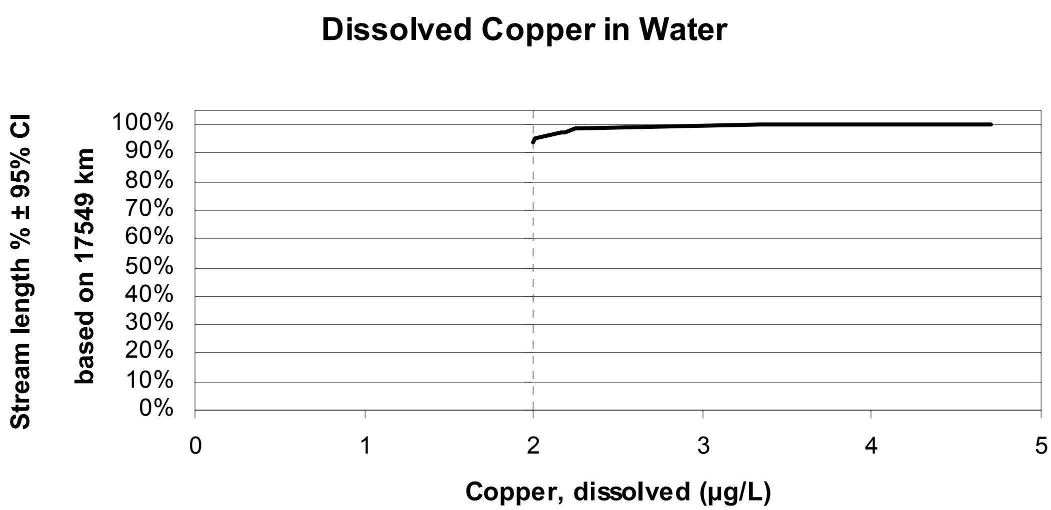
## Dissolved Chromium in Water




Dissolved Chromium in Water (Random): Detect = 2362 km / Nondetect = 15187 km

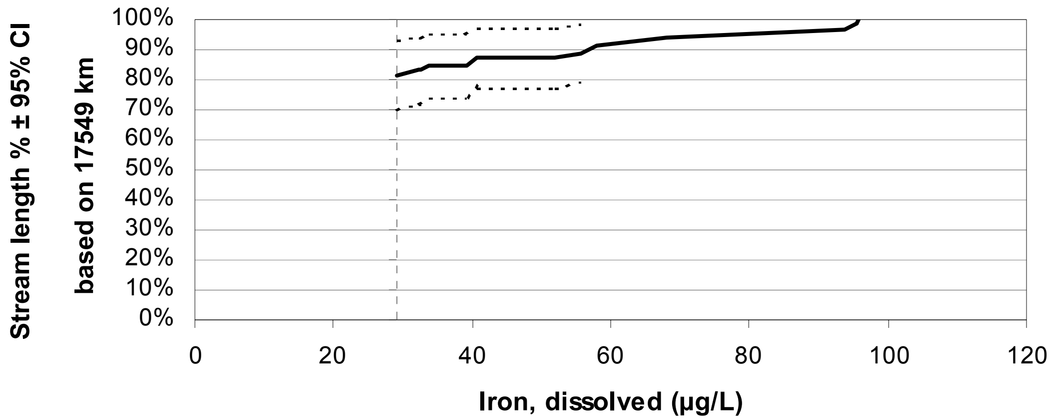



Copper in Water (Random): Detect = 5098 km / Nondetect = 16231 km



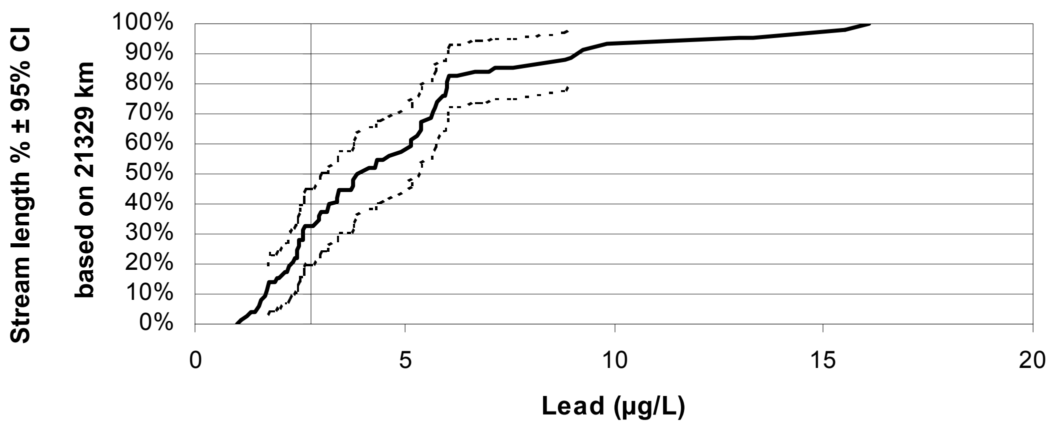

Dissolved Copper in Water (Random): Detect = 1069 km / Nondetect = 16480 km

## Dissolved Iron in Water




Dissolved Iron in Water (Random): Detect = 3226 km / Nondetect = 14323 km

## Lead in Water

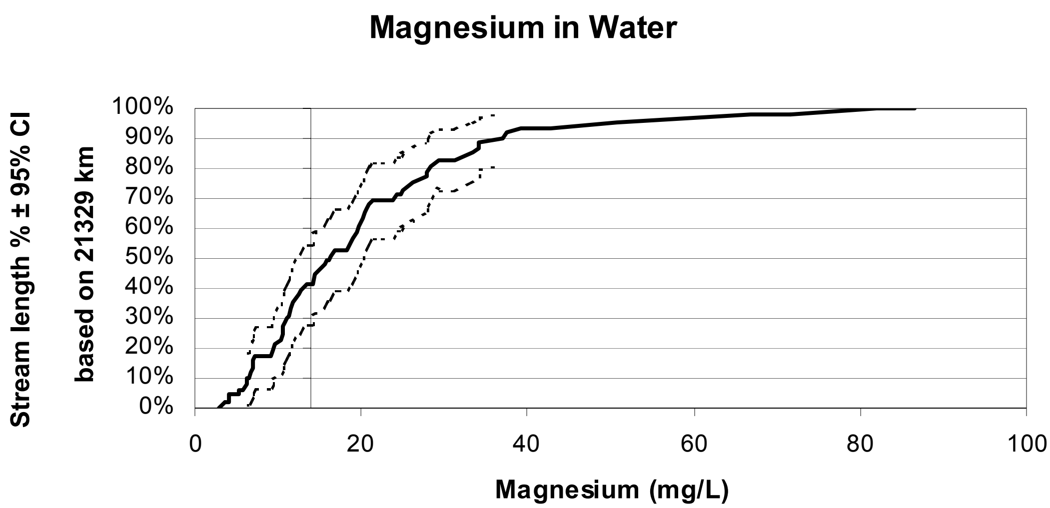



Lead in Water (Random): Detect = 21329 km / Nondetect = 0 km

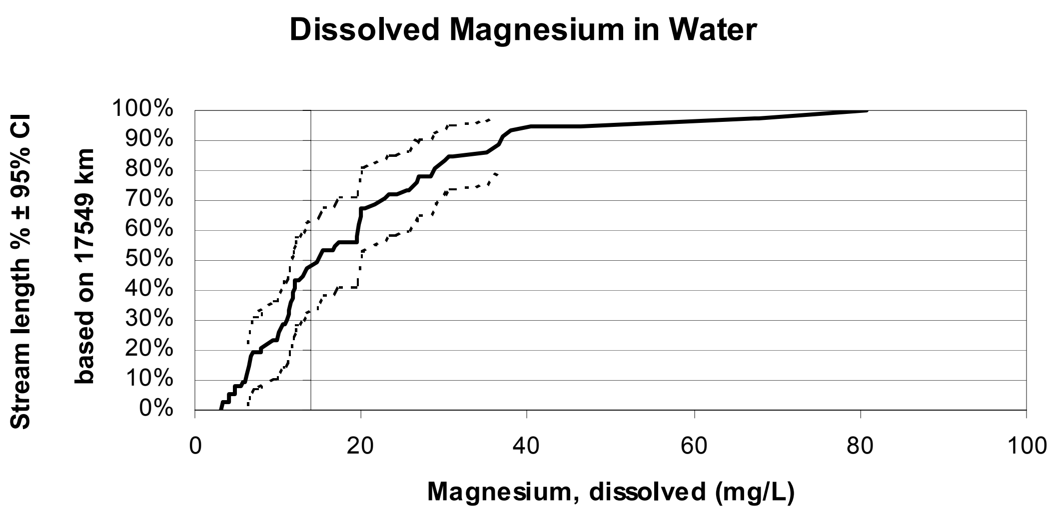
## Dissolved Lead in Water

| | | |
|---|---|---|
| **Random** | **17549 km** | **all values ≤ 1.07 ug/L** |
| **Reference** | **28/30 nd** | **median = 1** |

Dissolved Lead in Water (Random): Detect = 267 km / Nondetect = 17282 km

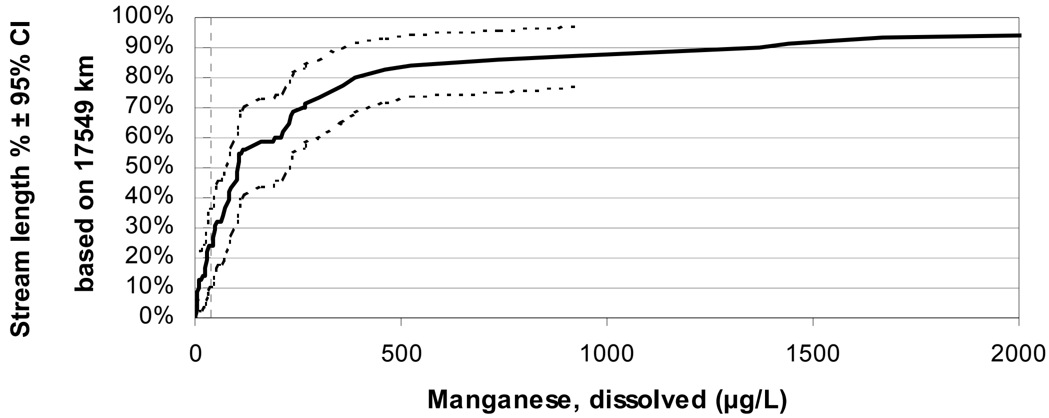



Magnesium in Water (Random): Detect = 21329 km / Nondetect = 0 km



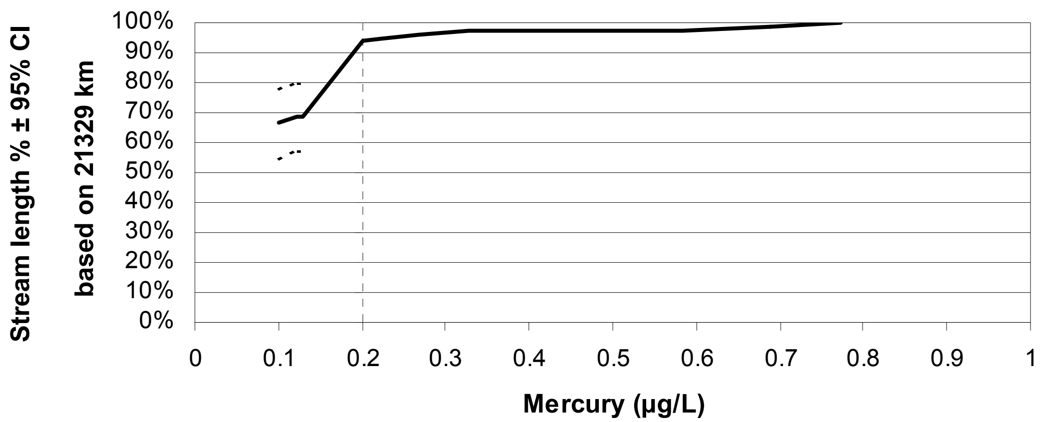

Dissolved Magnesium in Water (Random): Detect = 17549 km / Nondetect = 0 km

## Dissolved Manganese in Water



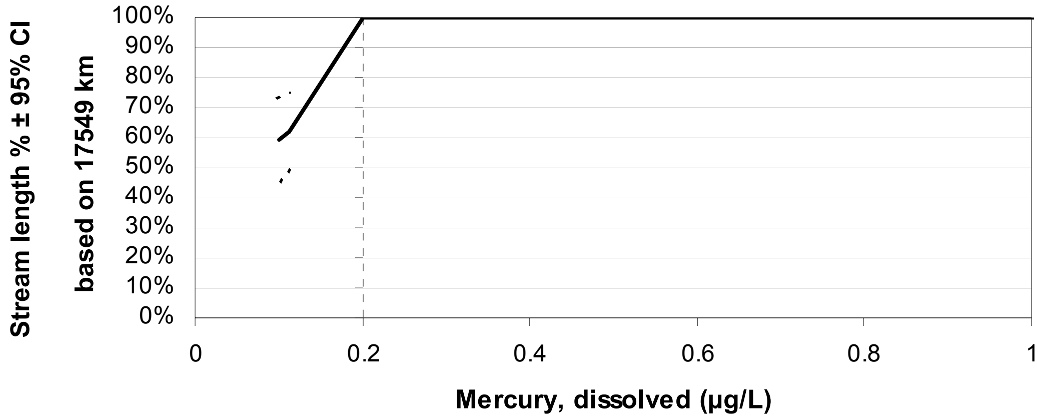

Dissolved Manganese in Water (Random): Detect = 17549 km / Nondetect = 0 km
Scale for dissolved manganese does not show last three outlier values of 2310, 2430, and 2690.

## Mercury in Water




Mercury in Water (Random): Detect = 1809 km / Nondetect = 19520 km

## Dissolved Mercury in Water




Dissolved Mercury in Water (Random): Detect = 472 km / Nondetect = 17077 km
Scale for Mercury does not show single outlier value of 7.29.

## Nickel in Water

| | | |
|---|---|---|
| **Random** | **21329 km** | **all values ≤ 20 ug/L** |
| **Reference** | **30/30 nd** | **median=20** |

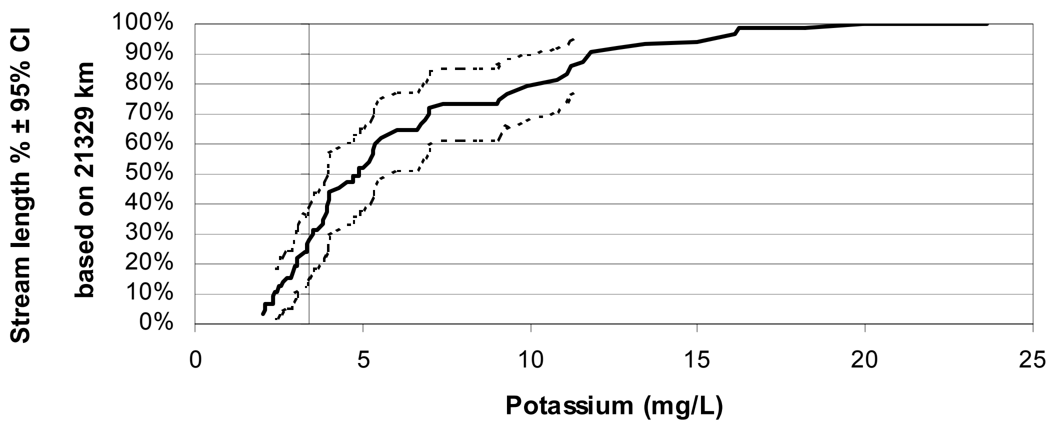
Nickel in Water (Random): Detect = 0 km / Nondetect = 21329 km

## Dissolved Nickel in Water

| | | |
|---|---|---|
| **Random** | **17549 km** | **all values below 8.56 ug/L** |
| **Reference** | **28/30 nd** | **median = 6** |

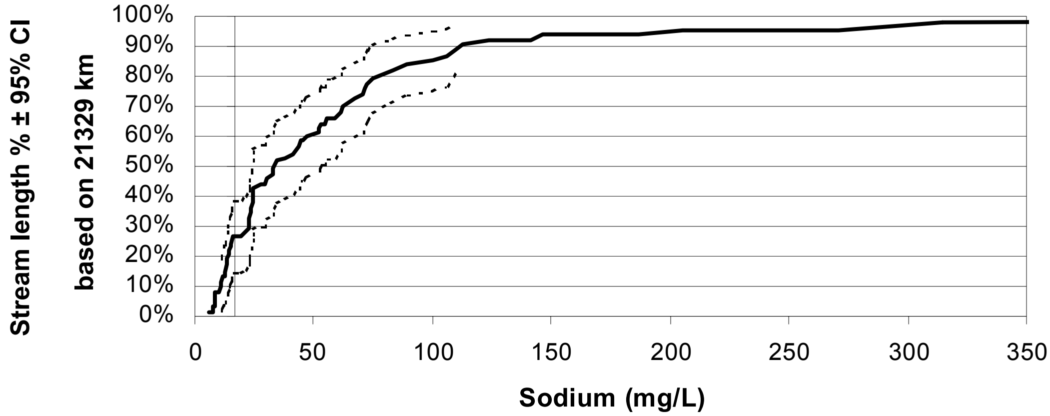
Dissolved Nickel in Water (Random): Detect = 0 km / Nondetect = 17549 km

## Potassium in Water



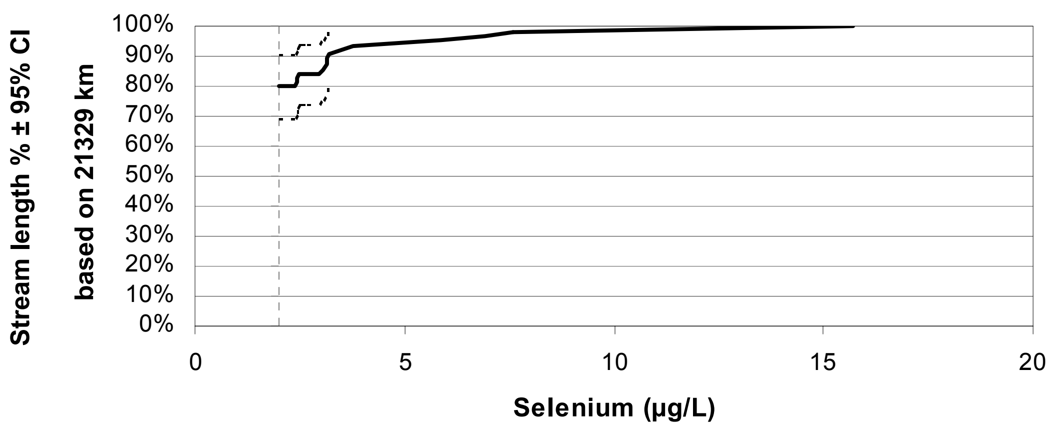

Potassium in Water (Random): Detect = 20589 km / Nondetect = 740 km

## Sodium in Water



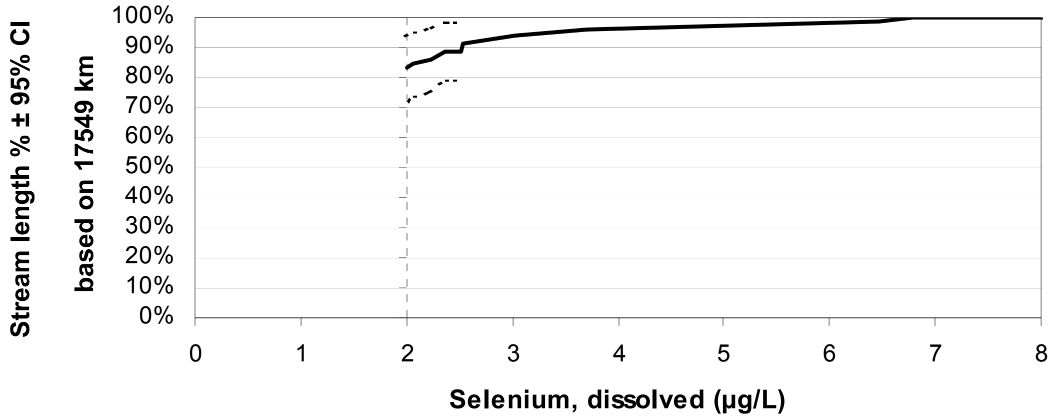

Sodium in Water (Random): Detect = 21329 km / Nondetect = 0 km
Note that scale for Sodium does not show one outlier value of 974.

## Selenium in Water




Selenium in Water (Random): Detect = 4234 km / Nondetect = 17095 km

## Dissolved Selenium in Water




Dissolved Selenium in Water (Random): Detect = 2959 km / Nondetect = 14590 km
Scale for selenium does not show one outlier value of 18.8.

## Silver in Water

| | | |
|---|---|---|
| **Random** | **21329 km** | **all values ≤ 25 ug/L** |
| **Reference** | **30/30 nd** | **median = 25** |

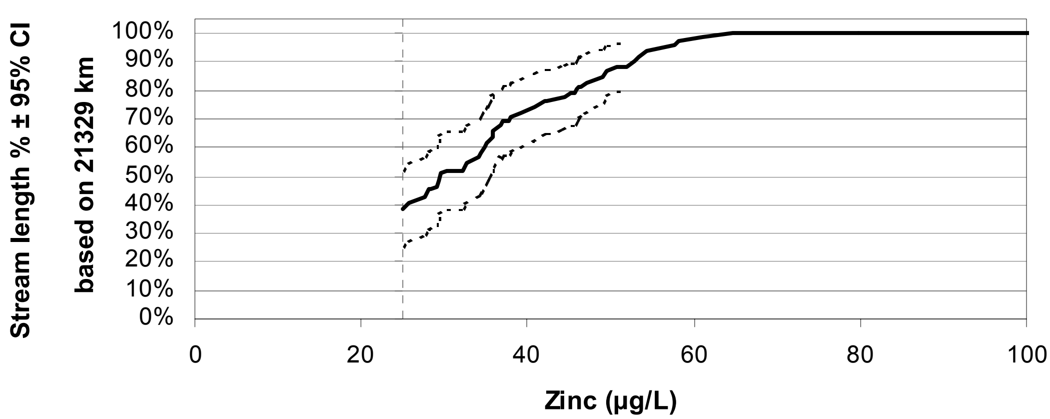
Silver in Water (Random): Detect = 0 km / Nondetect = 21329 km

## Dissolved Silver in Water

| | | |
|---|---|---|
| **Random** | **17282 km** | **all values ≤1 ug/L** |
| **Reference** | **28/30 nd** | **median = 1 ug/L** |

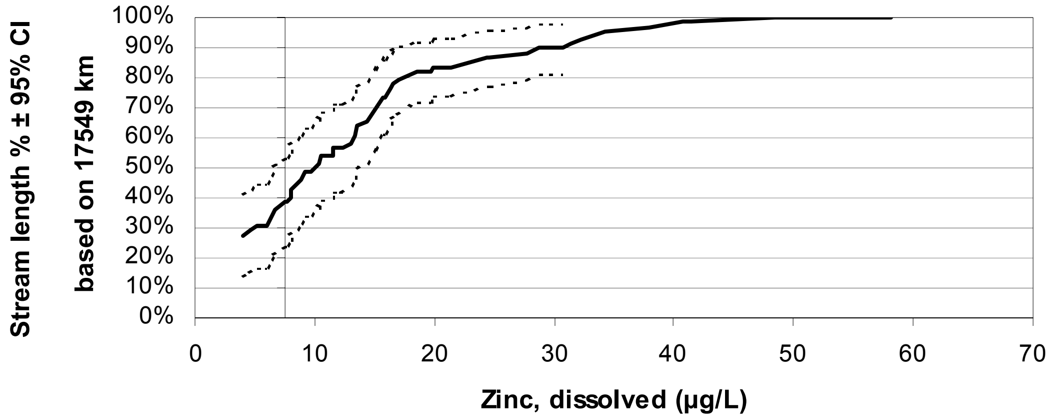
Dissolved Silver in Water (Random): Detect = 0 km / Nondetect = 17282 km

## Zinc in Water




Zinc in Water (Random): Detect = 13111 km / Nondetect = 8218 km
Scale for Zinc does not show last two outlier values: 106 and 172.

## Dissolved Zinc in Water



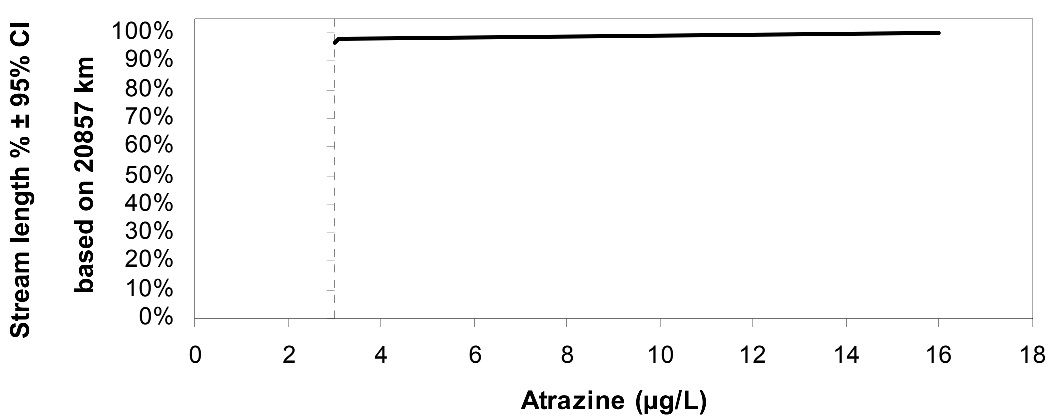

Dissolved Zinc in Water (Random): Detect = 12701 km / Nondetect = 4849 km

## ANALYTES IN WATER: BIOCIDES

### Alachlor in Water

**Random** **20857 km** **all values ≤ 0.32 ug/L**
**Reference** **29/30 nd,** **median=0.2**
Alachlor in Water (Random): Detect = 267 km / Nondetect = 20589 km

### Atrazine in Water




Atrazine in Water (Random): Detect = 740 km / Nondetect = 20117 km

### Diazinon in Water

**Random** **20857 km** **all values ≤ 0.4 ug/L**
**Reference** **20/30 nd** **median=0.4**
Diazinon in Water (Random): Detect = 0 km / Nondetect = 20857 km

## Chlordane in Water

| | | |
|---|---|---|
| **Random** | **20857 km** | **all values ≤ 0.2 ug/L** |
| **Reference** | **29/30 nd** | **median=0.2** |

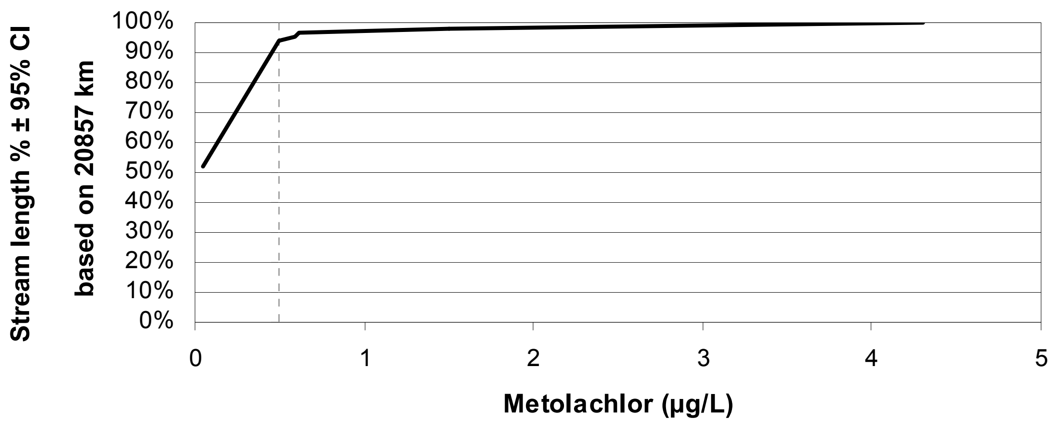
Chlordane in Water (Random): Detect = 0 km / Nondetect = 20857 km

## Chlorpyrifos in Water

| | | |
|---|---|---|
| **Random** | **20857 km** | **all values ≤ 0.056 ug/L** |
| **Reference** | **29/30 nd** | **median=0.05** |

Chlorpyrifos in Water (Random): Detect = 472 km / Nondetect = 20384 km

## Metolachlor in Water




Metolachlor in Water (Random): Detect = 1274 km / Nondetect = 19582 km

## Propachlor in Water

| | | |
|---|---|---|
| **Random** | **20857 km** | **all values ≤ 0.2 ug/L** |
| **Reference** | **29/30 nd** | **median=0.2** |

Propachlor in Water (Random): Detect = 0 km / Nondetect = 20857 km

## Trifluralin in Water

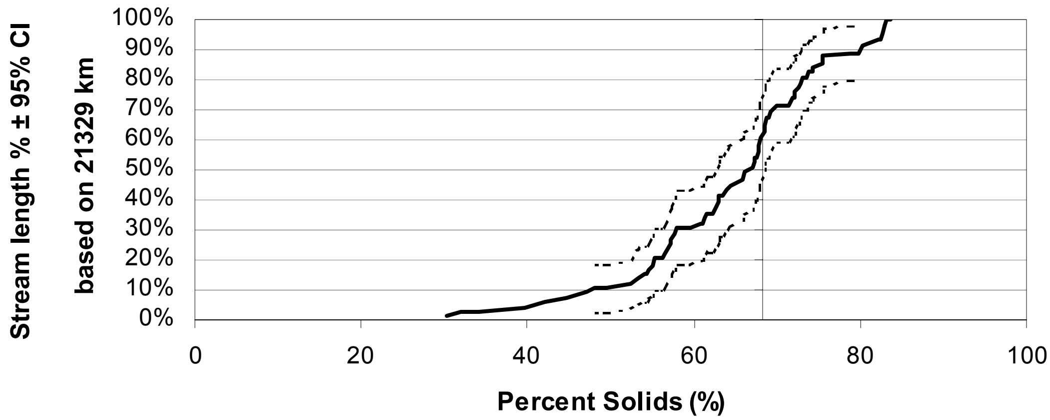
| | | |
|---|---|---|
| **Random** | **20857 km** | **all values ≤ 0.03 ug/L** |
| **Reference** | **20/30 nd** | **median=0.03** |

Trifluralin in Water (Random): Detect = 0 km / Nondetect = 20857 km

**Appendix G. Analytes in sediment: physical parameters, general chemistry, metals, and biocides.** Reporting considerations are the same as in Appendix F.

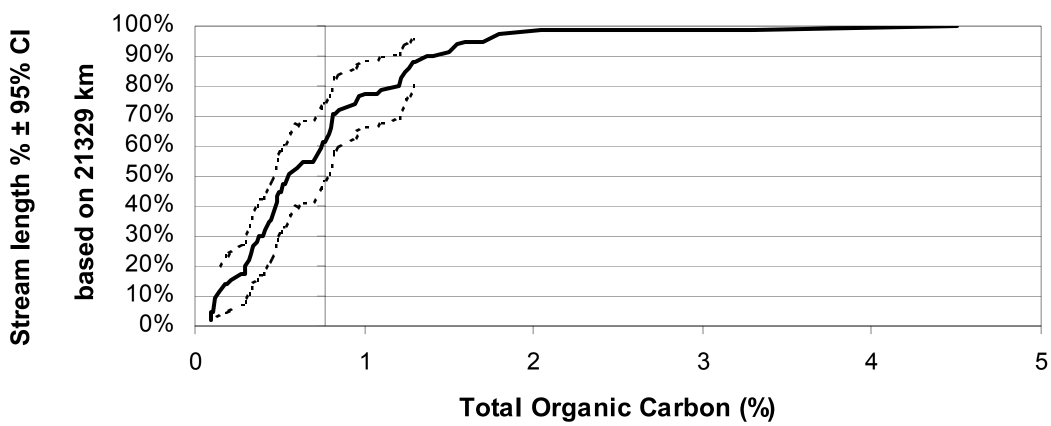
## ANALYTES IN SEDIMENT: PHYSICAL PARAMETERS AND GENERAL CHEMISTRY

### Percent Solids in Sediment



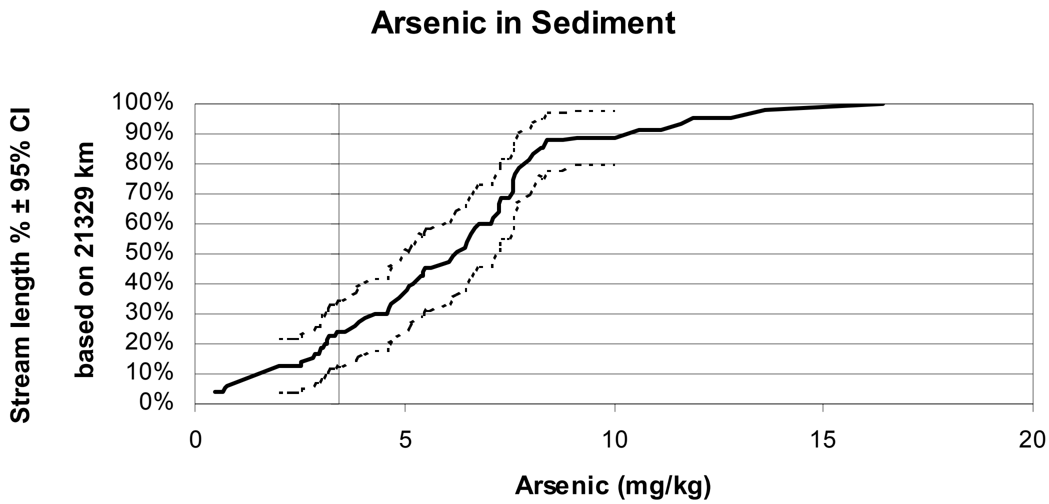

Percent Solids in Sediment (Random): Detect = 21329 km / Nondetect = 0 km

### Percent Total Organic Carbon in Sediment

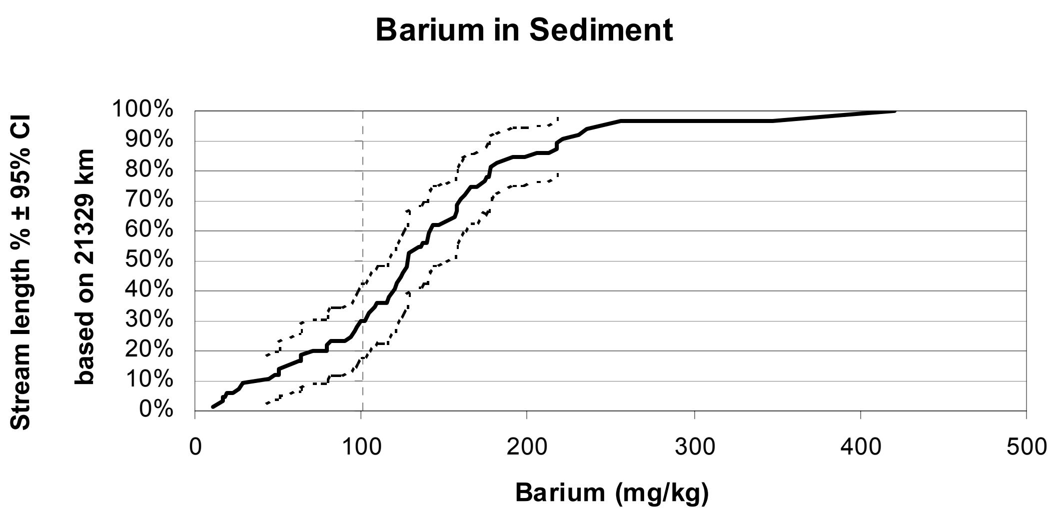



Percent Total Organic Carbon in Sediment (Random): Detect = 19787 km / Nondetect = 1542 km

# ANALYTES IN SEDIMENT: METALS

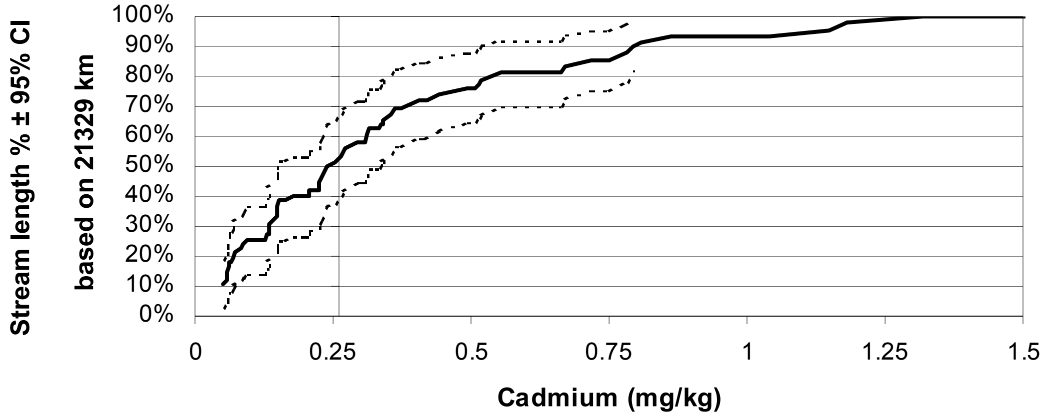



Arsenic in Sediment (Random): Detect = 19110 km / Nondetect = 2219 km



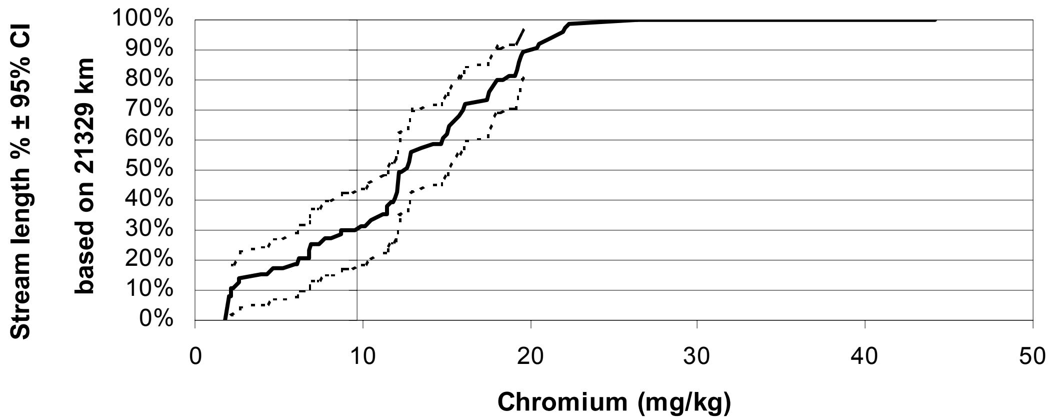

Barium in Sediment (Random): Detect = 21329 km / Nondetect = 0 km

## Cadmium in Sediment



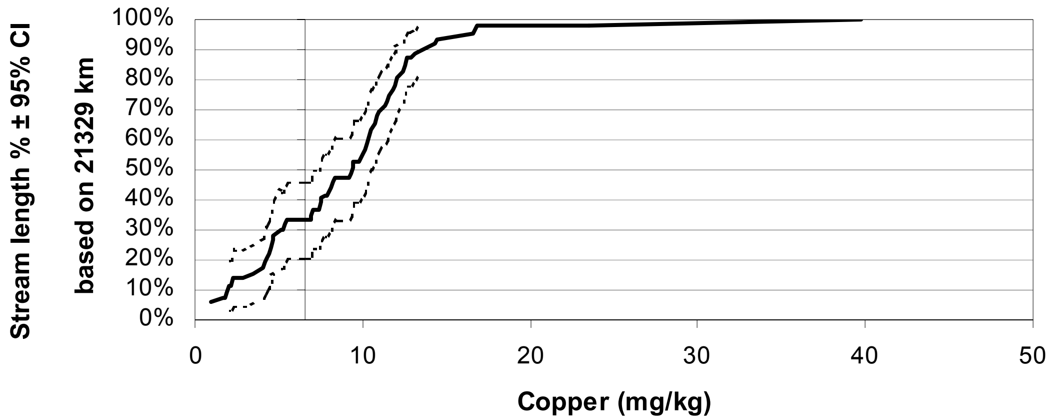

Cadmium in Sediment (Random): Detect = 19047 km / Nondetect = 2282 km
Scale for Cadmium does not show outlier values of 3.51, 11.6, and 500.

## Chromium in Sediment



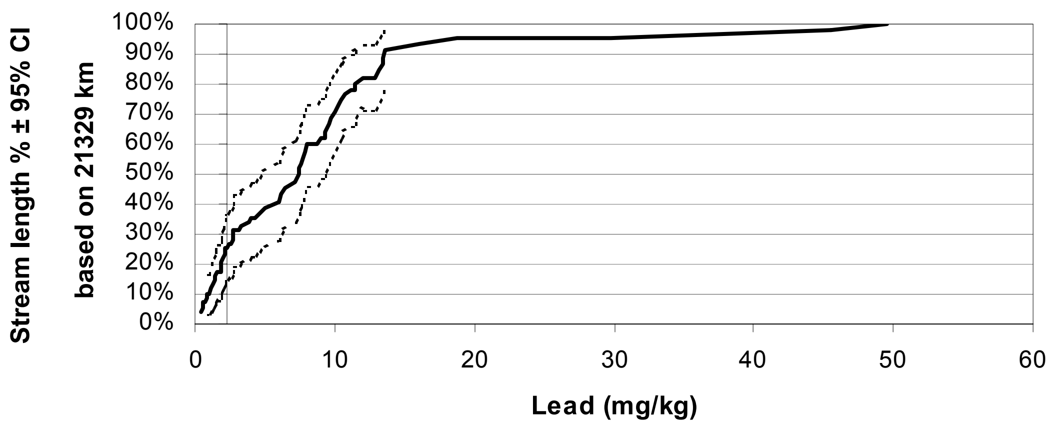

Chromium in Sediment (Random): Detect = 19582 km / Nondetect = 1747 km

## Copper in Sediment



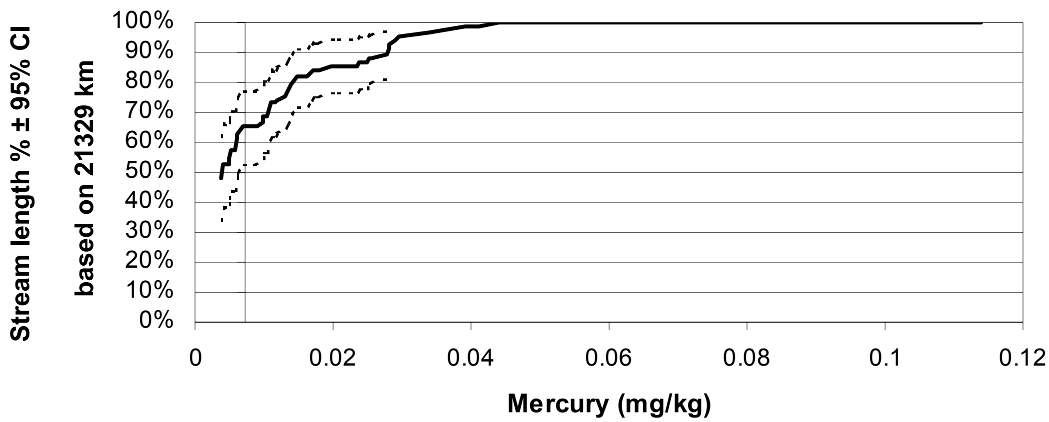

Copper in Sediment (Random): Detect = 19582 km / Nondetect = 1747 km

## Lead in Sediment



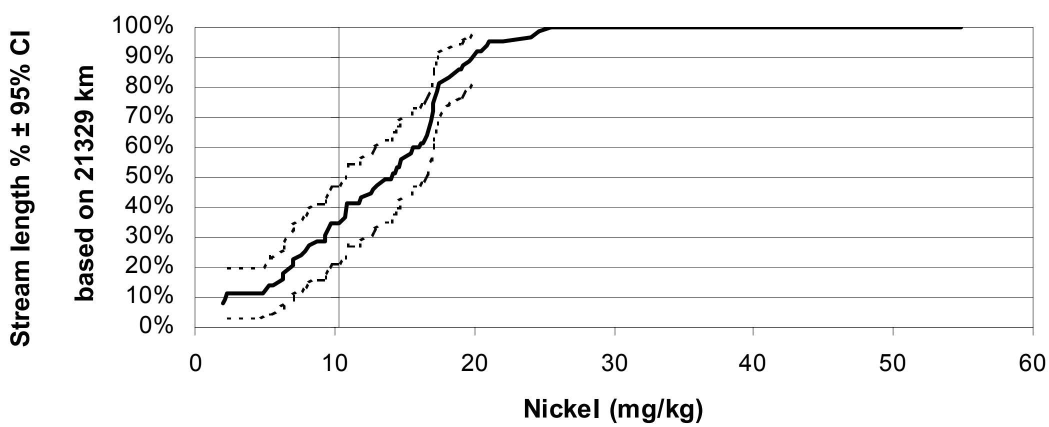

Lead in Sediment (Random): Detect = 20527 km / Nondetect = 802 km

## Mercury in Sediment



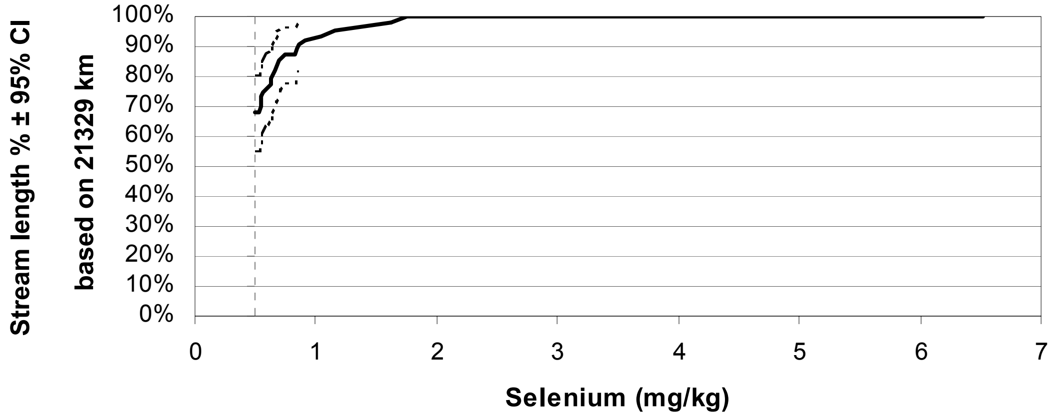

Mercury in Sediment (Random): Detect = 10071 km / Nondetect = 11258 km

## Nickel in Sediment




Nickel in Sediment (Random): Detect = 19582 km / Nondetect = 1747 km

## Selenium in Sediment



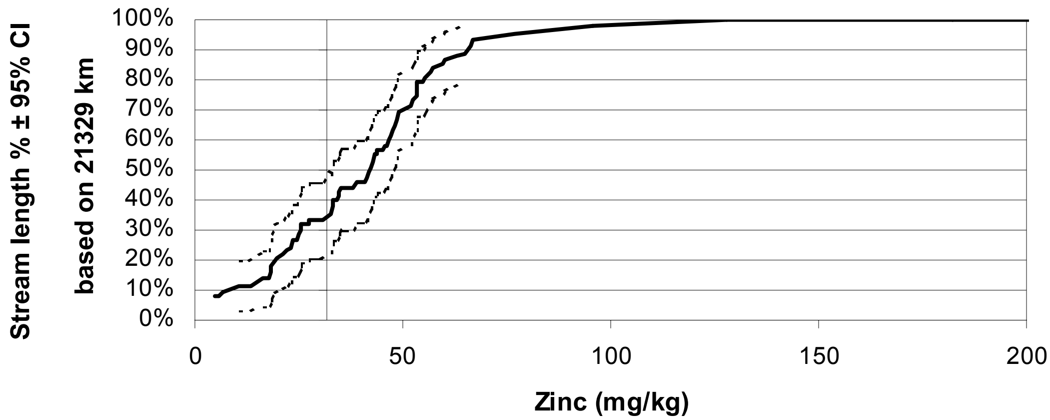

Selenium in Sediment (Random): Detect = 6863 km / Nondetect = 14466 km

## Silver in Sediment

| | | |
|---|---|---|
| Random | 21329 km | all values ≤ 2 mg/kg |
| Reference | 30/30 nd | median = 2 |

Silver in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

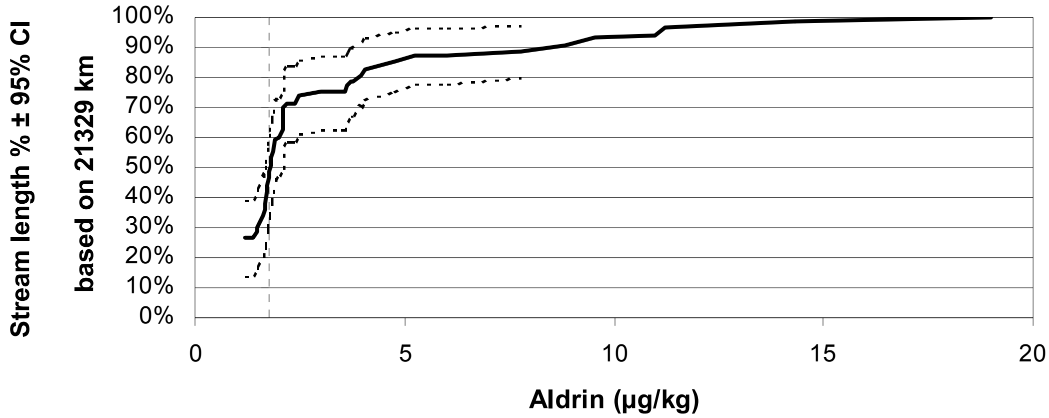
## Zinc in Sediment




Zinc in Sediment (Random): Detect = 19582 km / Nondetect = 1747 km
Scale for Zinc does not show one outlier value of 437.

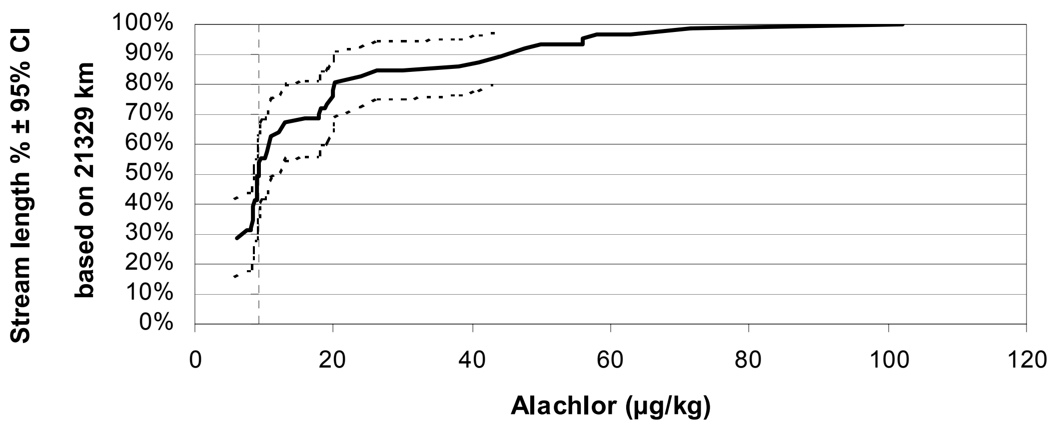
# ANALYTES IN SEDIMENT: BIOCIDES

## Aldrin in Sediment



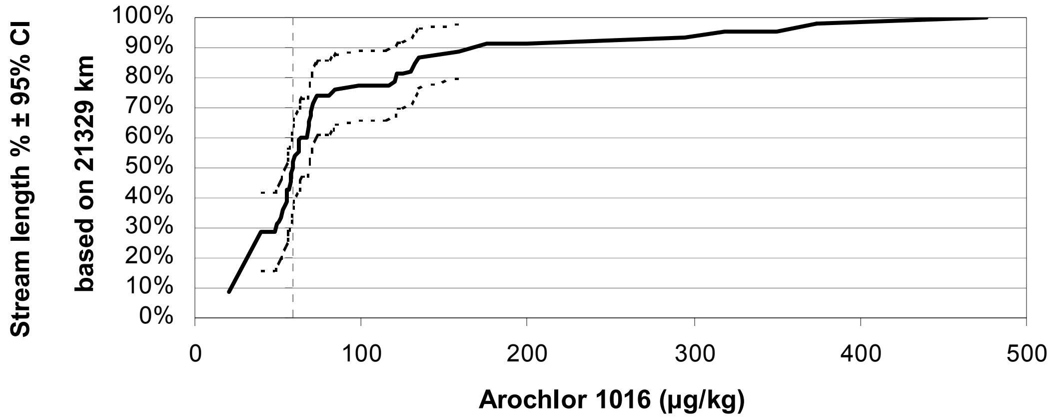

Aldrin in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Alachlor in Sediment



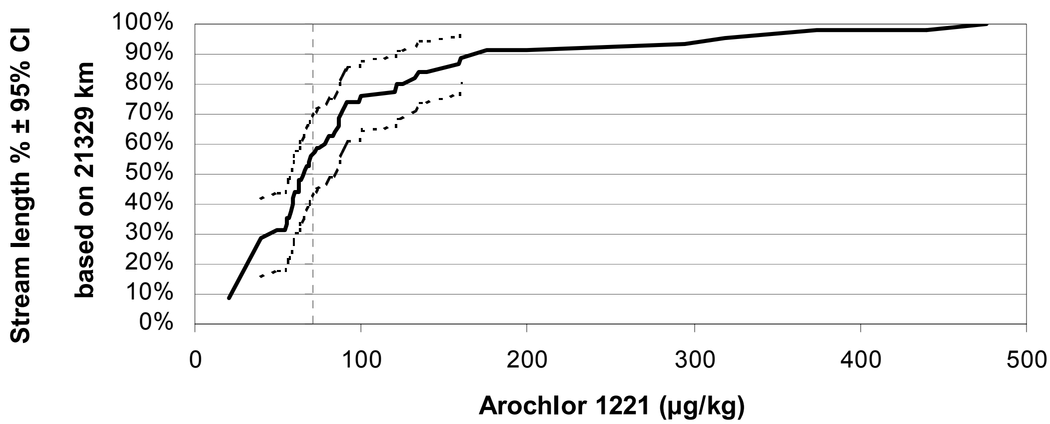

Alachlor in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Aroclor 1016 in Sediment

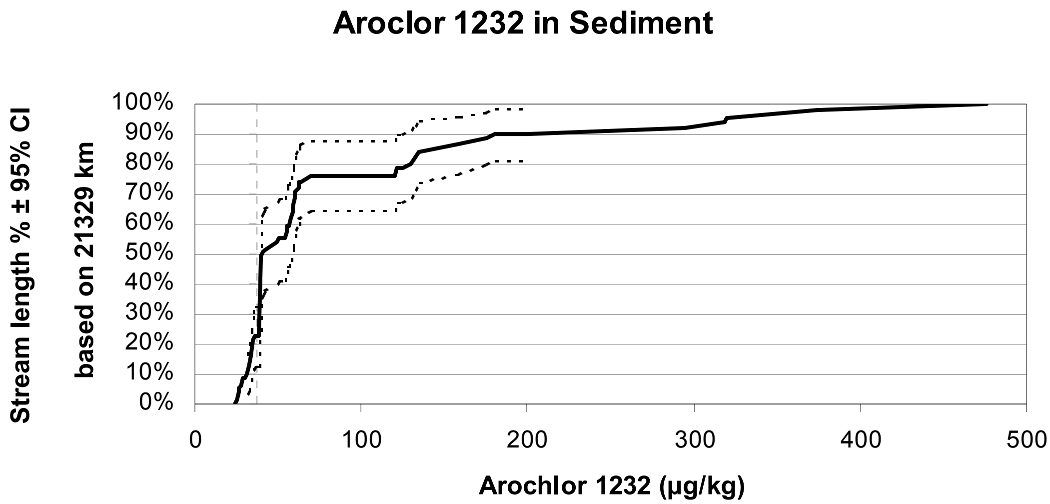



Arochlor 1016 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

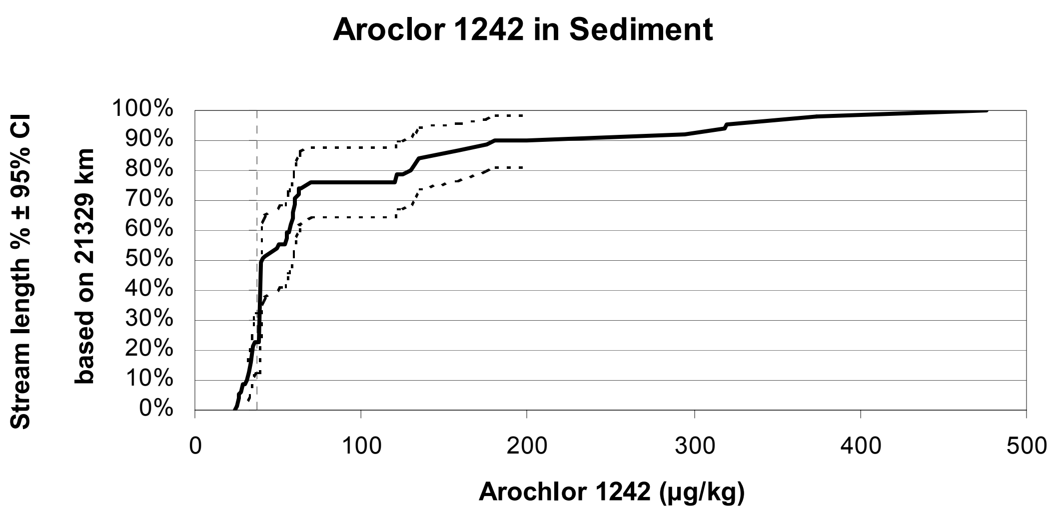
## Aroclor 1221 in Sediment



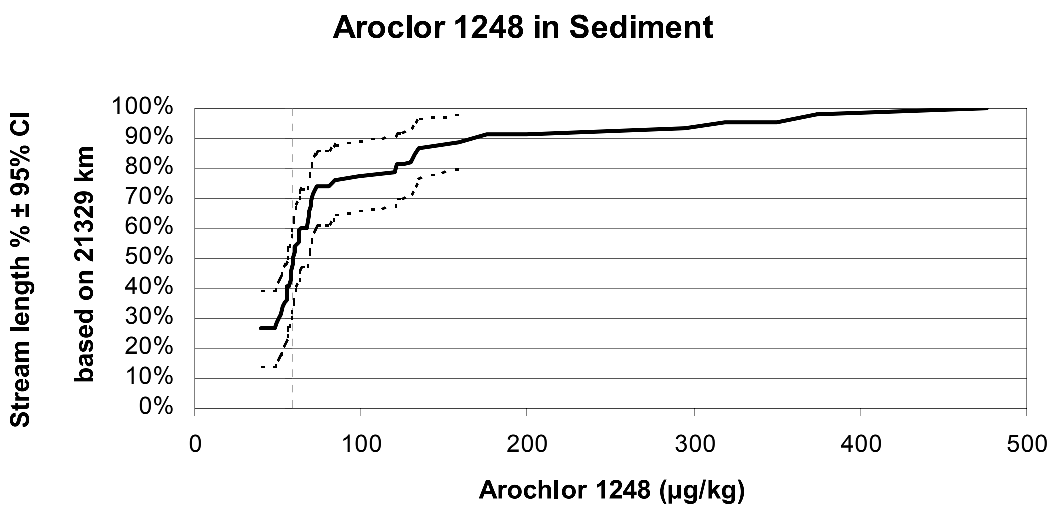

Arochlor 1221 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km



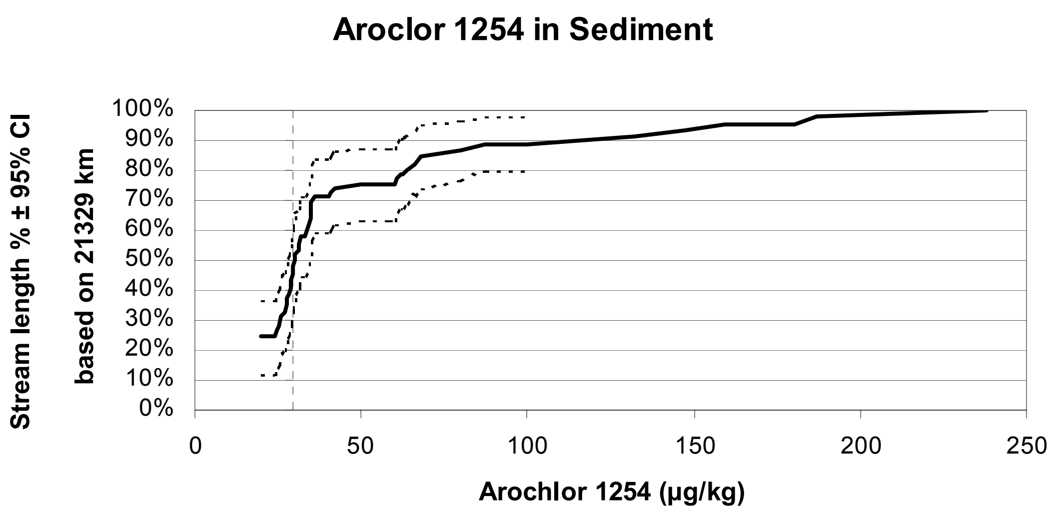

Arochlor 1232 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km




Arochlor 1242 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

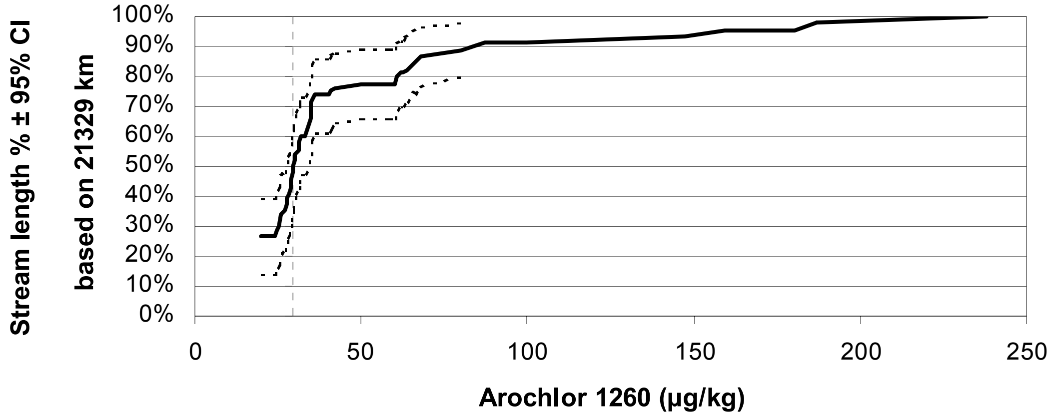



Arochlor 1248 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km



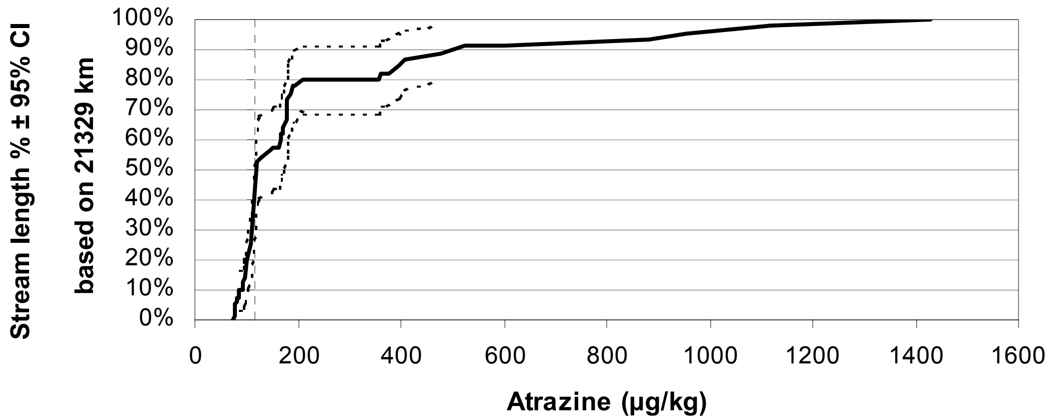

Arochlor 1254 in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Aroclor 1260 in Sediment

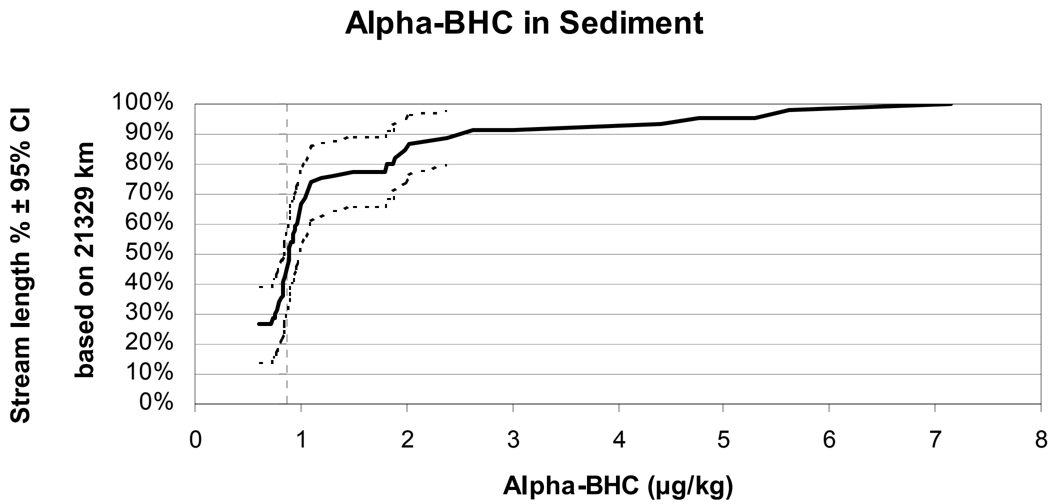



Arochlor 1260 in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

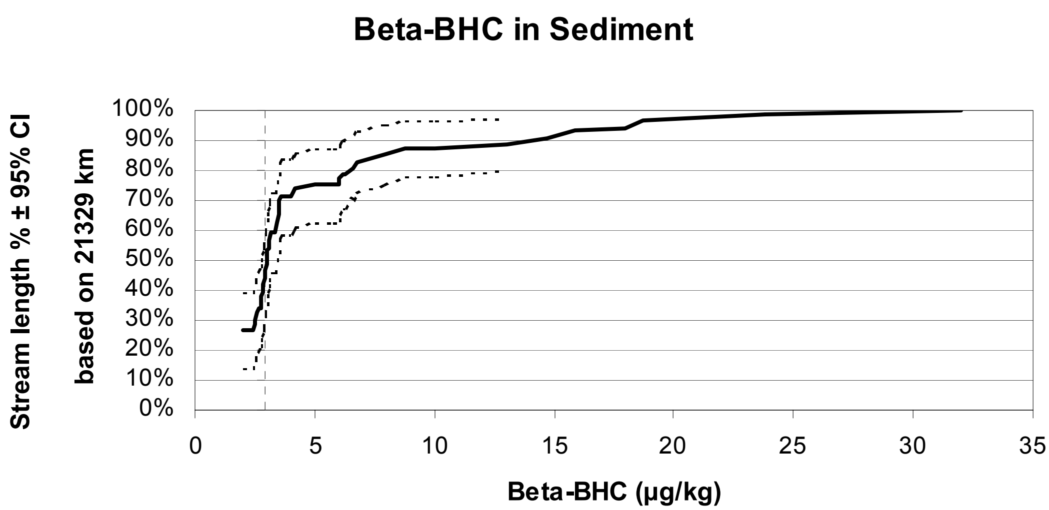
## Atrazine in Sediment




Atrazine in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

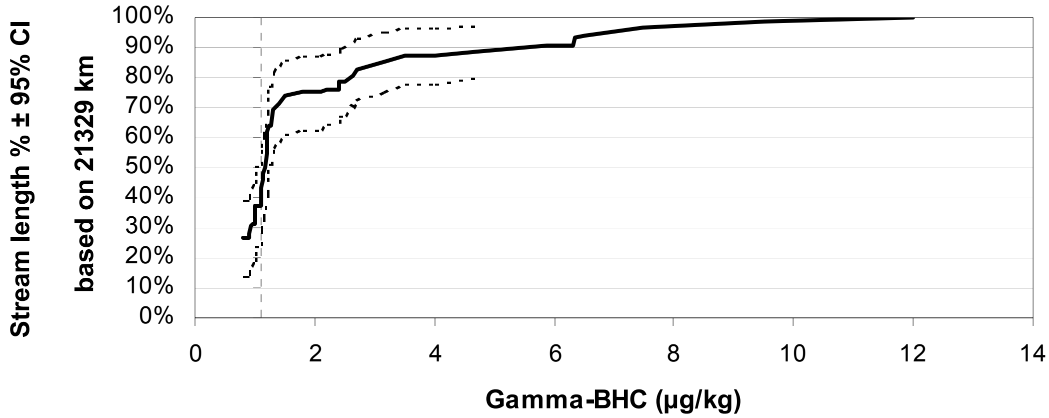



Alpha-BHC in Sediment (Random): Detect = 0 km / Nondetect = 21329 km



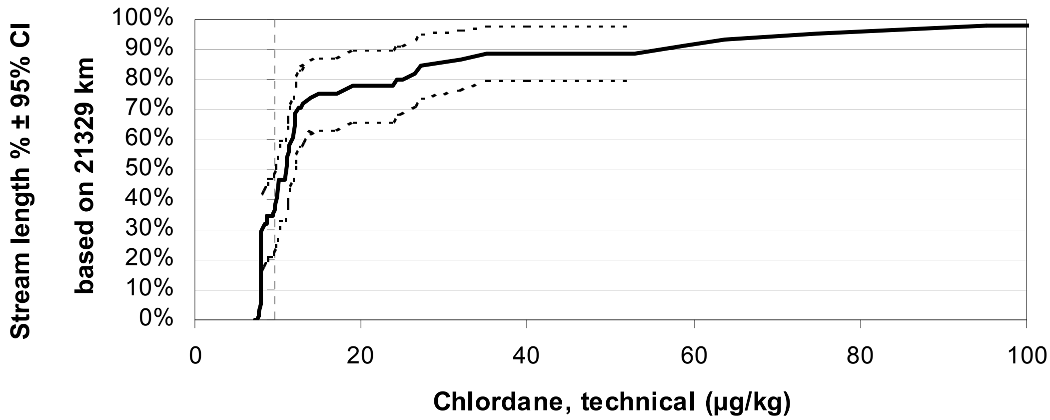

Beta-BHC in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Gamma-BHC in Sediment



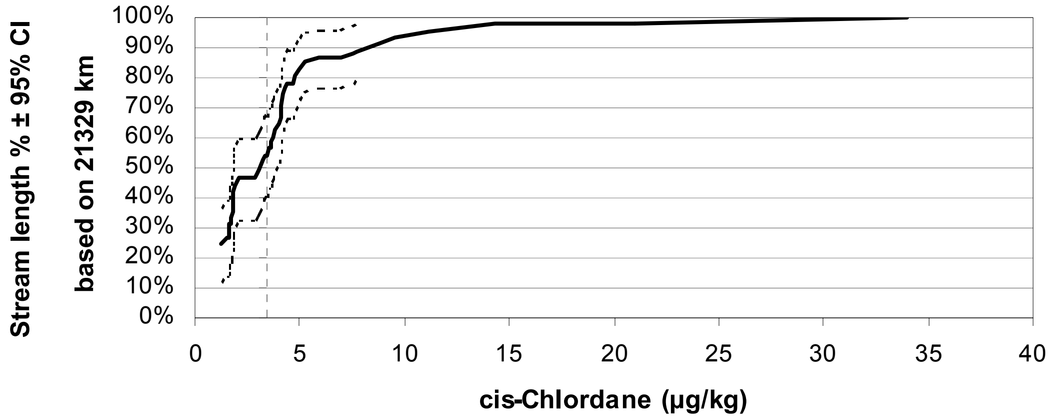

Gamma-BHC in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Chlordane, technical, in Sediment



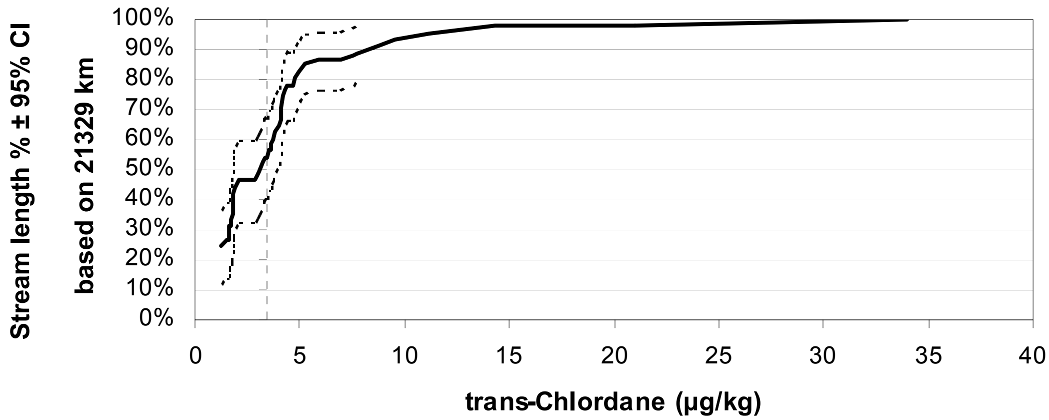

Chlordane, technical in Sediment (Random): Detect = 472 km / Nondetect = 20857 km
Scale for Chlordane does not include one outlier of 400.

## cis-Chlordane in Sediment



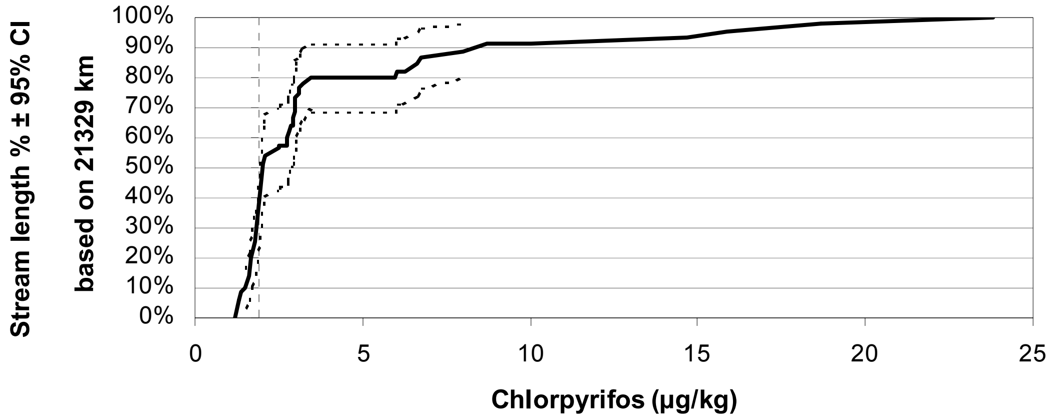

cis-Chlordane in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## trans-Chlordane in Sediment



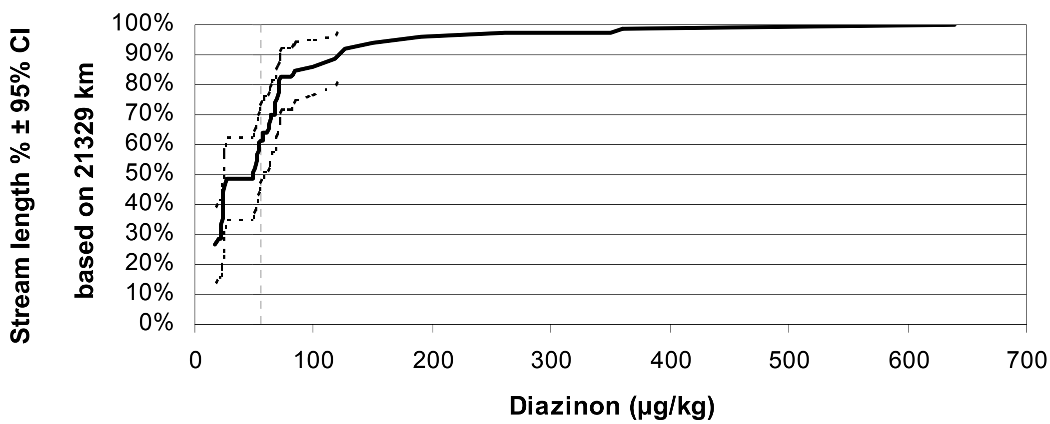

trans-Chlordane in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Chlorpyrifos in Sediment



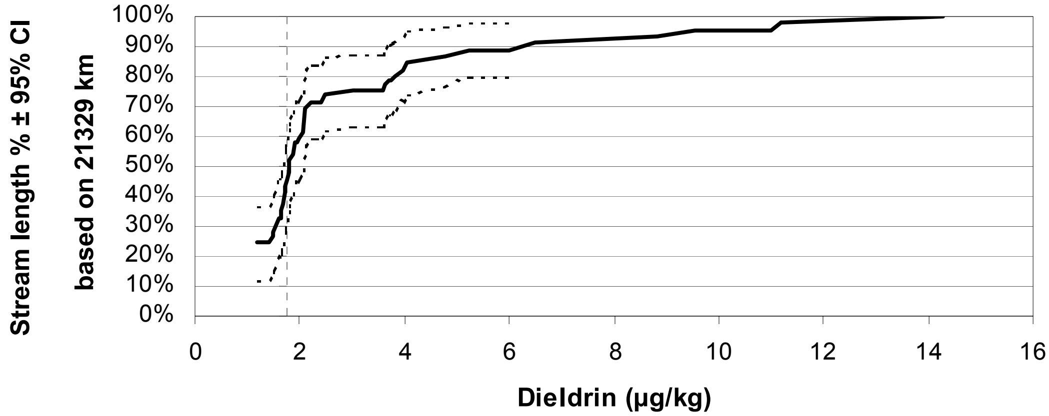

Chlorpyrifos in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Diazinon in Sediment



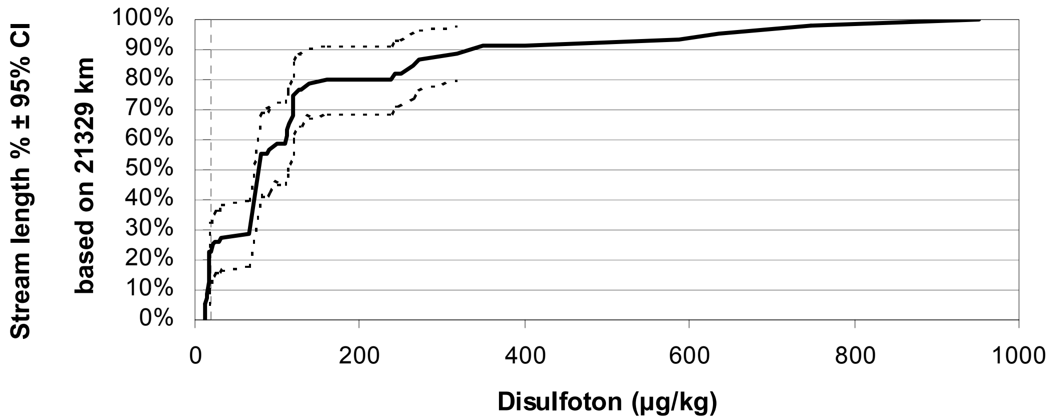

Diazinon in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Dieldrin in Sediment



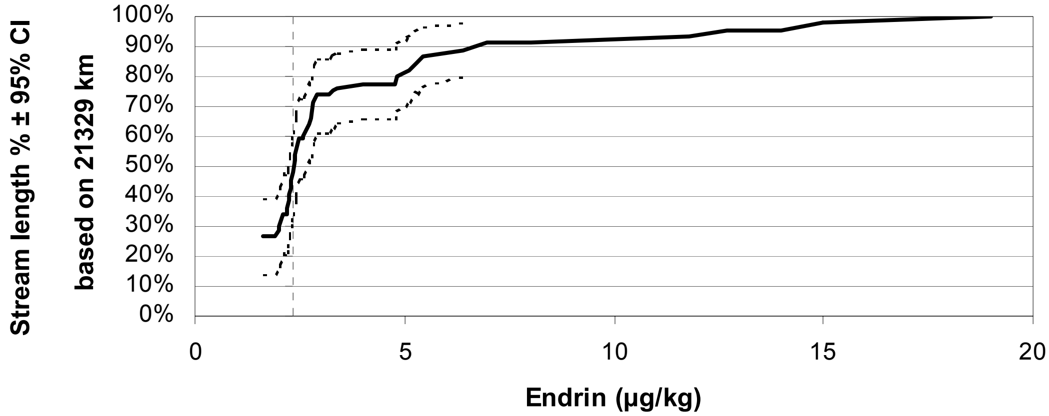

Dieldrin in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Disulfoton in Sediment



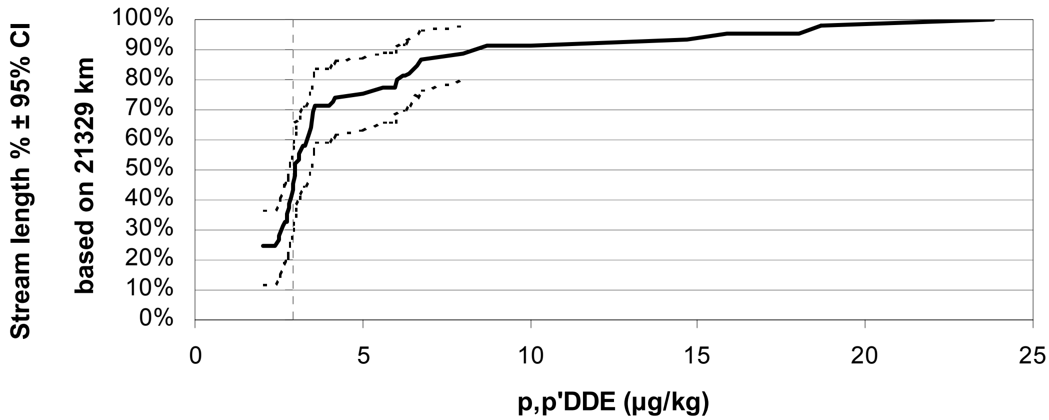

Disulfoton in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Endrin in Sediment

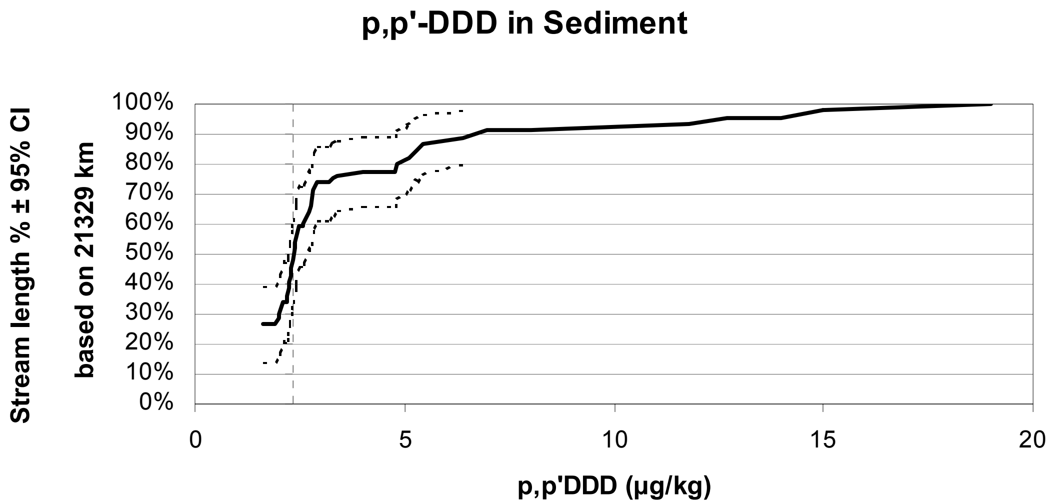



Endrin in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

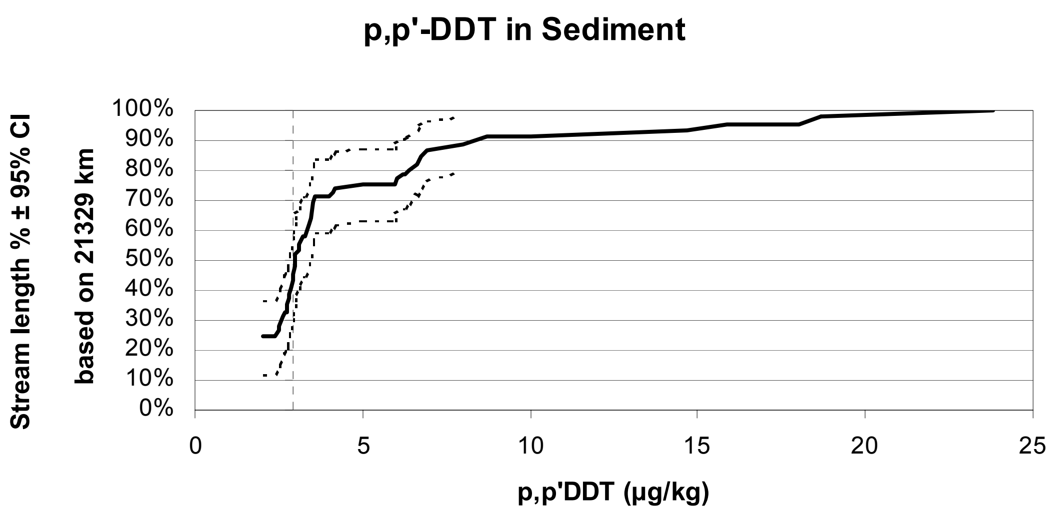
## p,p'-DDE in Sediment




p,p'-DDE in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

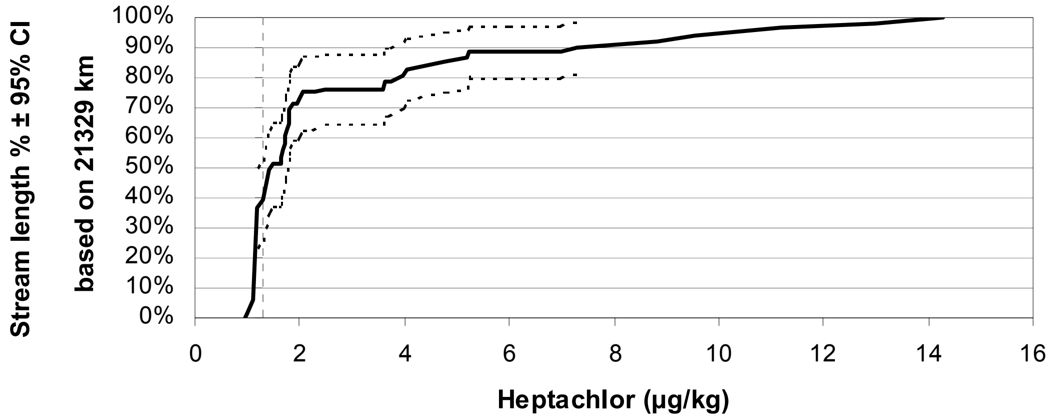



p,p'-DDD in Sediment (Random): Detect = 0 km / Nondetect = 21329 km



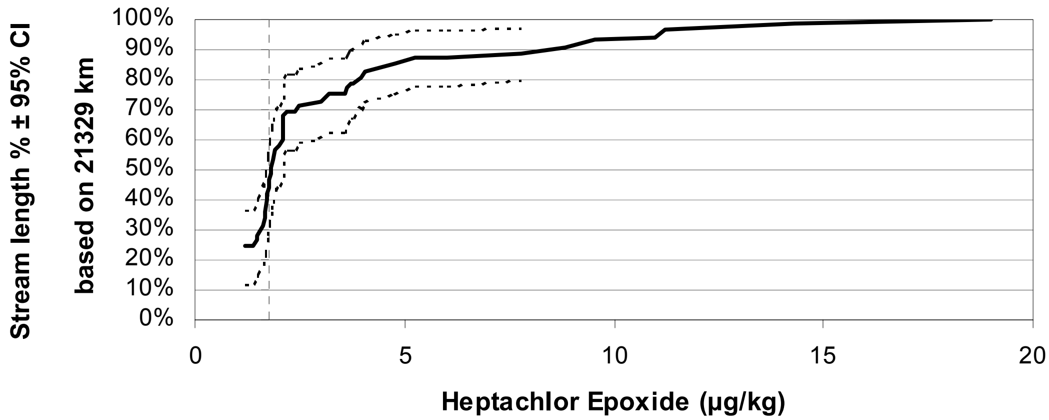

p,p'-DDT in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Heptachlor in Sediment



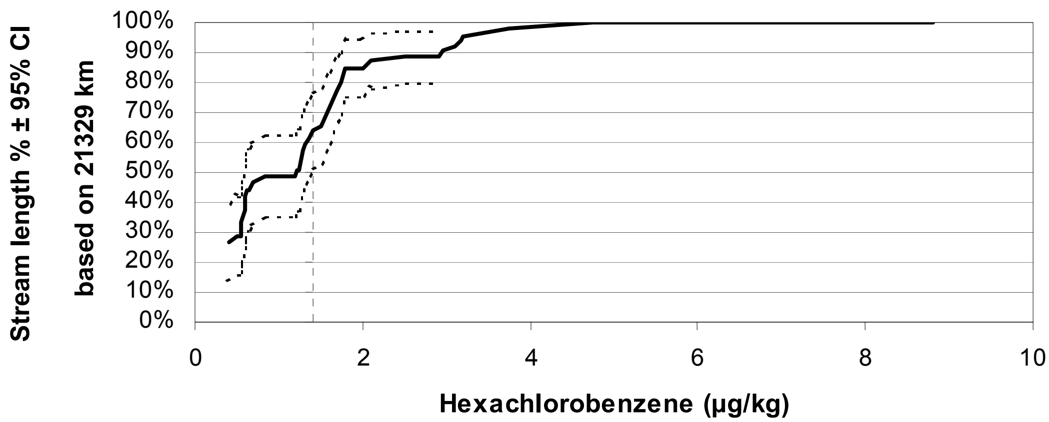

Heptachlor in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Heptachlor Epoxide in Sediment



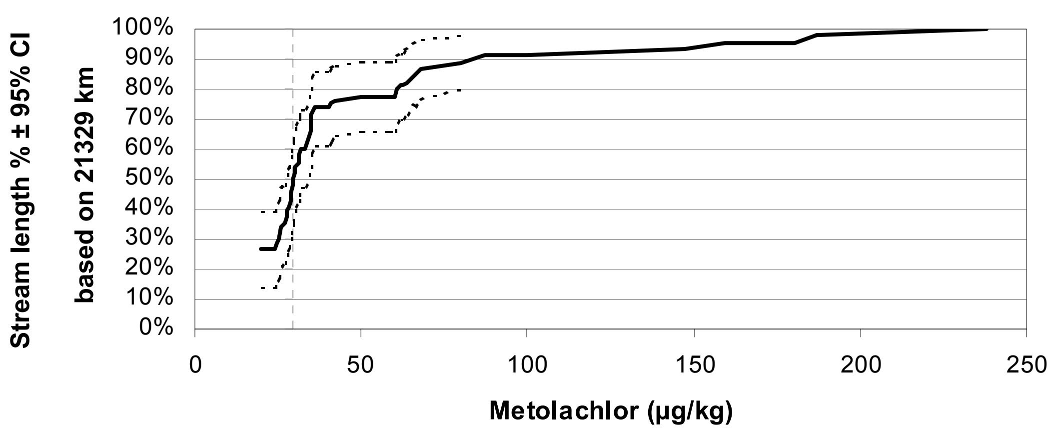

Heptachlor Epoxide in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Hexachlorobenzene in Sediment



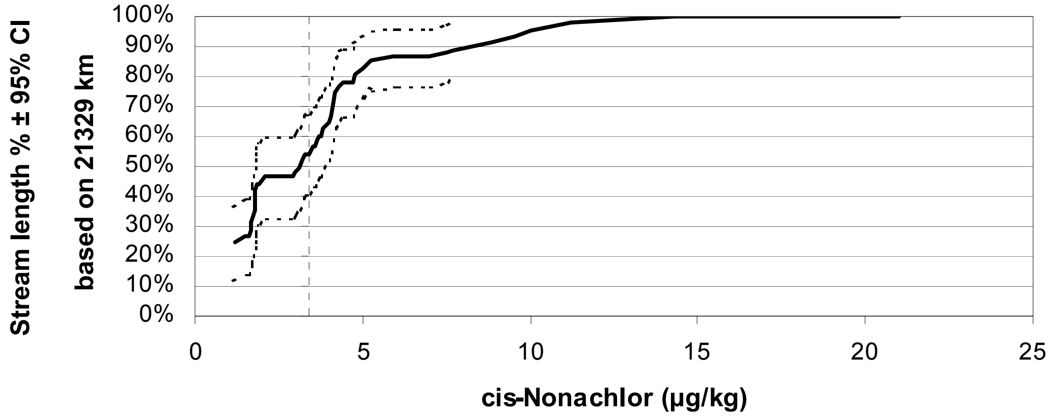

Hexachlorobenzene in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Metolachlor in Sediment



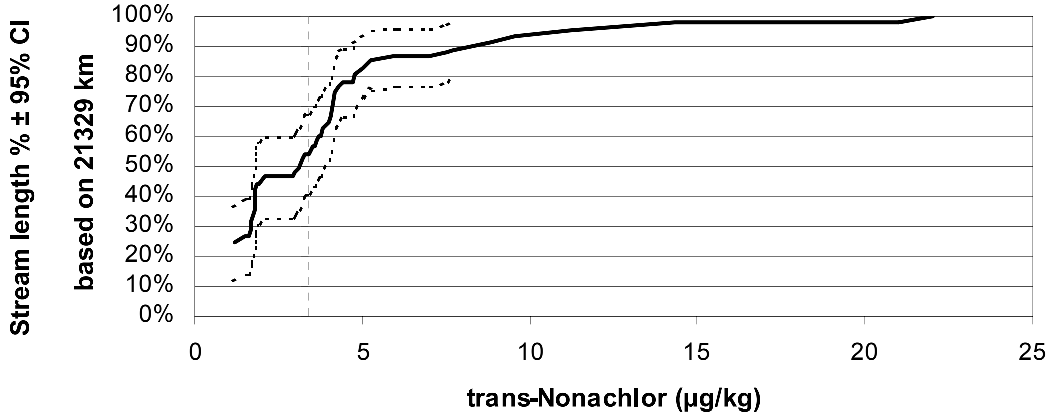

Metolachlor in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## cis-Nonachlor in Sediment



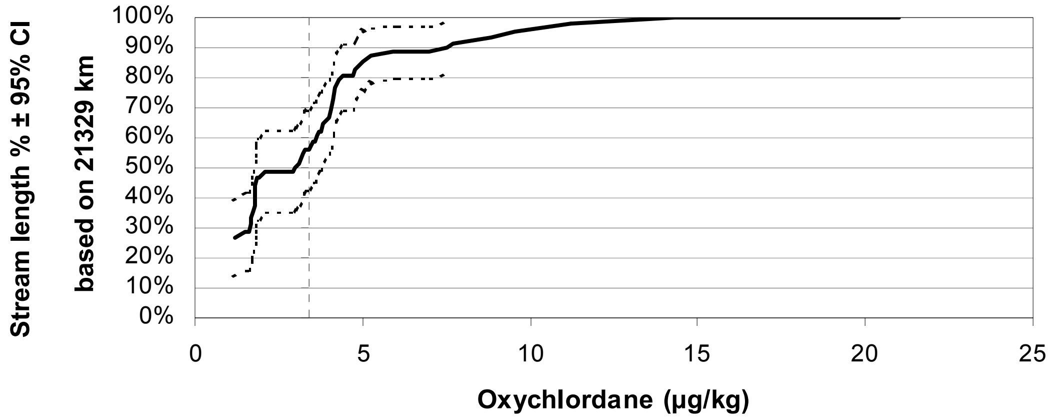

cis-Nonachlor in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## trans-Nonachlor in Sediment



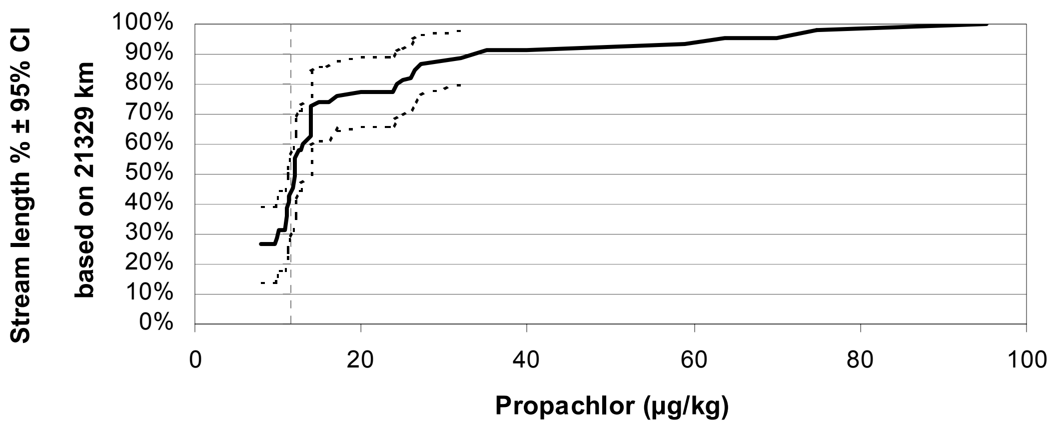

trans-Nonachlor in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Oxychlordane in Sediment



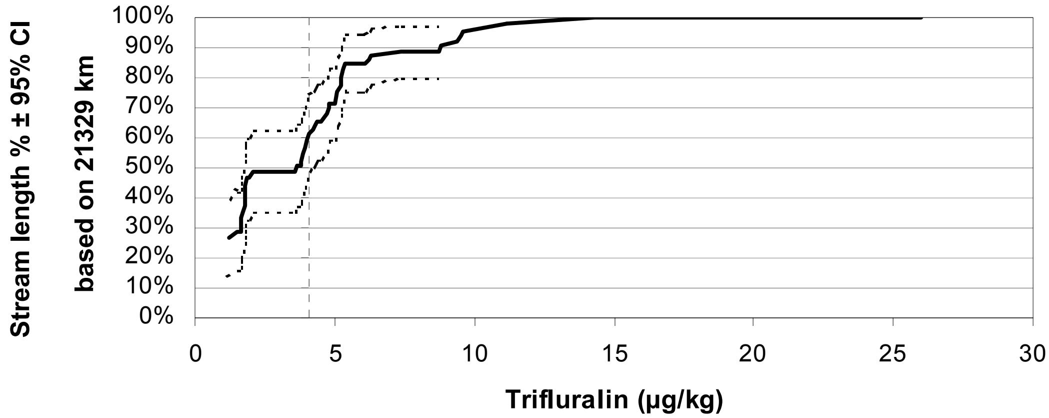

Oxychlordane in Sediment (Random): Detect = 472 km / Nondetect = 20857 km

## Propachlor in Sediment




Propachlor in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

## Trifluralin in Sediment




Trifluralin in Sediment (Random): Detect = 0 km / Nondetect = 21329 km

**Appendix H. Analytes in fish tissue: metals and biocides.** Reporting considerations are the same as in Appendix F.

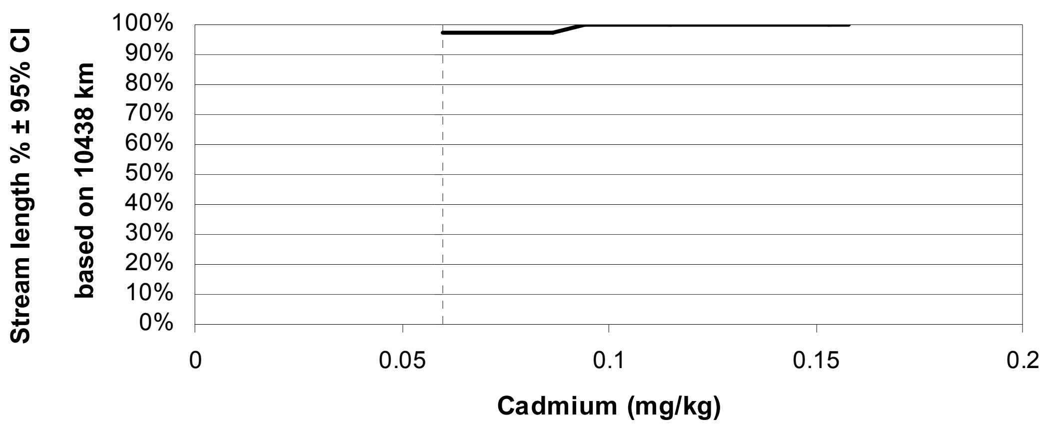
## ANALYTES IN FISH TISSUE: METALS

### Arsenic in Fish Tissue

| | | |
|---|---|---|
| Random | 10438 km | all values ≤ 0.5 mg/kg |
| Reference | 23/23 nd | median = 0.5 |

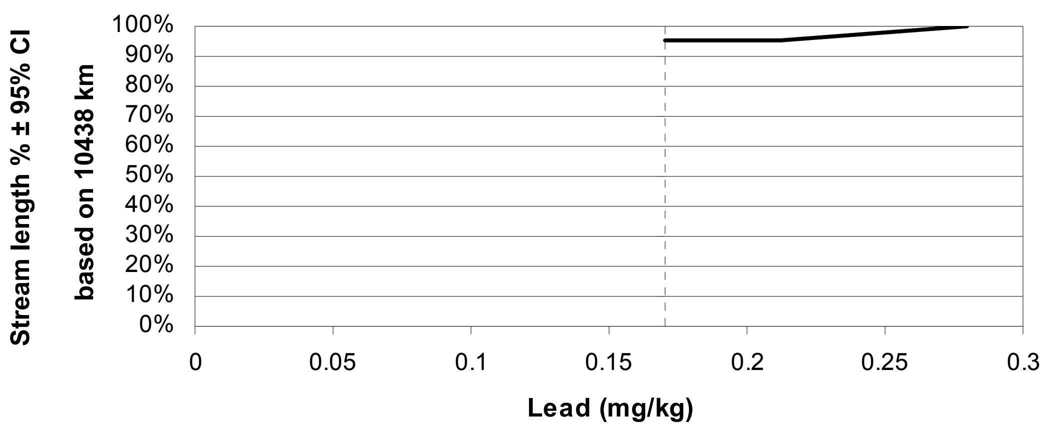
Arsenic in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

### Cadmium in Fish Tissue



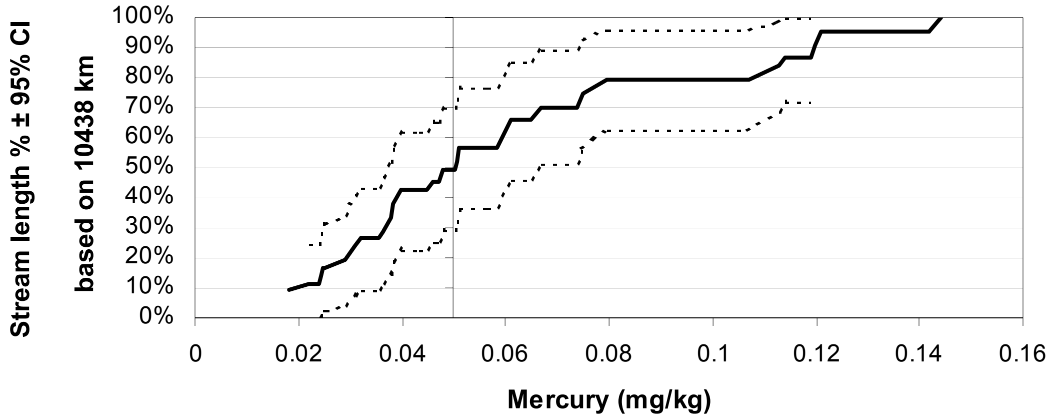

Cadmium in Fish Tissue (Random): Detect = 267 km / Nondetect = 10170 km

### Lead in Fish Tissue



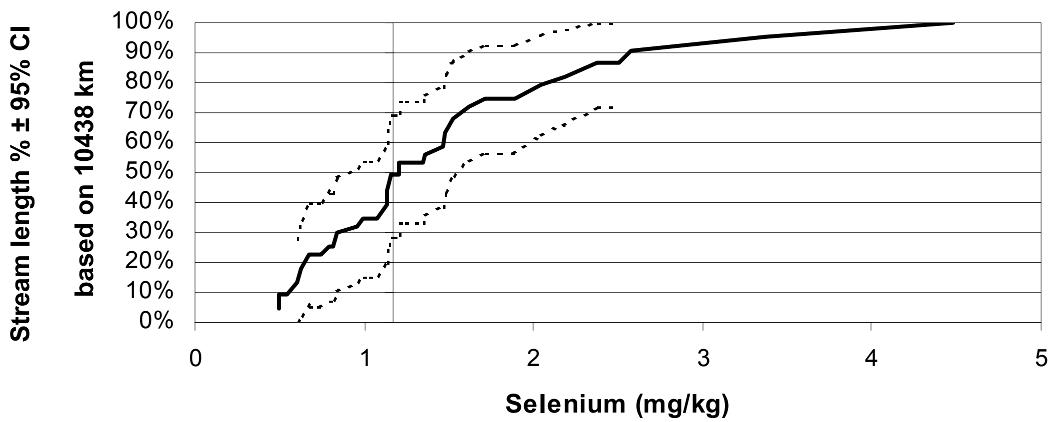

Lead in Fish Tissue (Random): Detect = 472 km / Nondetect = 9965 km

## Mercury in Fish Tissue




Mercury in Fish Tissue (Random): Detect = 9493 km / Nondetect = 945 km

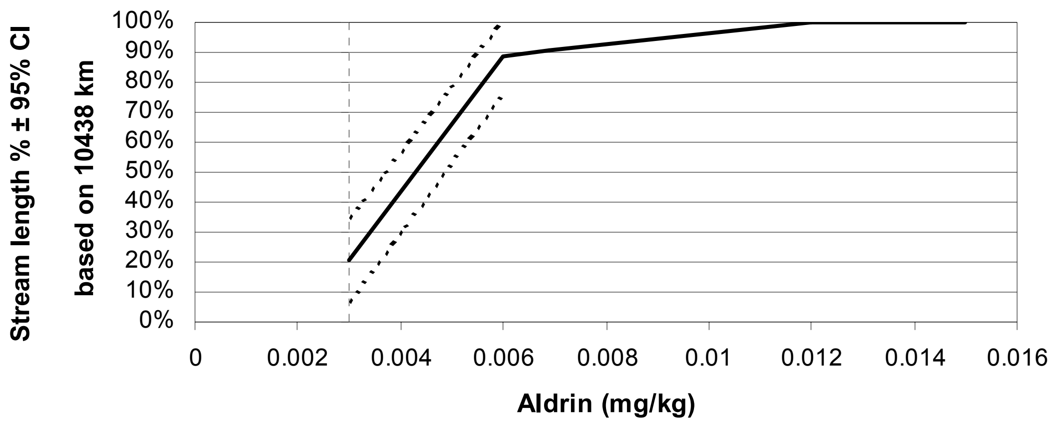
## Selenium in Fish Tissue




Selenium in Fish Tissue (Random): Detect = 9965 km / Nondetect = 472 km

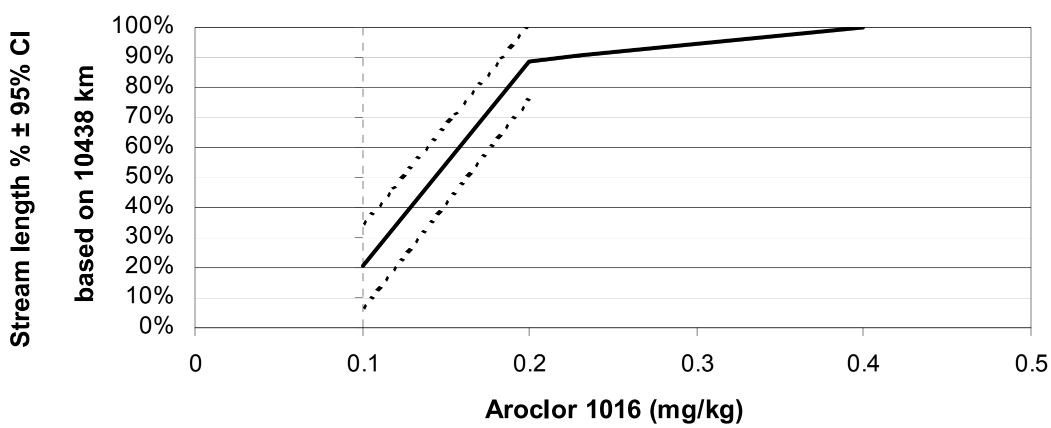
## ANALYTES IN FISH TISSUE: BIOCIDES

### Aldrin in Fish Tissue



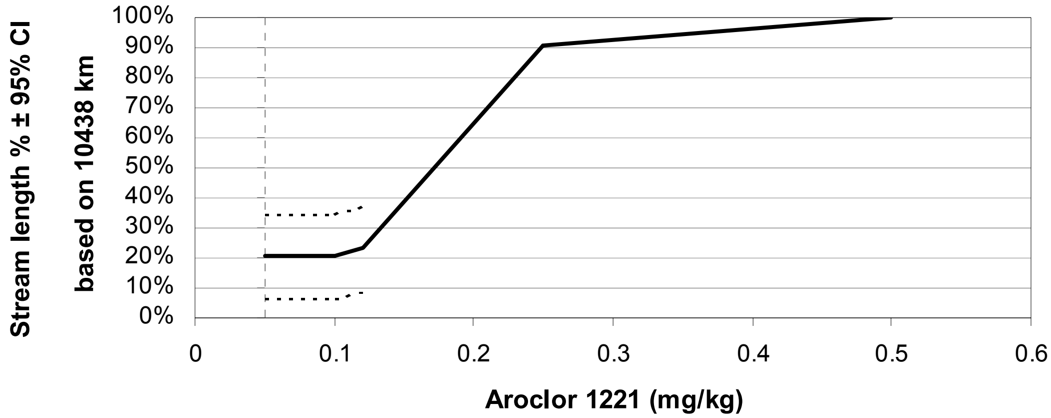

Aldrin in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

### Aroclor 1016 in Fish Tissue



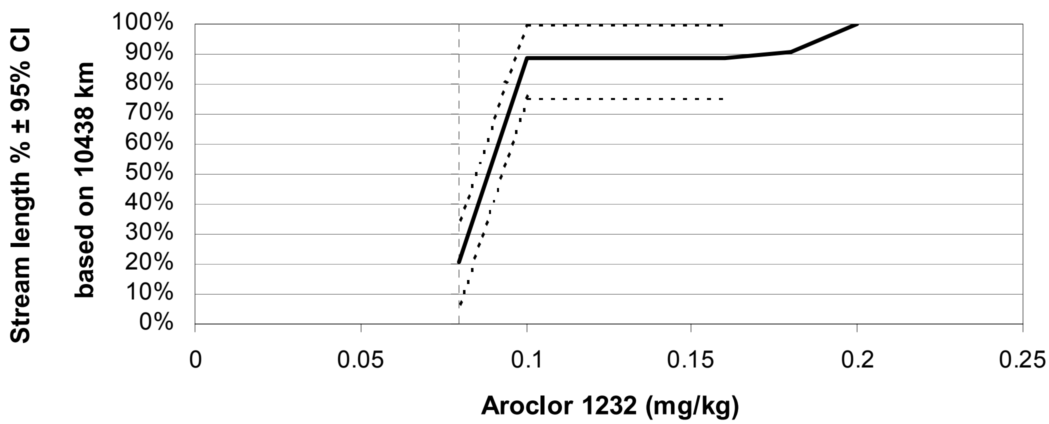

Aroclor 1016 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

## Aroclor 1221 in Fish Tissue

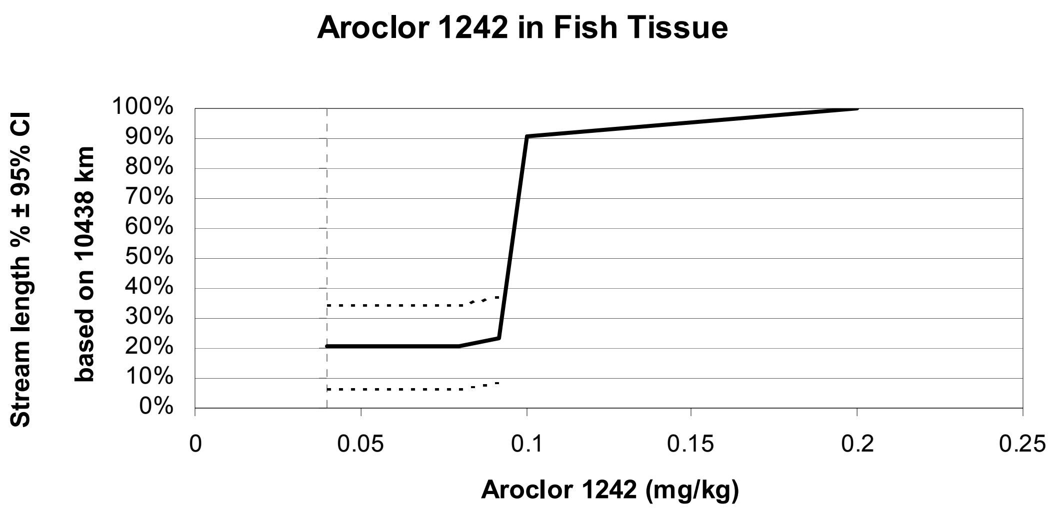



Aroclor 1221 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

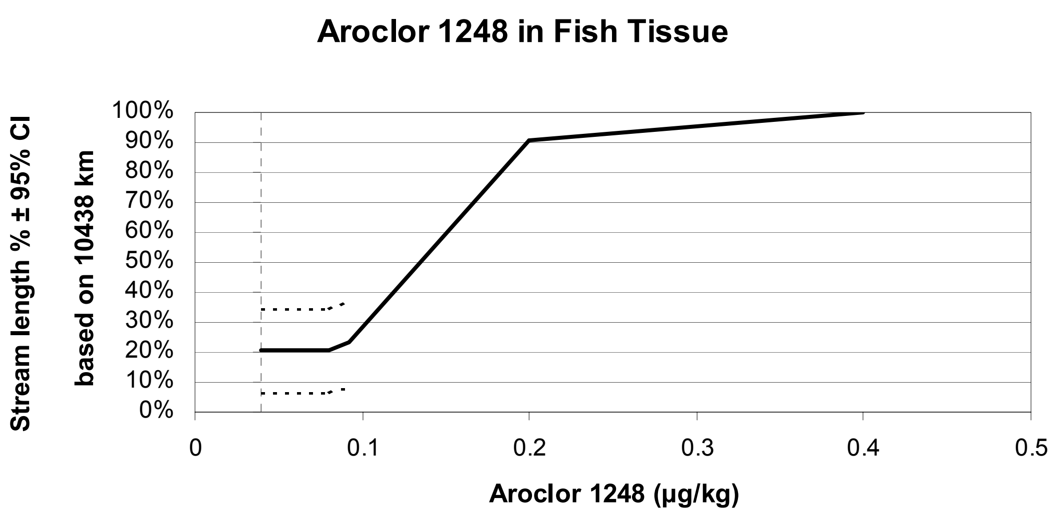
## Aroclor 1232 in Fish Tissue




Aroclor 1232 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

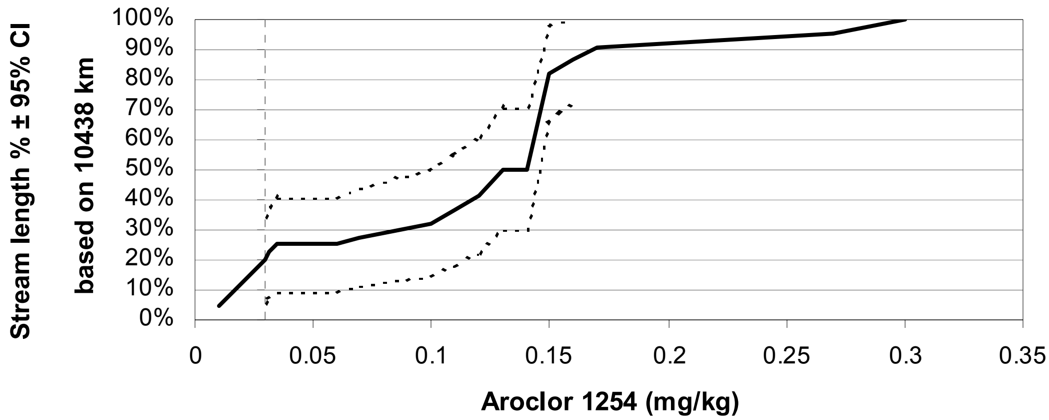



Aroclor 1242 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km



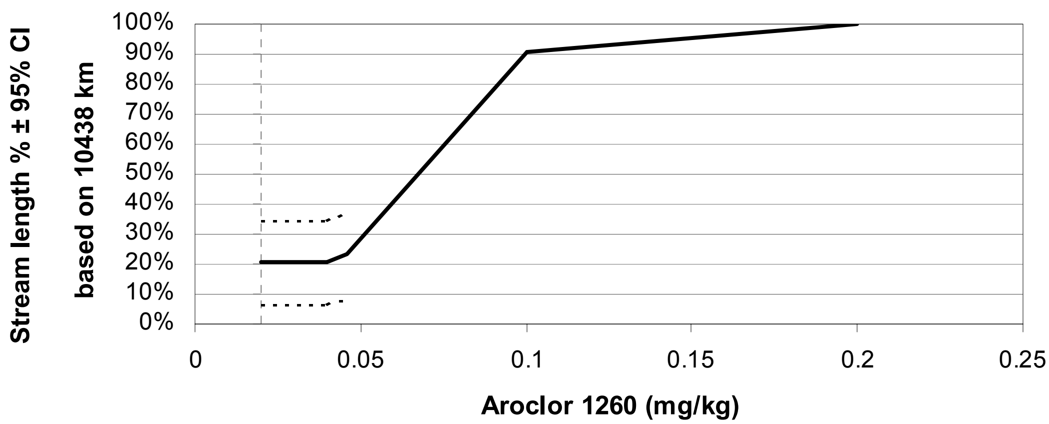

Aroclor 1248 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

## Aroclor 1254 in Fish Tissue

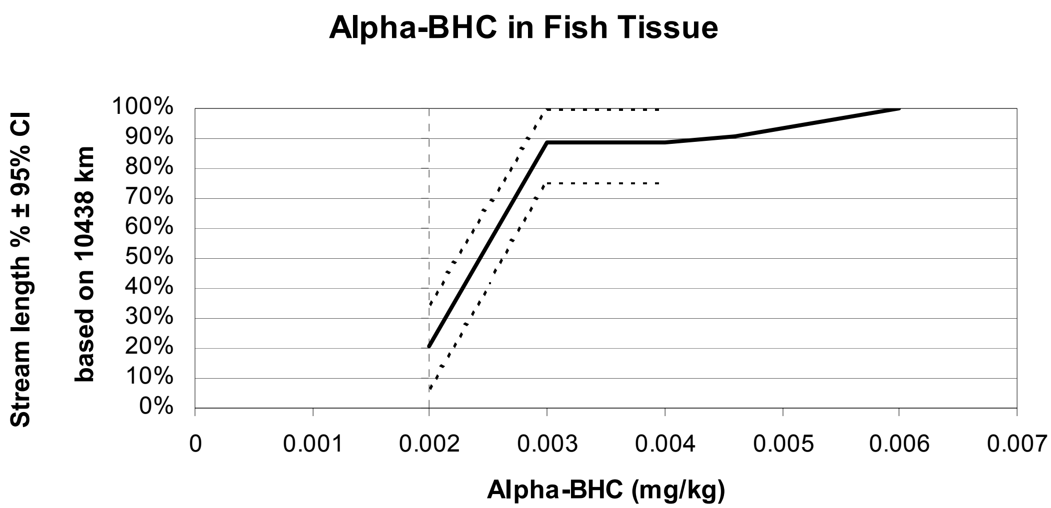



Aroclor 1254 in Fish Tissue (Random): Detect = 267 km / Nondetect = 10170 km

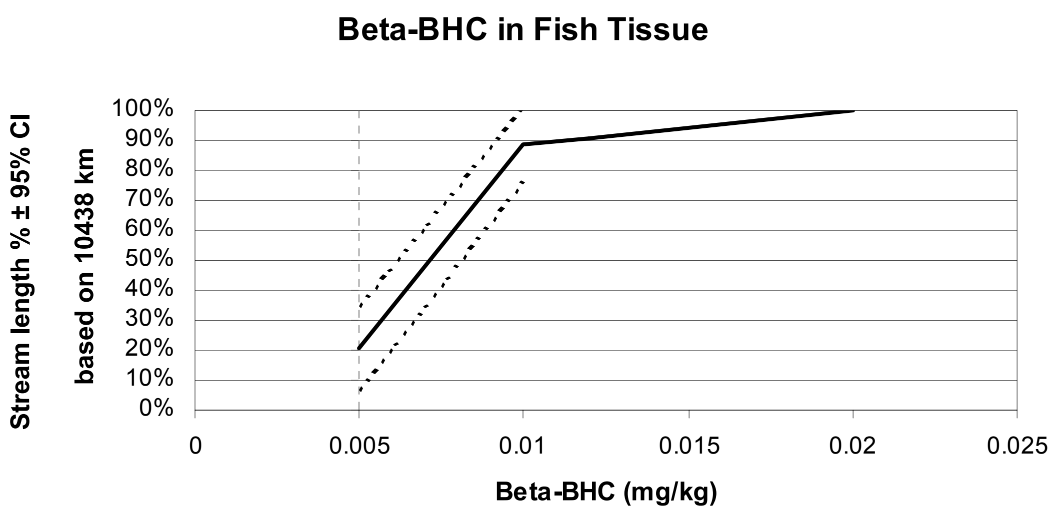
## Aroclor 1260 in Fish Tissue




Aroclor 1260 in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

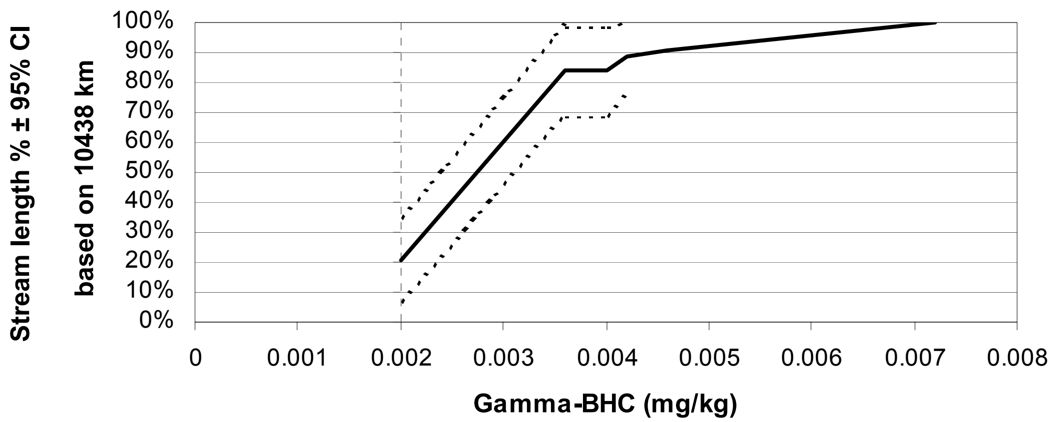



Alpha-BHC in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km



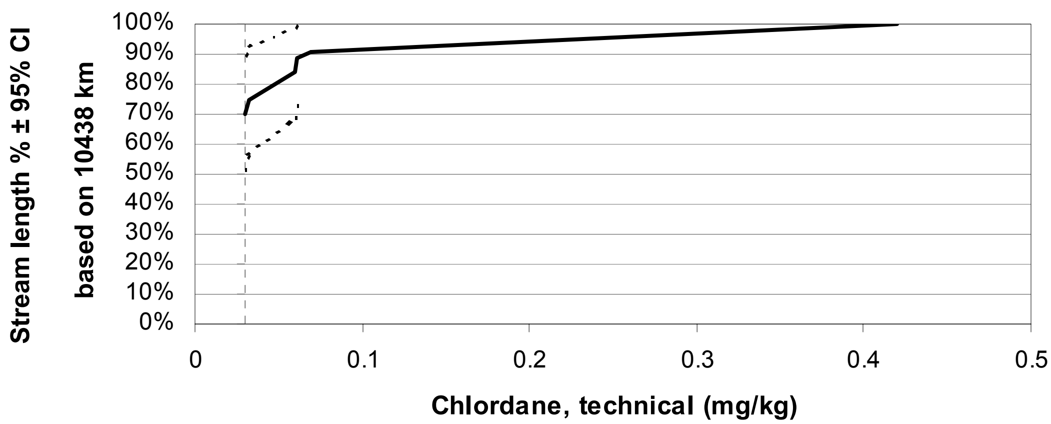

Beta-BHC in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

## Gamma-BHC in Fish Tissue



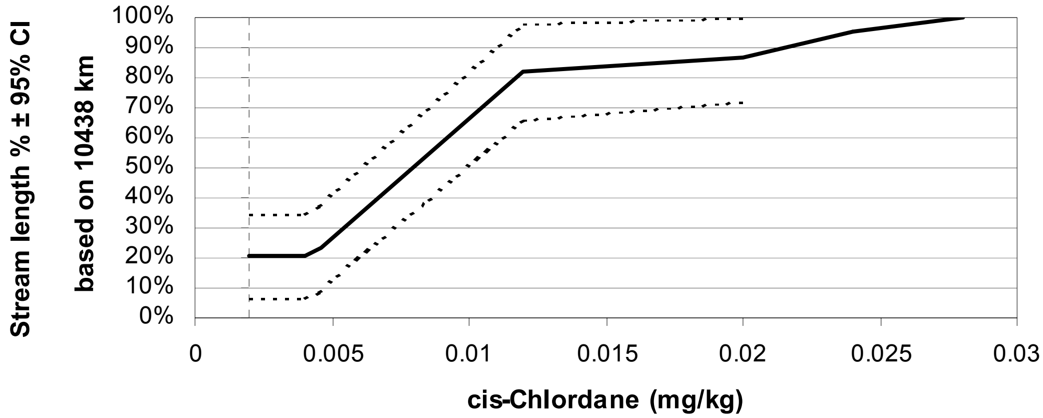

Gamma-BHC in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

## Chlordane, technical, in Fish Tissue



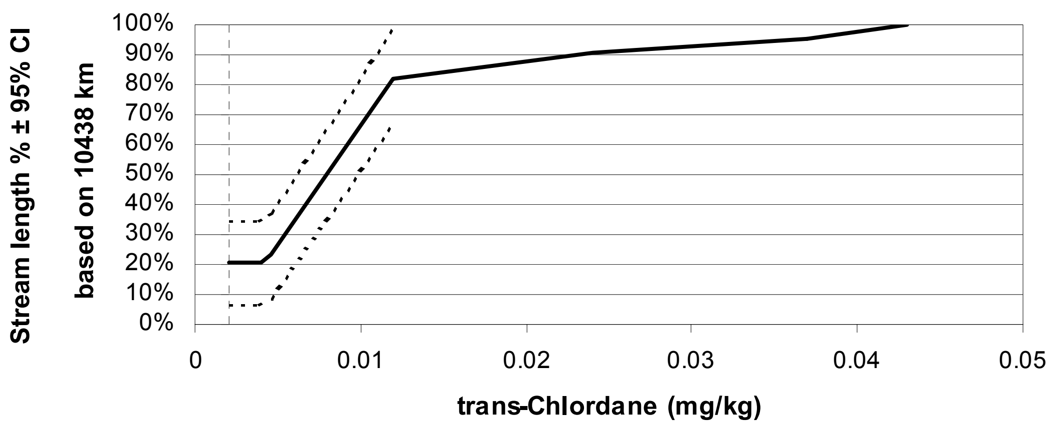

Chlordane, technical, in Fish Tissue (Random): Detect = 1890 km / Nondetect = 8548 km

## cis-Chlordane in Fish Tissue




cis-Chlordane in Fish Tissue (Random): Detect = 945 km / Nondetect = 9493 km

## trans-Chlordane in Fish Tissue



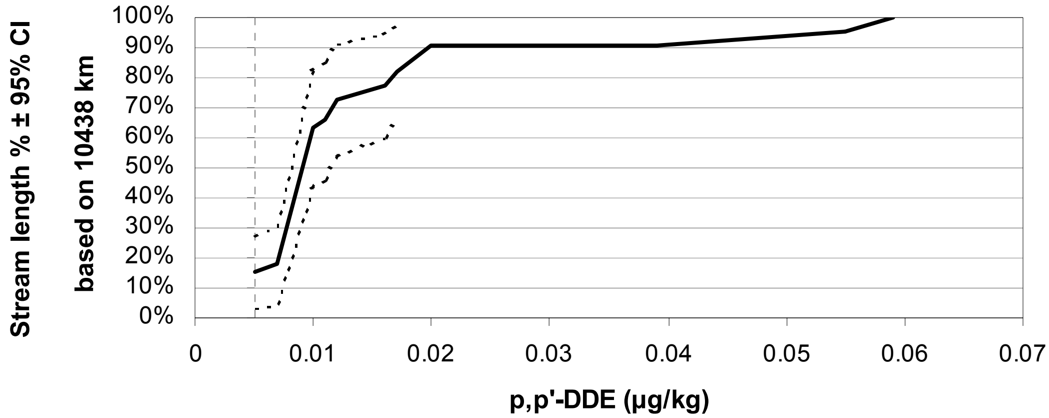

trans-Chlordane in Fish Tissue (Random): Detect = 945 km / Nondetect = 9493 km

## Chlorpyrifos in Fish Tissue

| | | |
|---|---|---|
| Random | 10437 km | all values ≤ 0.0023 mg/kg |
| Reference | 23/23 nd | median = 0.001 mg/kg |

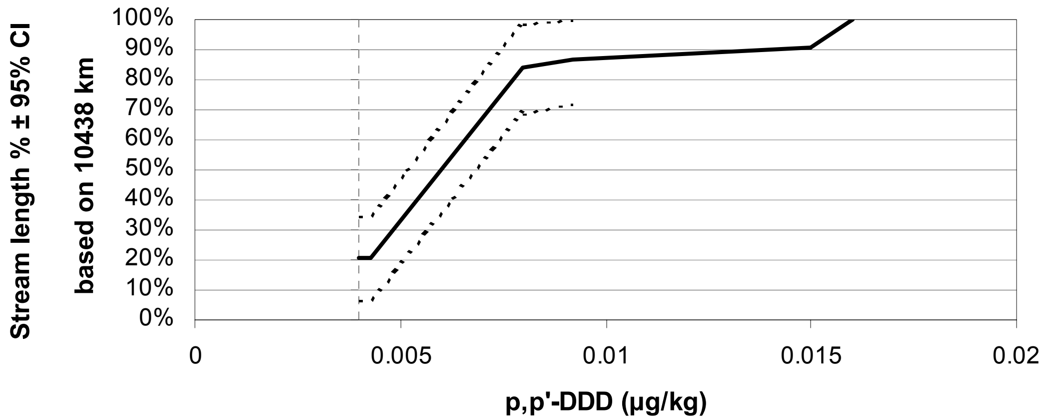
Chlorpyrifos in Fish Tissue: Detect = 0 km / Nondetect = 10438 km

## p,p'-DDE in Fish Tissue



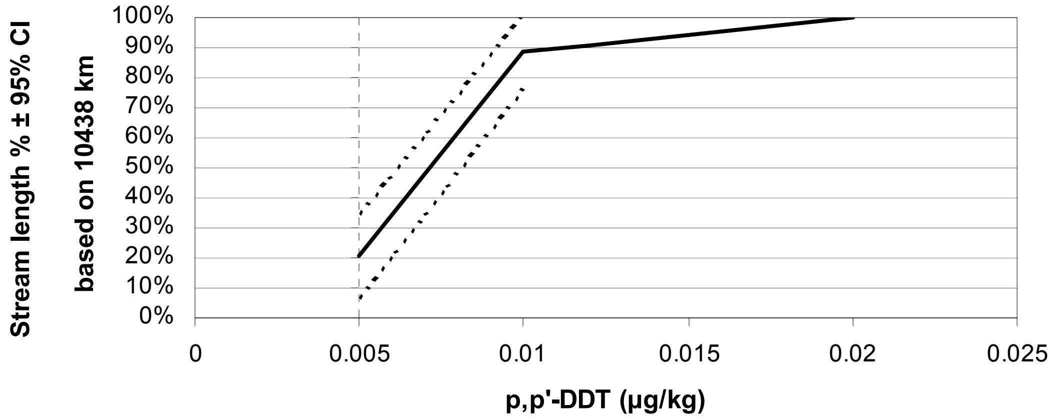

p,p'-DDE in Fish Tissue: Detect = 2897 km / Nondetect = 7541 km

## p,p'-DDD in Fish Tissue




p,p'-DDD in Fish Tissue: Detect = 472 km / Nondetect = 9965 km

## p,p'-DDT in Fish Tissue



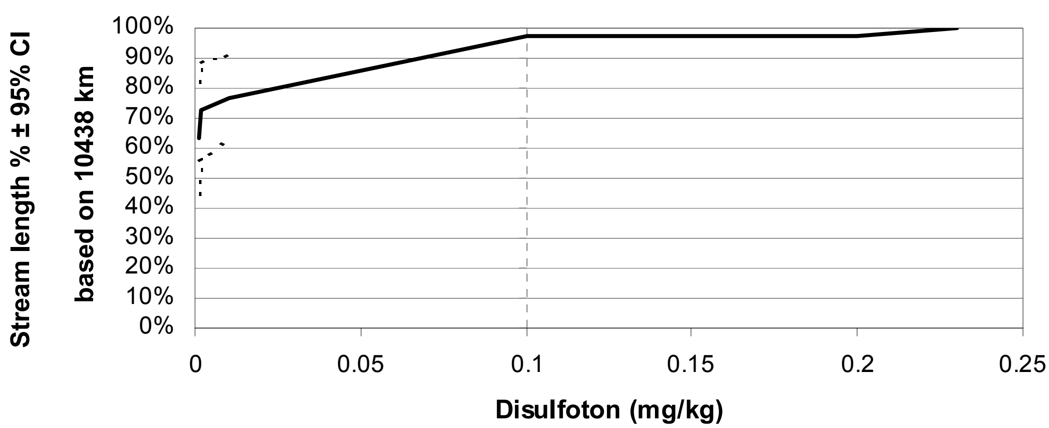

p,p'-DDT in Fish Tissue: Detect = 0 km / Nondetect = 10438 km

## Diazinon in Fish Tissue

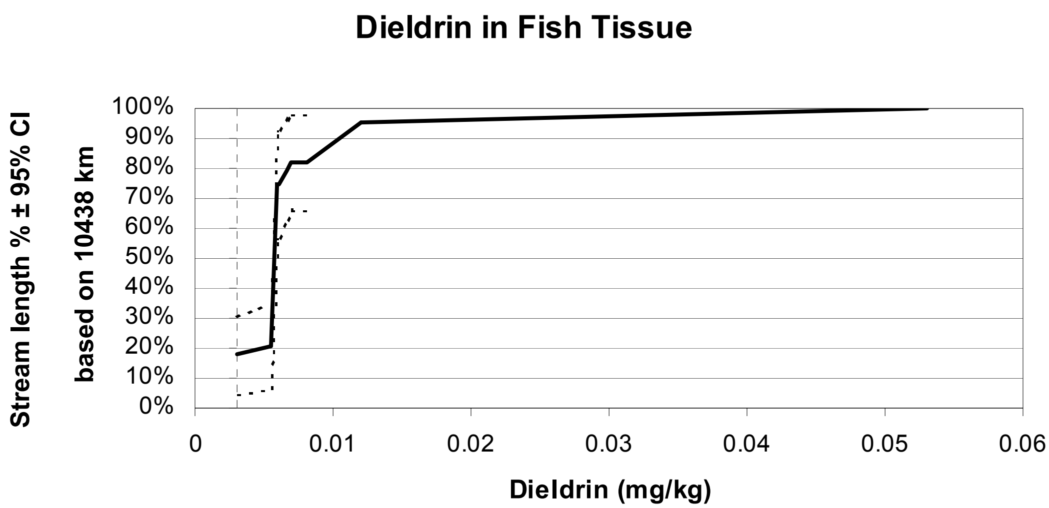
| | | |
|---|---|---|
| Random | 8032 km | all values ≤ 0.4 mg/kg |
| Reference | 8/23 nd | median = 0.2 |

Diazinon in Fish Tissue: Detect = 0 km / Nondetect = 8032 km

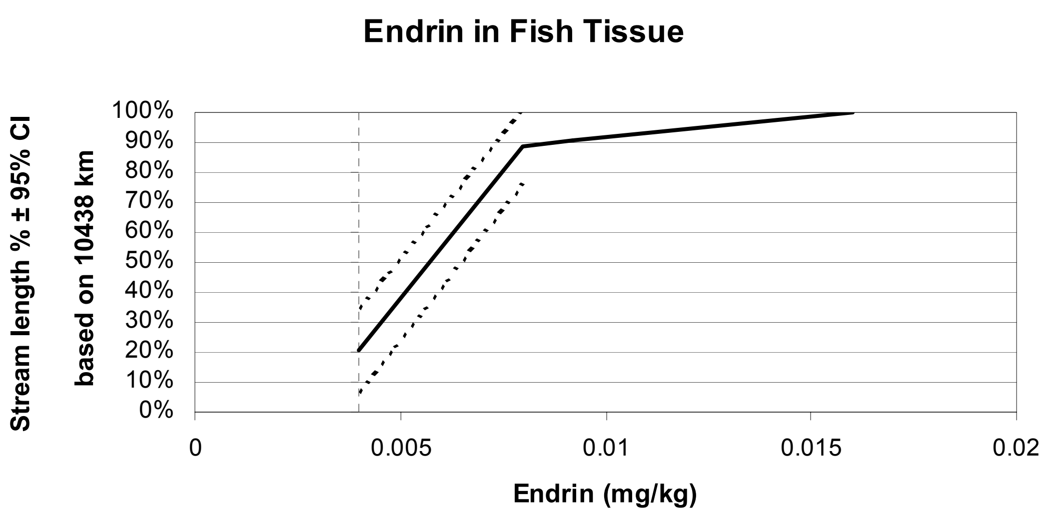
## Disulfoton in Fish Tissue



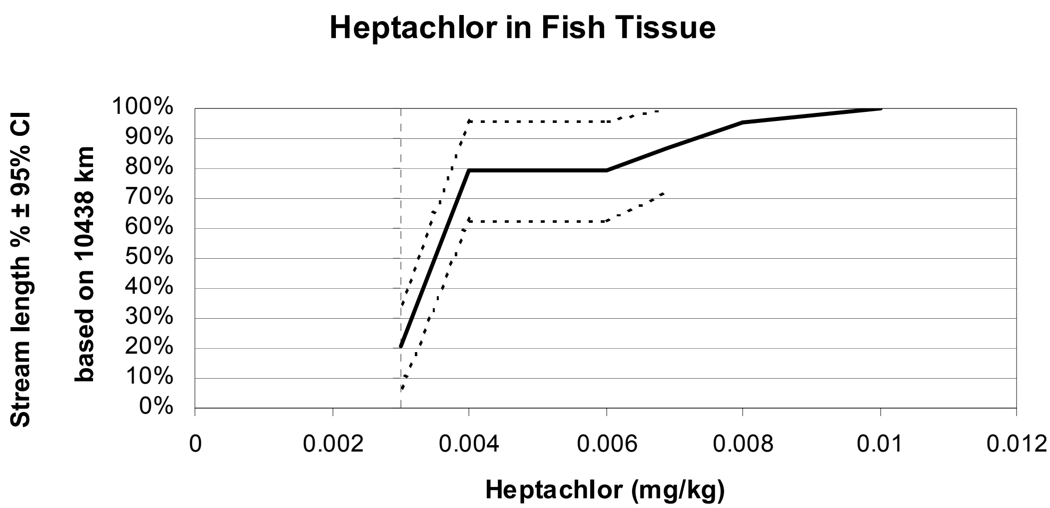

Disulfoton in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km



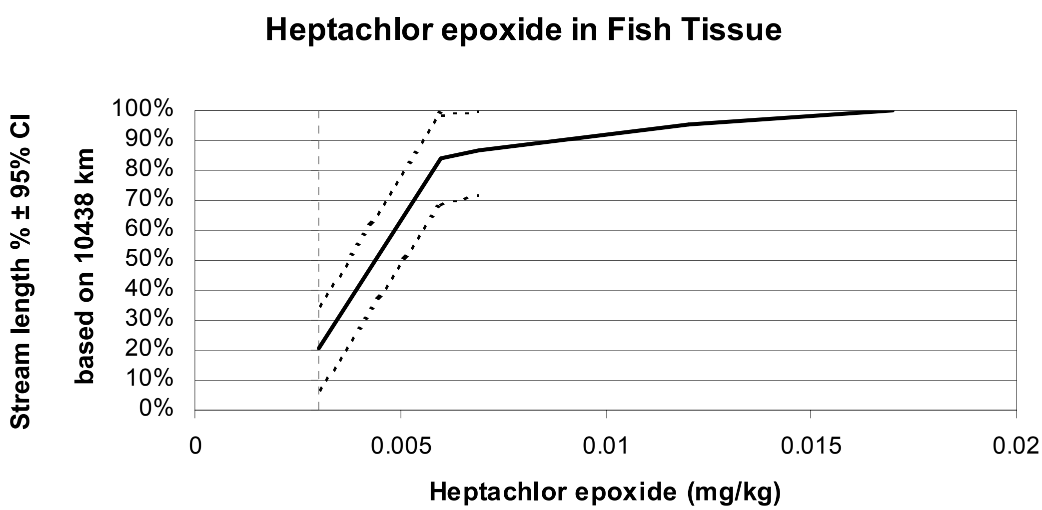

Dieldrin in Fish Tissue (Random): Detect = 1685 km / Nondetect = 8753 km




Endrin in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

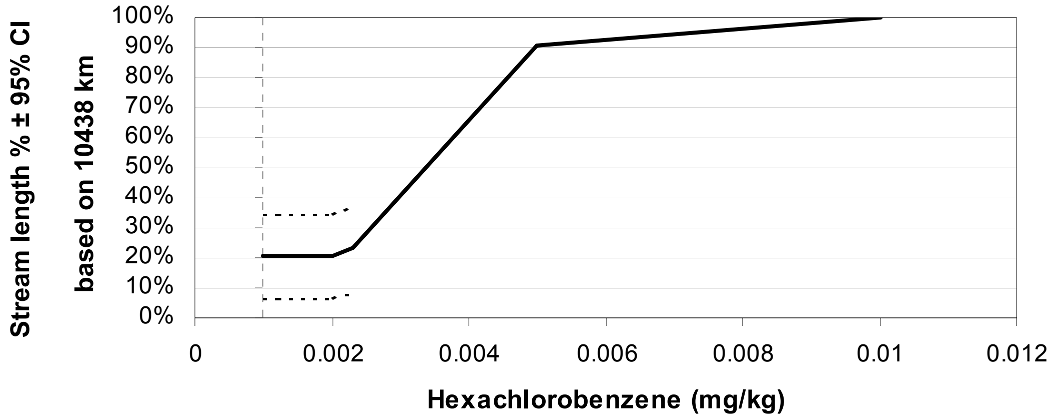



Heptachlor in Fish Tissue (Random): Detect = 945 km / Nondetect = 9493 km



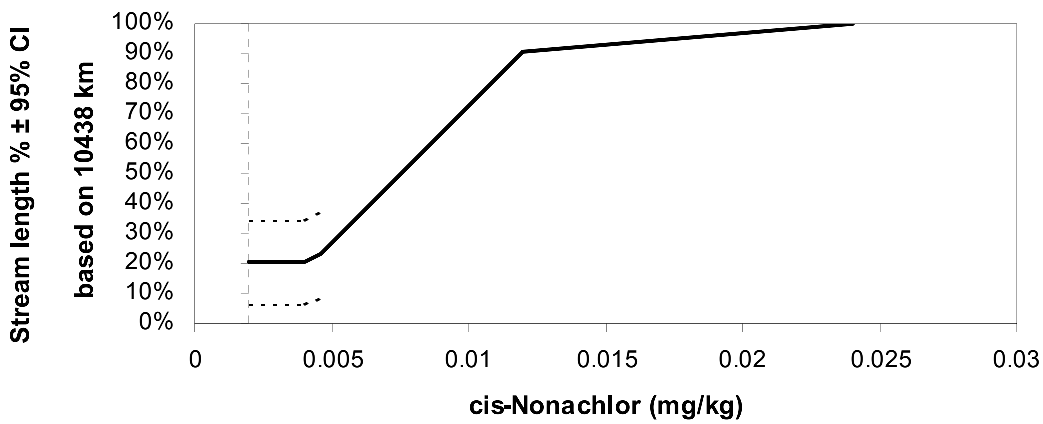

Heptachlor epoxide in Fish Tissue (Random): Detect = 472 km / Nondetect = 9965 km

## Hexachlorobenzene in Fish Tissue



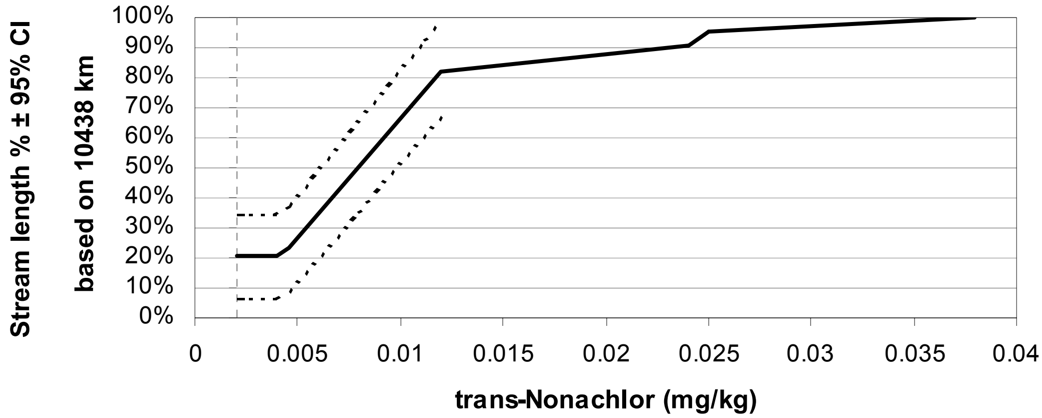

Hexachlorobenzene in Fish Tissue (Random): Detect = 0 km / Nondetect = 10438 km

## cis-Nonachlor in Fish Tissue



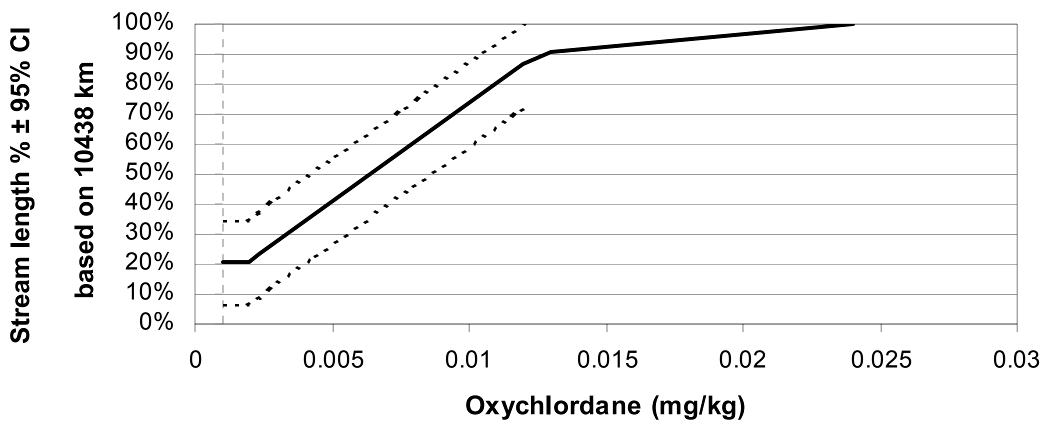

cis-Nonachlor in Fish Tissue (Random): Detect = 472 km / Nondetect = 9965 km

## trans-Nonachlor in Fish Tissue




trans-Nonachlor in Fish Tissue (Random): Detect = 1212 km / Nondetect = 9225 km

## Oxychlordane in Fish Tissue




Oxychlordane in Fish Tissue (Random): Detect = 472 km / Nondetect = 9965 km

**Appendix I. Water, sediment, and tissue chemistry compared to criteria, benchmarks, and guidelines.** Note that estimates are derived only from the "random" population of sites.

**Water chemistry.** Criteria are from the Kansas Aquatic Life Use Criteria (KDHE Bureau of Water 2004) and values are expressed as the estimated number of wadeable stream km in Kansas (out of 21,239 total), plus or minus 95% confidence intervals, that would meet or fail to meet the ALU criteria. A single asterisk (*) indictes analytes for which the criterion was calculated on a site-specific basis because of its dependence on hardness (metals) or pH and temperature (ammonia). Nondetect values represent only those sites for which the nondetect reporting limit was *above* the ALU criterion; when the reporting limit was below the ALU criterion, it was considered to have met the criterion. Criteria for dissolved oxygen, pH, and temperature are the same for expected, special, and restricted categories. "N/A" sites are those for which data were not available and/or criteria were not calculable.

| ANALYTE | ALU CRITERION | CATEGORY | | | |
|---|---|---|---|---|---|
| | | PASS | FAIL | NONDETECT | N/A |
| temperature | (all) | 20322 ± 1467 | | | 1480 ± 1467 |
| dissolved oxy | (all) | 14814 ± 2701 | 5980 ± 2578 | | 1007 ± 1172 |
| pH | (all) | 20527 ± 1277 | 267 ± 527 | | 1007 ± 1172 |
| silver | acute* | 8343 ± 2846 | | 12986 ± 2846 | |
| chromium | chronic | 21329 ± 0 | | | |
| copper | acute* | 21329 ± 0 | | | |
| copper | chronic* | 21329 ± 0 | | | |
| nickel | acute* | 21329 ± 0 | | | |
| nickel | chronic* | 21329 ± 0 | | | |
| zinc | acute* | 21329 ± 0 | | | |
| zinc | chronic* | 21329 ± 0 | | | |
| arsenic | acute | 21329 ± 0 | | | |
| arsenic | chronic | 21329 ± 0 | | | |
| cadmium | acute* | 21329 ± 0 | | | |
| cadmium | chronic* | | | | |
| lead | acute* | 21329 ± 0 | | | |
| lead | chronic* | 17549 ± 2362 | 3780 ± 2362 | | |
| selenium | acute | 21329 ± 0 | | | |
| selenium | chronic | 19849 ± 1466 | 1480 ± 1466 | | |
| mercury | acute | 21329 ± 0 | | | |
| mercury | chronic | 21062 ± 527 | 267 ± 527 | | |
| alachlor | acute | 20857 ± 923 | | | 472 ± 923 |
| alachlor | chronic | 20857 ± 923 | | | 472 ± 923 |
| propachlor | chronic | 20857 ± 923 | | | 472 ± 923 |
| atrazine | acute | 20857 ± 923 | | | 472 ± 923 |
| atrazine | chronic | 20117 ± 1380 | 740 ± 1055 | | 472 ± 923 |
| chlorpyrifos | acute | 20857 ± 923 | | | 472 ± 923 |
| chlorpyrifos | chronic | | 472 ± 923 | 20384 ± 1288 | 472 ± 923 |
| diazinon | chronic | 11339 ± 2881 | | 9518 ± 2845 | 472 ± 923 |
| chloride | acute | 21062 ± 527 | | | 267 ± 527 |

| ANALYTE | ALU CRITERION | CATEGORY | | | |
|---|---|---|---|---|---|
| ammonia | acute, no salmonids* | 20794 ± 743 | | | 535 ± 743 |
| ammonia | chronic, early life pres.* | | | | 21329 ± 0 |
| ammonia | chronic, no early life* | 19725 ± 1272 | 535 ± 743 | 535 ± 743 | 535 ± 743 |
| chlordane, technical | acute | 20857 ± 923 | | | 472 ± 923 |
| chlordane, technical | chronic | | | 20857 ± 923 | 472 ± 923 |

**Sediment Benchmarks.** Guidelines are derived from the document, "Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines" (Ingersoll, MacDonald et al. 2000). All values are expressed in estimated number of Kansas wadeable stream km (out of 26,445) plus or minus 95% CI. Other reporting considerations are as for water chemistry.

| ANALYTE | CATEGORY | | | |
|---|---|---|---|---|
| | PASS | FAIL | NDT | NA |
| Arsenic | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Cadmium | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Chlordane | 16070 ± 3210 | 472 ± 923 | 4787 ± 2596 | 5116 ± 2589 |
| Chromium | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Copper | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Dieldrin | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Endrin | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Heptachlor Epoxide | 21062 ± 2621 | 0 ± 0 | 267 ± 527 | 5116 ± 2589 |
| Lead | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Lindane (gamma BHC) | 18905 ± 2960 | 0 ± 0 | 2424 ± 1911 | 5116 ± 2589 |
| Mercury | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Nickel | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| SumDDD | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| SumDDE | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| SumDDT | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |
| Zinc | 21329 ± 2589 | 0 ± 0 | 0 ± 0 | 5116 ± 2589 |

**Fish Tissue Guidelines.** Whole-fish guidelines are not available for human consumption. Therefore, whole fish tissue chemistry here is compared to filet tissue screening values for designation of "green areas" for human consumption; estimates should be interpreted with caution. REC = recreational fishing; SUB = subsistence fishing. All values are expressed in estimated number of stream km (out of 26445) plus or minus 95% confidence interval. Other reporting considerations are as for water chemistry.

| ANALYTE - guideline | PASS | FAIL | Nondetect | Unknown | NA |
|---|---|---|---|---|---|
| AroclorSum - REC | 10170 ± 3191 | 267 ± 527 | | | 16008 ± 3199 |
| AroclorSum - SUB | | 267 ± 527 | | 10170 ± 3191 | 16008 ± 3199 |
| Arsenic - REC | | | 10438 ± 3199 | | 16008 ± 3199 |
| Arsenic - SUB | | | 10438 ± 3199 | | 16008 ± 3199 |
| Cadmium - REC | 10438 ± 3199 | | | | 16008 ± 3199 |

| ANALYTE - guideline | PASS | FAIL | Nondetect | Unknown | NA |
|---|---|---|---|---|---|
| Cadmium - SUB | 10438 ± 3199 | | | | 16008 ± 3199 |
| ChlordaneSum - REC | 9493 ± 3136 | 945 ± 1292 | | | 16008 ± 3199 |
| ChlordaneSum - SUB | | 1890 ± 1789 | | 8548 ± 3050 | 16008 ± 3199 |
| Chlorpyrifos - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Chlorpyrifos - SUB | 10438 ± 3199 | | | | 16008 ± 3199 |
| DDTsum - REC | | | | 10438 ± 3199 | 16008 ± 3199 |
| DDTsum - SUB | | 945 ± 1292 | | 9493 ± 3136 | 16008 ± 3199 |
| Dieldrin - REC | | 1685 ± 1641 | 8753 ± 3083 | | 16008 ± 3199 |
| Dieldrin - SUB | | 1685 ± 1641 | 8753 ± 3083 | | 16008 ± 3199 |
| Disulfoton - REC | 10170 ± 3191 | | 267 ± 527 | | 16008 ± 3199 |
| Disulfoton - SUB | 8032 ± 3116 | | 2406 ± 1549 | | 16008 ± 3199 |
| Endrin - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Endrin - SUB | 10438 ± 3199 | | | | 16008 ± 3199 |
| HeptachlorEpoxide - REC | 2139 ± 1464 | 472 ± 923 | 7826 ± 3082 | | 16008 ± 3199 |
| HeptachlorEpoxide - SUB | | 472 ± 923 | 9965 ± 3170 | | 16008 ± 3199 |
| Hexachlorobenzene - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Hexachlorobenzene - SUB | 2406 ± 1549 | | 8032 ± 3116 | | 16008 ± 3199 |
| Lindane - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Lindane - SUB | 8753 ± 3083 | | 1685 ± 1641 | | 16008 ± 3199 |
| Mercury - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Mercury - SUB | 5918 ± 2682 | 4519 ± 2564 | | | 16008 ± 3199 |
| Selenium - REC | 10438 ± 3199 | | | | 16008 ± 3199 |
| Selenium - SUB | 9493 ± 3136 | 945 ± 1292 | | | 16008 ± 3199 |

**Appendix J. Physical habitat characteristics of reference sites.** This table shows summary statistics for the 30 reference sites.

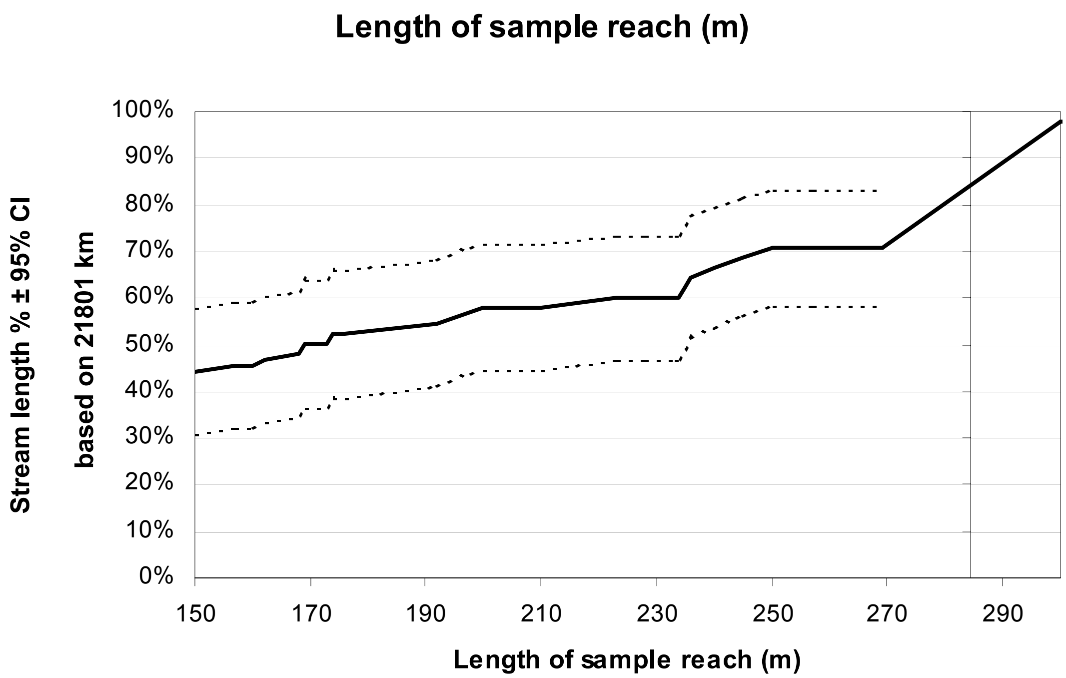
| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all |
|---|---|---|---|---|---|---|---|---|---|
| xbka | Bank Angle--mean (degrees) | 30 | 14.55 | 27.27 | 37.27 | 49.77 | 101.59 | 40.98 | 18.02 |
| xun | Undercut Distance--Mean (m) | 30 | 0.00 | 0.00 | 0.02 | 0.06 | 0.18 | 0.04 | 0.05 |
| XBKF | Bankfull Width--Mean (m) | 30 | 3.78 | 8.59 | 16.56 | 21.01 | 54.85 | 17.67 | 11.45 |
| XBKF | Bankfull Height-Mean (m) | 30 | 0.31 | 0.56 | 0.67 | 0.88 | 1.14 | 0.71 | 0.23 |
| XINC | Channel Incision Ht.-Mean (m) | 30 | 0.67 | 2.15 | 3.00 | 3.85 | 6.05 | 3.02 | 1.27 |
| xpcm | Rip Can & MidLayer Present (Frac. reach) | 30 | 0.00 | 0.55 | 0.80 | 1.00 | 1.00 | 0.72 | 0.31 |
| xpcmg | Riparian 3-Layers Present (Fract. reach) | 30 | 0.00 | 0.55 | 0.80 | 1.00 | 1.00 | 0.72 | 0.31 |
| xcl | Riparian Canopy > 0.3m DBH (Cover) | 30 | 0.00 | 0.02 | 0.04 | 0.17 | 0.37 | 0.09 | 0.10 |
| xgb | Rip Ground Layer Barren (Cover) | 30 | 0.00 | 0.23 | 0.30 | 0.37 | 0.56 | 0.29 | 0.13 |
| XC | Riparian Veg Canopy Cover | 30 | 0.00 | 0.06 | 0.12 | 0.34 | 0.76 | 0.22 | 0.22 |
| XG | Riparian Veg Ground Layer Cover | 30 | 0.05 | 0.25 | 0.35 | 0.42 | 0.85 | 0.36 | 0.17 |
| XCMW | Rip Veg Canopy+Mid Layer Woody Cover | 30 | 0.01 | 0.15 | 0.29 | 0.59 | 1.19 | 0.39 | 0.33 |
| XCMGW | Rip Veg Canopy+Mid+Ground Woody Cover | 30 | 0.02 | 0.20 | 0.36 | 0.66 | 1.50 | 0.48 | 0.39 |
| pcan | Riparian Canopy Coniferous (Fract reach) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| xcdenbk | Mean Bank Canopy Density (%) | 30 | 0.88 | 53.48 | 80.61 | 89.84 | 98.93 | 69.47 | 26.47 |
| xcdenmid | Mean Mid-channel Canopy Density (%) | 30 | 0.44 | 18.85 | 50.53 | 61.23 | 90.11 | 42.55 | 26.73 |
| XEMBED | Mean Embeddedness--Channel+Margin (%) | 30 | 31.00 | 46.82 | 66.14 | 81.27 | 100.00 | 65.45 | 22.16 |
| xfc | Fish Cvr-Filamentous Algae (Areal Prop) | 30 | 0.00 | 0.00 | 0.02 | 0.07 | 0.40 | 0.07 | 0.11 |
| xfc | Fish Cvr-Aq. Macrophytes (Areal Prop) | 30 | 0.00 | 0.00 | 0.00 | 0.09 | 0.67 | 0.07 | 0.15 |
| xfc | Fish Cvr-Large Woody Debris (Areal Prop) | 30 | 0.00 | 0.00 | 0.01 | 0.04 | 0.15 | 0.03 | 0.04 |
| xfc | Fish Cvr-Brush&Small Debris (Areal Prop) | 30 | 0.00 | 0.01 | 0.03 | 0.05 | 0.11 | 0.04 | 0.03 |
| xfc | Fish Cvr-Overhang Veg (Areal Prop) | 30 | 0.00 | 0.02 | 0.05 | 0.11 | 0.52 | 0.09 | 0.12 |
| xfc | Fish Cvr-Undercut Banks (Areal Prop) | 30 | 0.00 | 0.00 | 0.01 | 0.04 | 0.49 | 0.04 | 0.09 |
| xfc | Fish Cvr-Boulders (Areal Prop) | 30 | 0.00 | 0.00 | 0.01 | 0.06 | 0.38 | 0.07 | 0.11 |
| xfc | Fish Cvr-Artif. Structs. (Areal Prop) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.01 |
| xfc | Fish Cvr-All Types (Sum Areal Prop) | 30 | 0.04 | 0.12 | 0.23 | 0.33 | 1.11 | 0.27 | 0.21 |
| xfc | Fish Cvr-Natural Types (Sum Areal Prop) | 30 | 0.04 | 0.12 | 0.23 | 0.33 | 1.11 | 0.26 | 0.21 |
| xfc | Fish Cvr-LWD,RCK,UCBorHUM(Sum Area Prop) | 30 | 0.00 | 0.05 | 0.10 | 0.19 | 0.49 | 0.14 | 0.13 |
| w1 | Rip Dist--Sum All Types (ProxWt Pres) | 30 | 0.06 | 0.52 | 1.22 | 1.63 | 2.42 | 1.17 | 0.61 |
| w1 | Rip Dist--Sum NonAg Types (ProxWt Pres) | 30 | 0.00 | 0.07 | 0.27 | 0.77 | 1.76 | 0.45 | 0.48 |

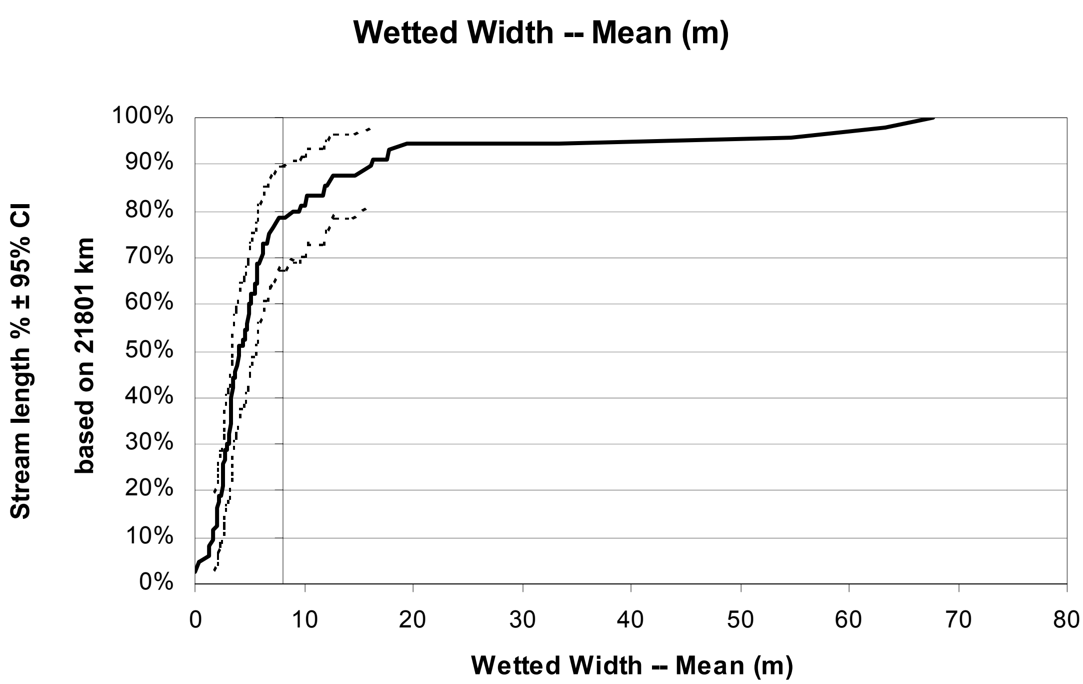
| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all |
|---|---|---|---|---|---|---|---|---|---|
| w1 | Rip Dist--Sum Agric Types (ProxWt Pres) | 30 | 0.00 | 0.09 | 0.63 | 1.50 | 1.58 | 0.72 | 0.62 |
| w1h | Rip Dist--Wall/Bank Revet. (ProxWt Pres) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 0.03 | 0.11 |
| w1h | Rip Dist--Pipes infl/effl (ProxWt Pres) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.01 |
| lsub | Substrate-Mean Log10(Diam Class mm) | 30 | -2.11 | 0.00 | 0.87 | 1.41 | 2.18 | 0.62 | 1.09 |
| Ltest | Log10[Erod. Substr Dia.(mm)]-Fast est | 30 | -0.03 | 0.52 | 0.71 | 1.00 | 1.52 | 0.74 | 0.36 |
| LRBS | Log10[Relative Bed Stability] - Fast est | 30 | -2.68 | -0.29 | 0.03 | 0.42 | 1.63 | -0.13 | 0.97 |
| ldmb | Log10[Erod. Substr Dia.(mm)]-Est. 2 | 30 | 0.25 | 0.87 | 1.06 | 1.31 | 1.83 | 1.06 | 0.40 |
| lrbs | Log10[Rel. Bed Stability] - Est. 2 | 30 | -3.09 | -0.84 | -0.28 | 0.07 | 1.63 | -0.45 | 1.00 |
| reachlen | Length of sample reach (m) | 30 | 150.00 | 176.00 | 284.50 | 300.00 | 1970.00 | 302.83 | 320.59 |
| xslope | Channel Slope -- reach mean (%) | 30 | 0.05 | 0.11 | 0.18 | 0.29 | 0.81 | 0.25 | 0.20 |
| rpgt75 | Resid Pools >75cm deep (number/reach) | 30 | 0.00 | 0.00 | 1.00 | 2.00 | 4.00 | 0.97 | 1.10 |
| rpgt100 | Resid Pools >100cm deep (number/reach) | 30 | 0.00 | 0.00 | 0.00 | 1.00 | 3.00 | 0.57 | 0.86 |
| rpmxdep | Maximum residual depth in reach (cm) | 30 | 14.70 | 56.77 | 91.83 | 119.23 | 221.76 | 87.58 | 43.06 |
| rpxarea | Mean vert. profile area of RPs (m2/pool) | 30 | 0.54 | 2.69 | 7.46 | 16.52 | 138.76 | 15.04 | 25.75 |
| rp100 | Mean Residual Depth (cm or m2/100m) | 30 | 3.11 | 13.99 | 20.98 | 35.11 | 62.01 | 25.49 | 15.41 |
| lsubd | Substrate-StDev LOG10(Diam Class mm) | 30 | 0.00 | 0.78 | 1.35 | 1.67 | 2.39 | 1.25 | 0.66 |
| PCT | Substrate Fines -- Silt/Clay/Muck (%) | 30 | 0.00 | 3.64 | 12.73 | 16.36 | 100.00 | 17.90 | 22.56 |
| PCT | Substrate Sand -- .06-2 mm (%) | 30 | 0.00 | 0.00 | 5.45 | 30.91 | 100.00 | 20.06 | 30.50 |
| PCT | Substrate Hardpan -- (%) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 10.00 | 0.70 | 2.29 |
| pct | Substrate Concrete (%) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PCT | Substrate Sand & Fines -- <2 mm (%) | 30 | 0.00 | 16.36 | 26.36 | 50.91 | 100.00 | 37.96 | 32.72 |
| PCT | Substrate <= Fine Gravel (<=16 mm) (%) | 30 | 16.36 | 30.91 | 43.64 | 78.18 | 100.00 | 53.31 | 28.31 |
| PCT | Substrate >= Coarse Gravel (>16 mm) (%) | 30 | 0.00 | 10.91 | 55.45 | 69.09 | 83.64 | 43.97 | 29.90 |
| PCT | Substrate Bedrock (%) | 30 | 0.00 | 0.00 | 2.16 | 9.09 | 50.91 | 7.05 | 11.40 |
| PCT | Substrate Wood or Detritus -- (%) | 30 | 0.00 | 0.00 | 0.00 | 3.64 | 21.82 | 1.94 | 4.30 |
| v1w | LWD Vol in Bkf chnl (m3/m2-all sizes) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| v4w | LWD Vol in Bkf chnl (m3/m2-L,X) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| v1tm100 | LWD Vol in/abv Bf chan(#/100m-all sizes) | 30 | 0.00 | 0.74 | 3.67 | 7.01 | 15.01 | 4.46 | 4.34 |
| v4tm100 | LWD Vol in/abv Bf chan (#/100m-L,X) | 30 | 0.00 | 0.00 | 0.00 | 2.33 | 9.42 | 1.34 | 2.16 |
| sinu | Channel Sinuosity (m/m) | 30 | 1.01 | 1.05 | 1.11 | 1.29 | 2.49 | 1.23 | 0.30 |
| xdepth | Thalweg Mean Depth (cm) | 30 | 20.62 | 25.80 | 40.42 | 68.69 | 100.46 | 47.13 | 22.43 |
| sddepth | Std Dev of Thalweg Depth (cm) | 30 | 4.22 | 16.01 | 21.78 | 33.64 | 57.24 | 24.71 | 12.74 |

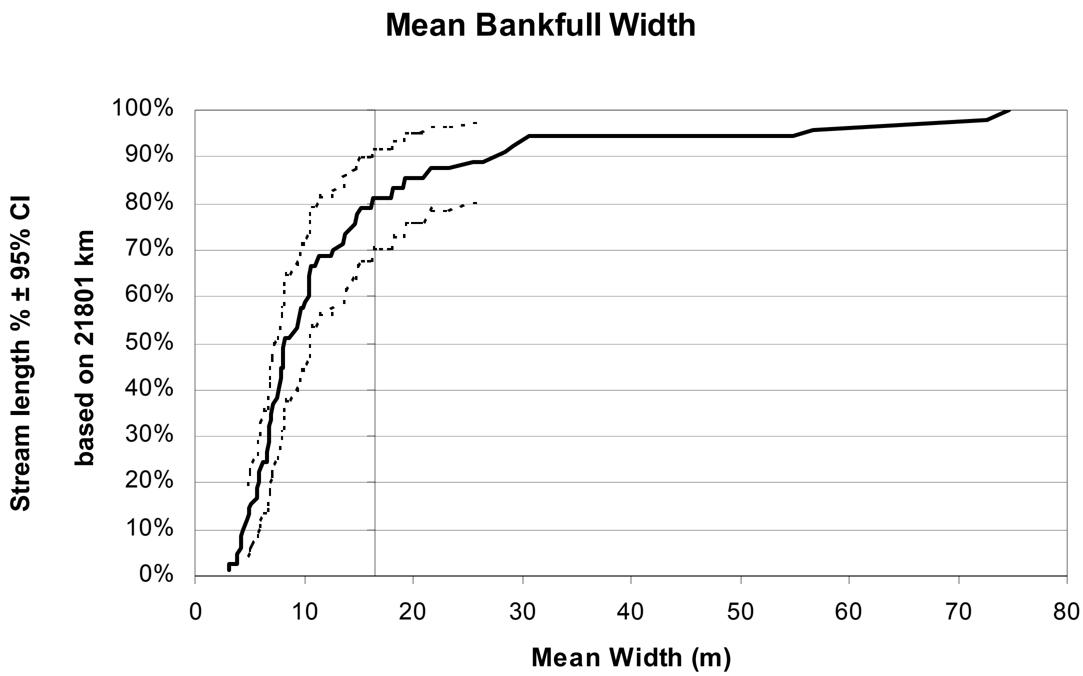
| code | analyte | n-all | min-all | p25-all | p50-all | p75-all | max-all | mean-all | stdev-all |
|---|---|---|---|---|---|---|---|---|---|
| xwidth | Wetted Width -- Mean (m) | 30 | 2.44 | 4.57 | 8.08 | 13.80 | 33.38 | 10.38 | 7.65 |
| xwxd | Mean Width*Depth Product (m2) | 30 | 0.64 | 1.76 | 3.16 | 10.59 | 27.72 | 6.31 | 6.38 |
| xwd | Mean Width/Depth Ratio (m/m) | 30 | 10.06 | 17.68 | 24.84 | 39.24 | 71.28 | 28.62 | 15.96 |
| sdwxd | Std Dev of Width*Depth Product (m2) | 30 | 0.43 | 1.31 | 2.83 | 5.40 | 10.34 | 3.61 | 2.84 |
| pct | Falls (% of reach) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| pct | Fast Wtr Hab (% riffle & faster) | 30 | 0.00 | 2.00 | 11.00 | 18.00 | 30.00 | 10.87 | 9.12 |
| pct | Slow Wtr Hab (% Glide & Pool) | 30 | 62.67 | 79.00 | 87.00 | 95.00 | 100.00 | 87.02 | 10.42 |
| pct | Pools -- All Types (% of reach) | 30 | 0.00 | 0.00 | 19.17 | 42.00 | 68.00 | 24.43 | 22.56 |
| pct | Dry Channel or Subsurf Flow (%) | 30 | 0.00 | 0.00 | 0.00 | 0.00 | 37.33 | 2.11 | 7.13 |
| pct | Side channel presence (% of reach) | 30 | 0.00 | 0.00 | 1.00 | 8.00 | 52.00 | 5.82 | 10.69 |

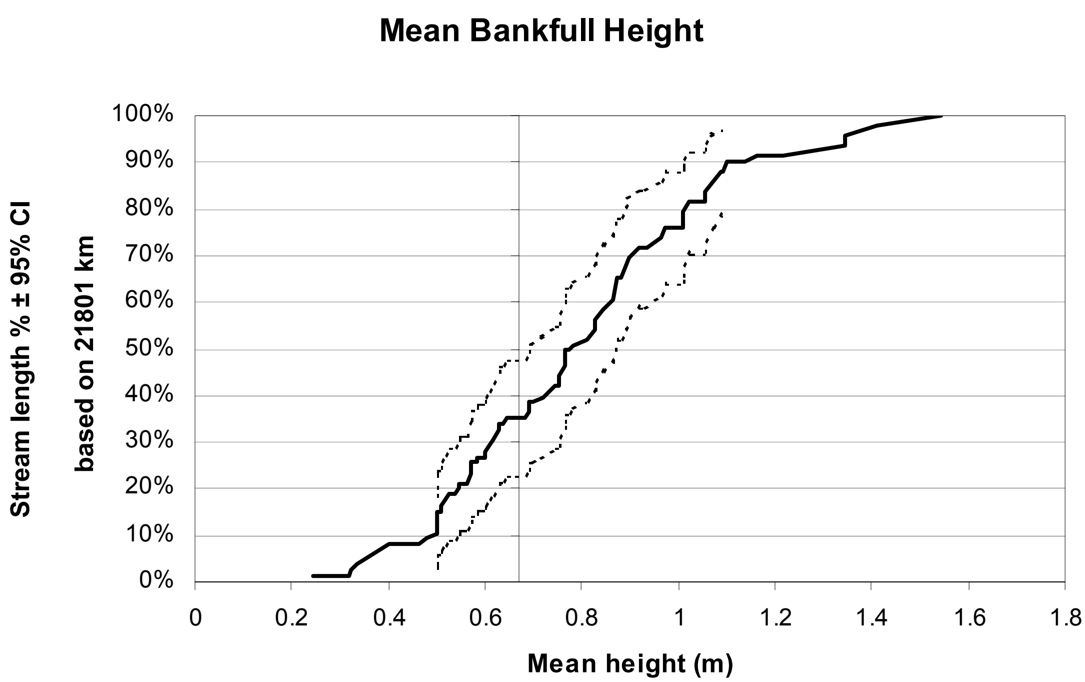
**Appendix K.  Physical habitat characteristics.**

## PHYSICAL HABITAT:
## CHANNEL AND REACH MORPHOLOGY

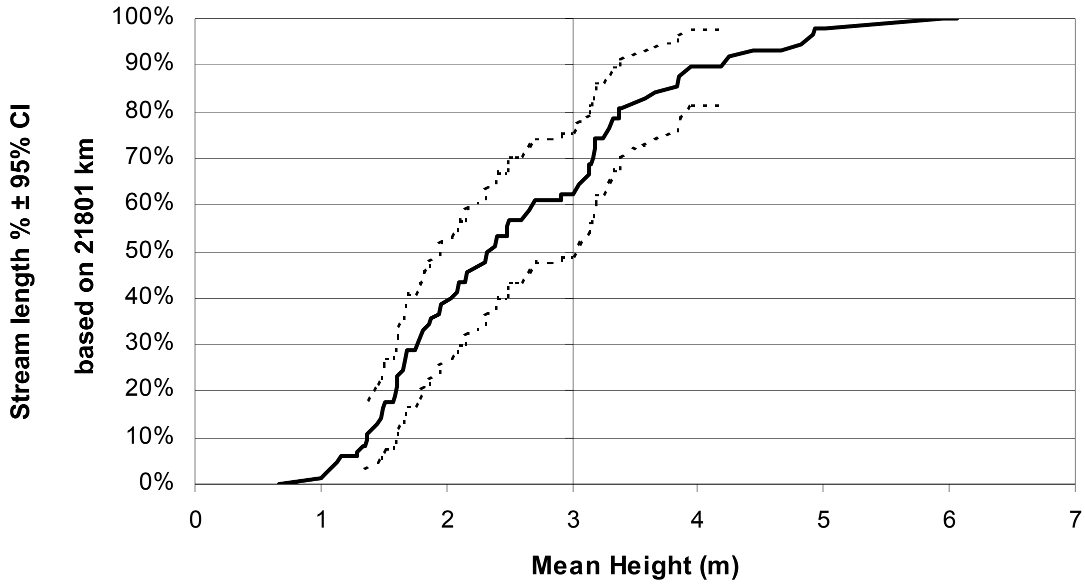


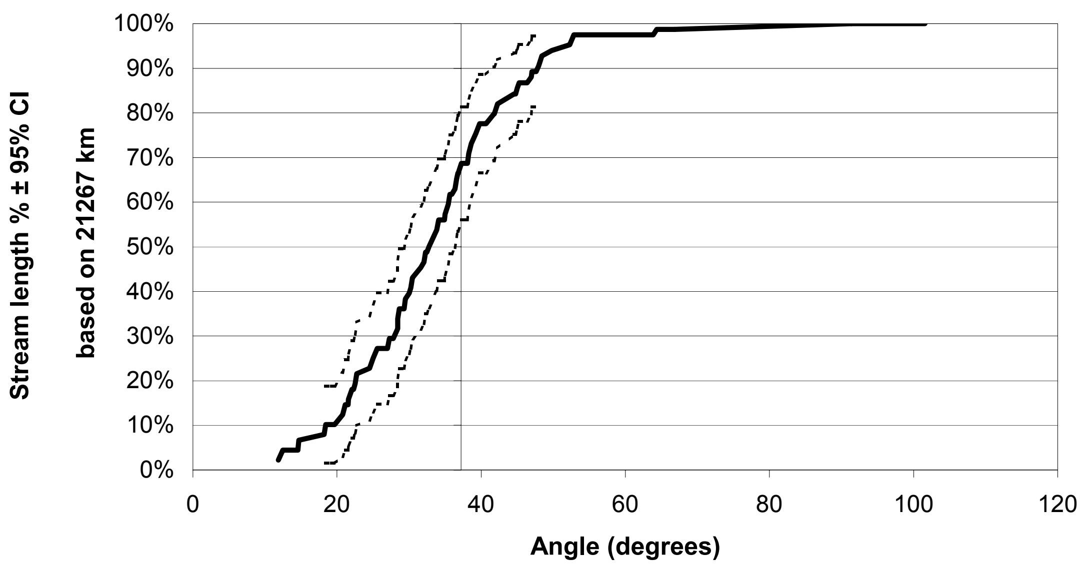

Mean Bankfull Width
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
80
Mean Width (m)


Mean Bankfull Height
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Mean height (m)

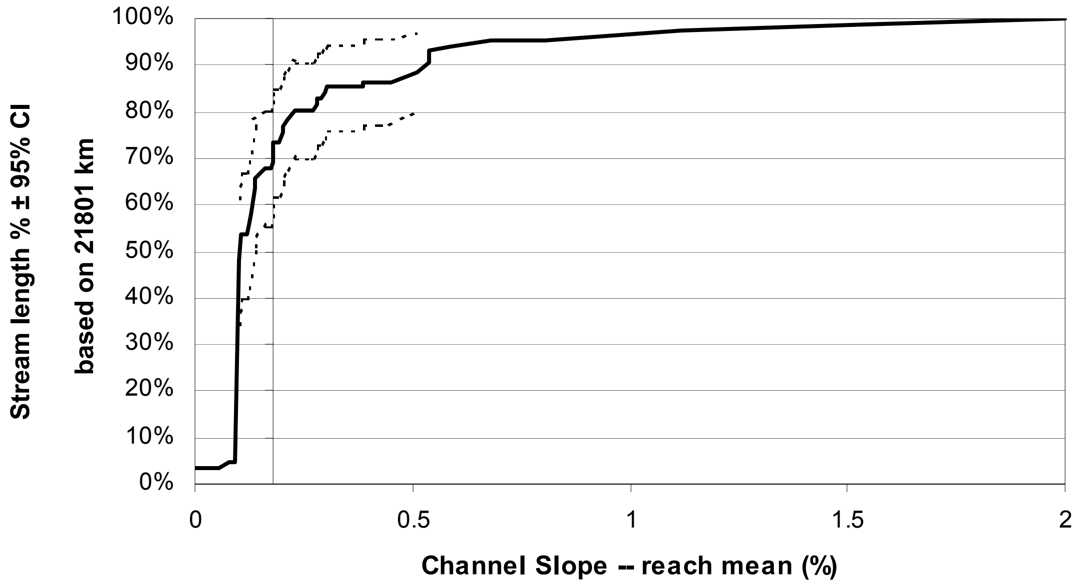
**Mean Channel Incision Height**



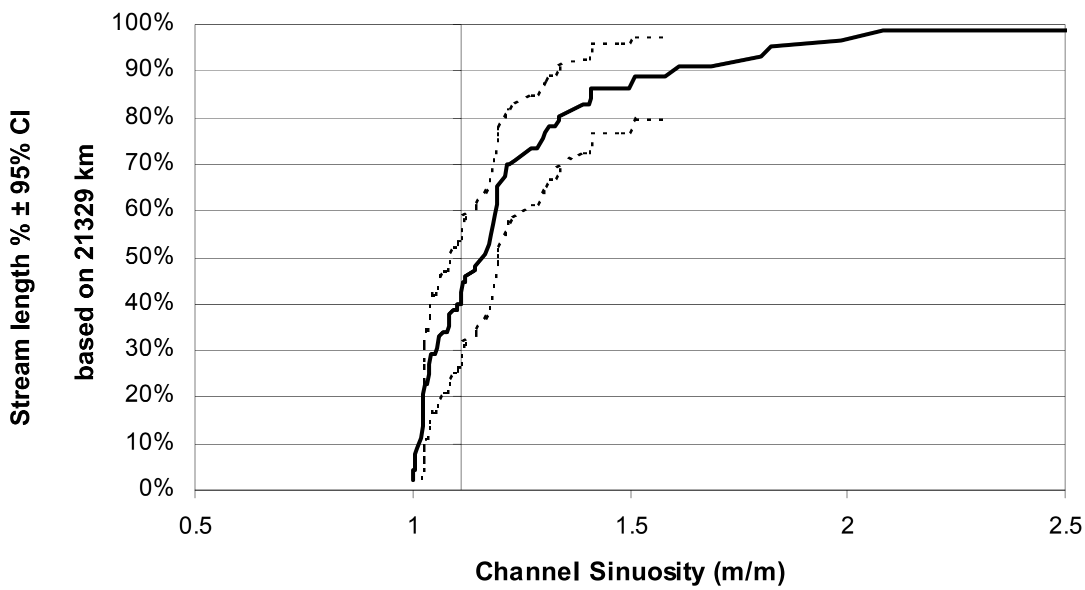

**Mean Bank Angle**



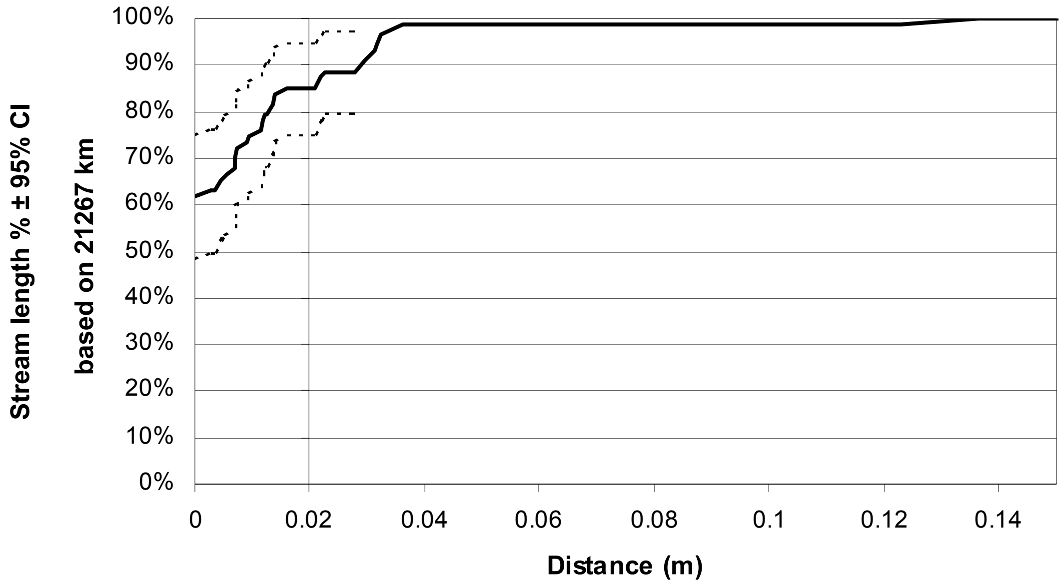
## Channel Slope -- reach mean (%)



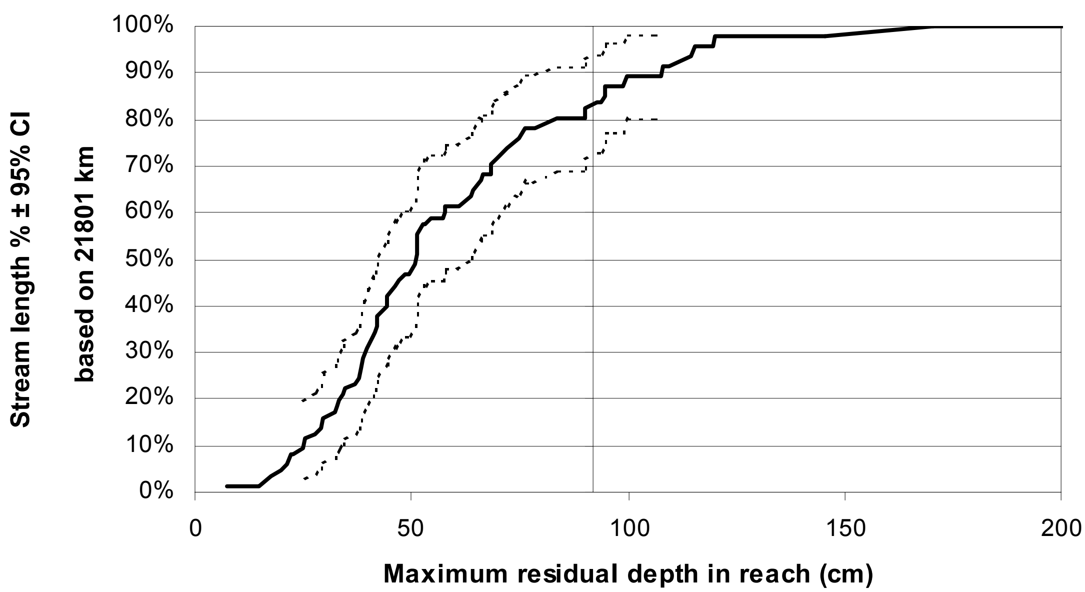

## Channel Sinuosity (m/m)



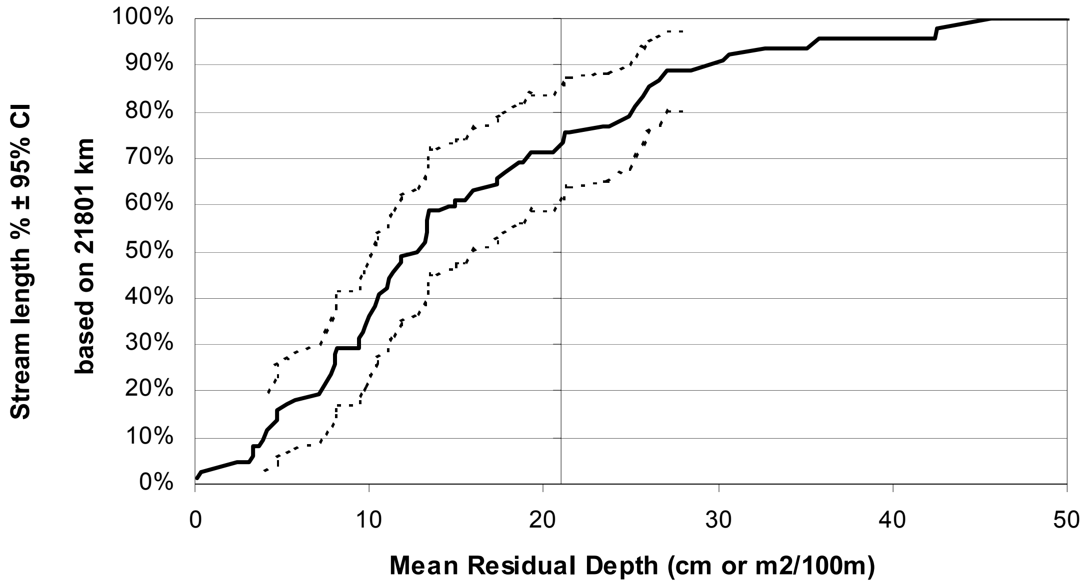
## Mean Undercut Distance



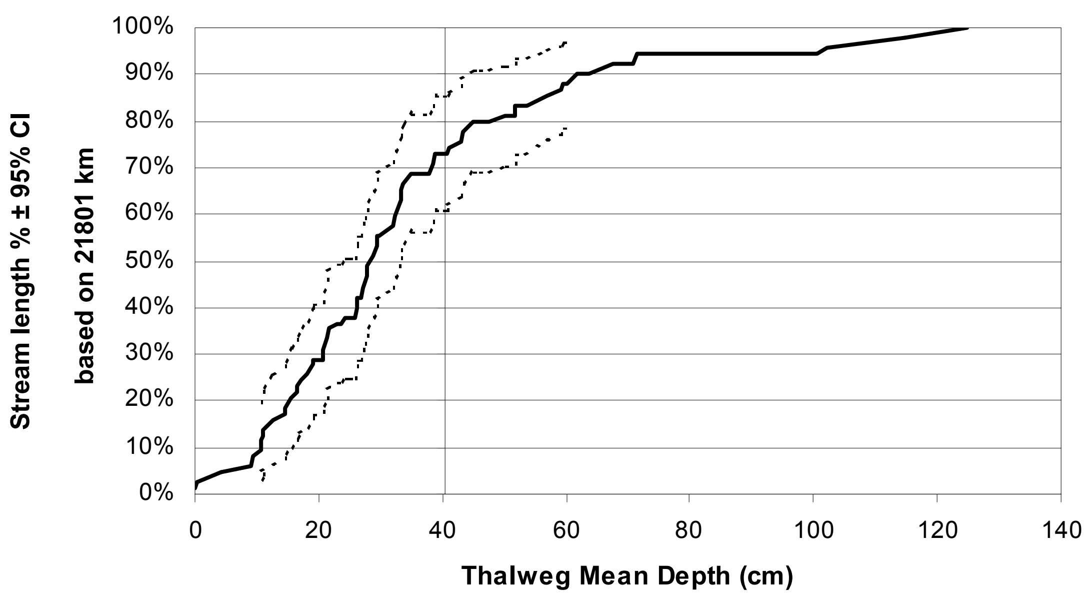

## Maximum residual depth in reach (cm)

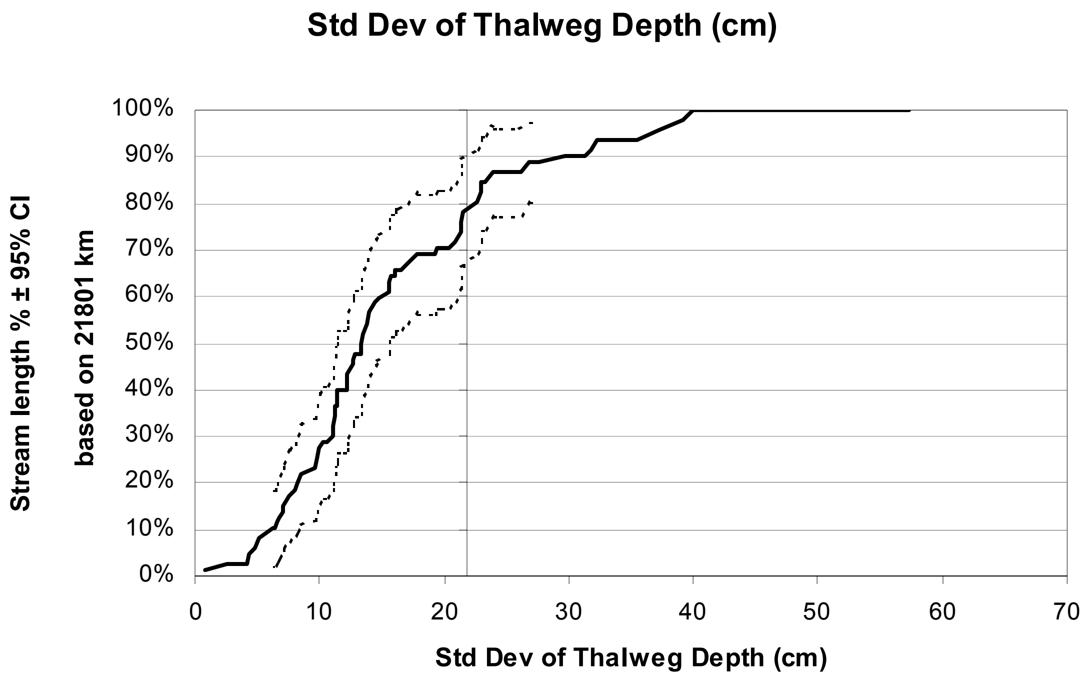


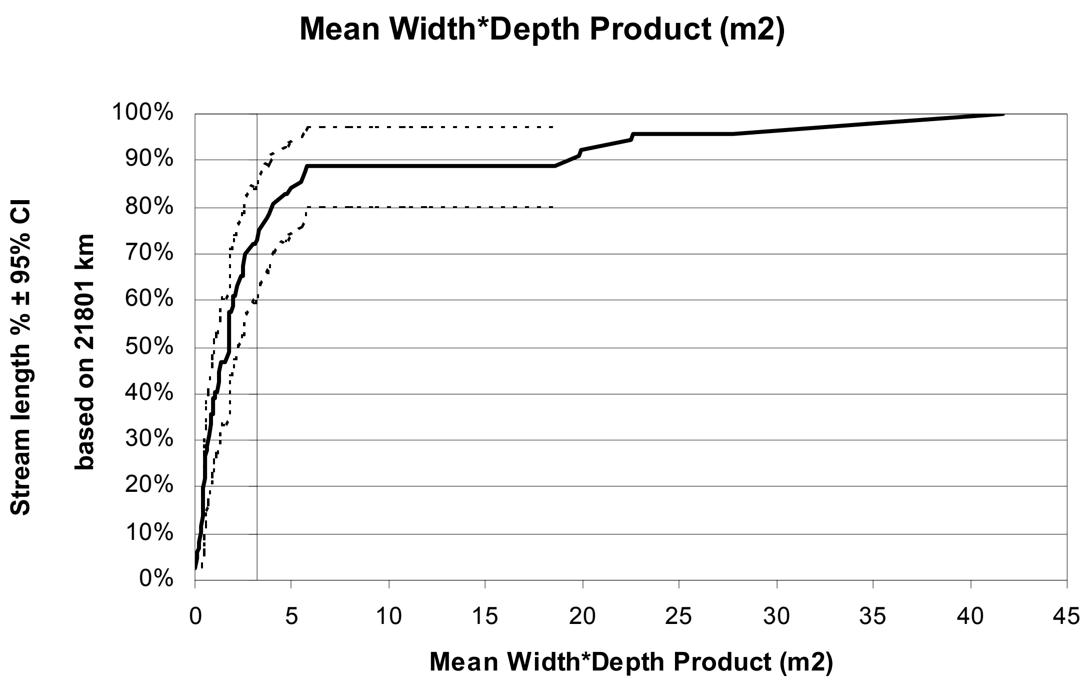
## Mean Residual Depth (cm or m2/100m)



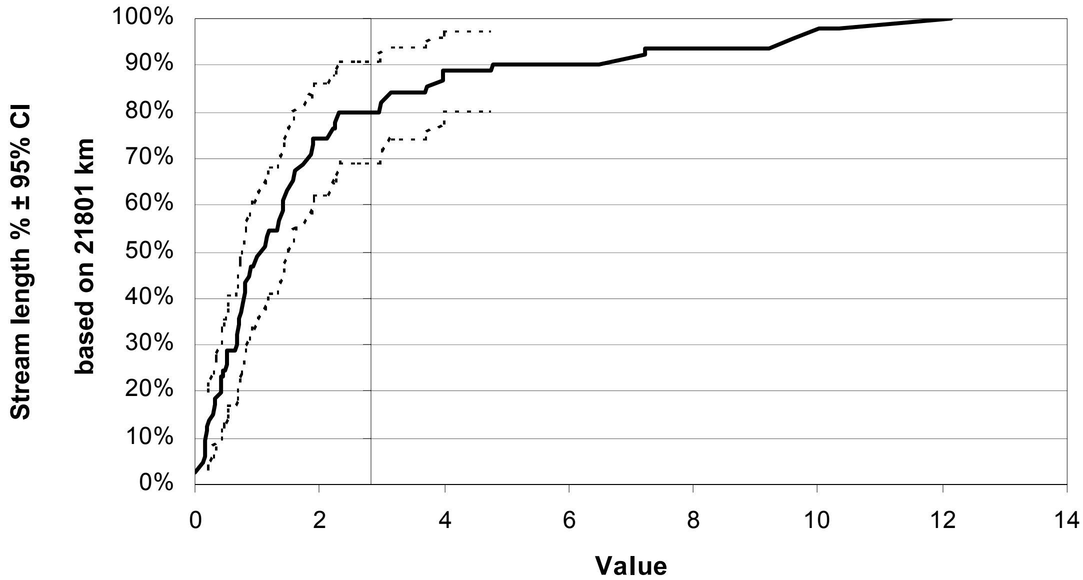

## Thalweg Mean Depth (cm)



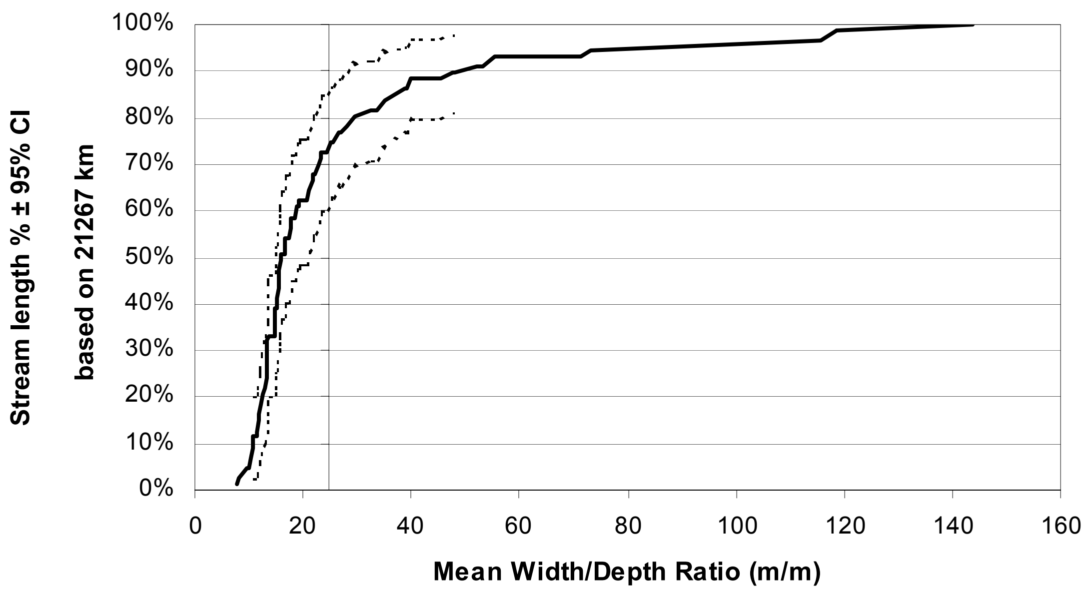

Std Dev of Thalweg Depth (cm)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
10
20
30
40
50
60
70
Std Dev of Thalweg Depth (cm)
Stream length % ± 95% CI
based on 21801 km


Mean Width*Depth Product (m2)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
5
10
15
20
25
30
35
40
45
Mean Width*Depth Product (m2)
Stream length % ± 95% CI
based on 21801 km

## Std Dev of Width*Depth Product (m2)




## Mean Width/Depth Ratio (m/m)



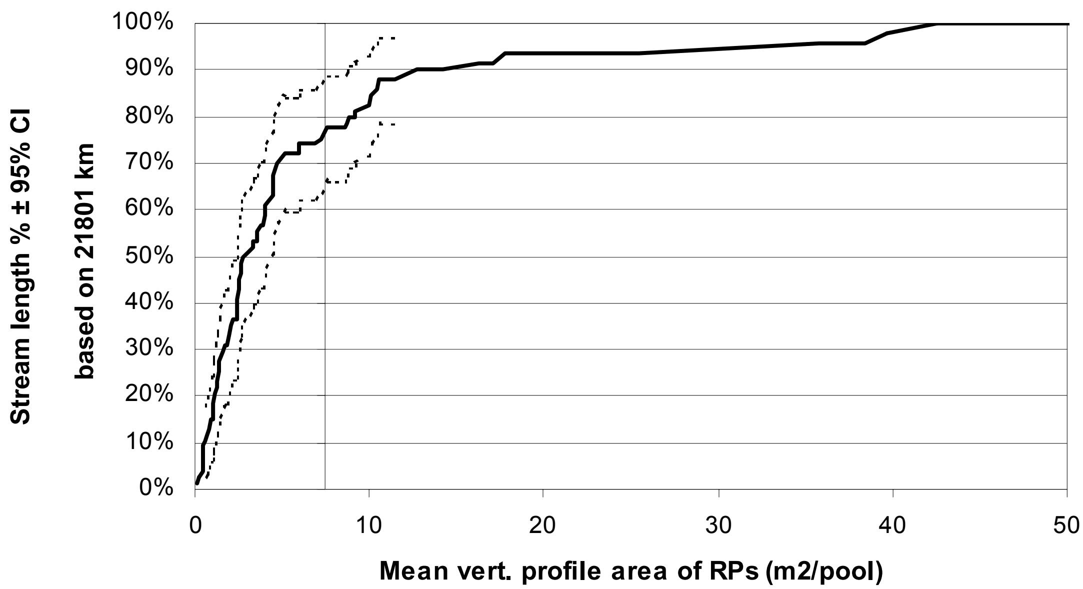

## Residual pools >75 cm deep (number/reach)

| | | |
|---|---|---|
| **Random** | **21801 km** | **75% of km =0; all values ≤ 4** |
| **Reference** | **30/30 meas** | **median = 1** |

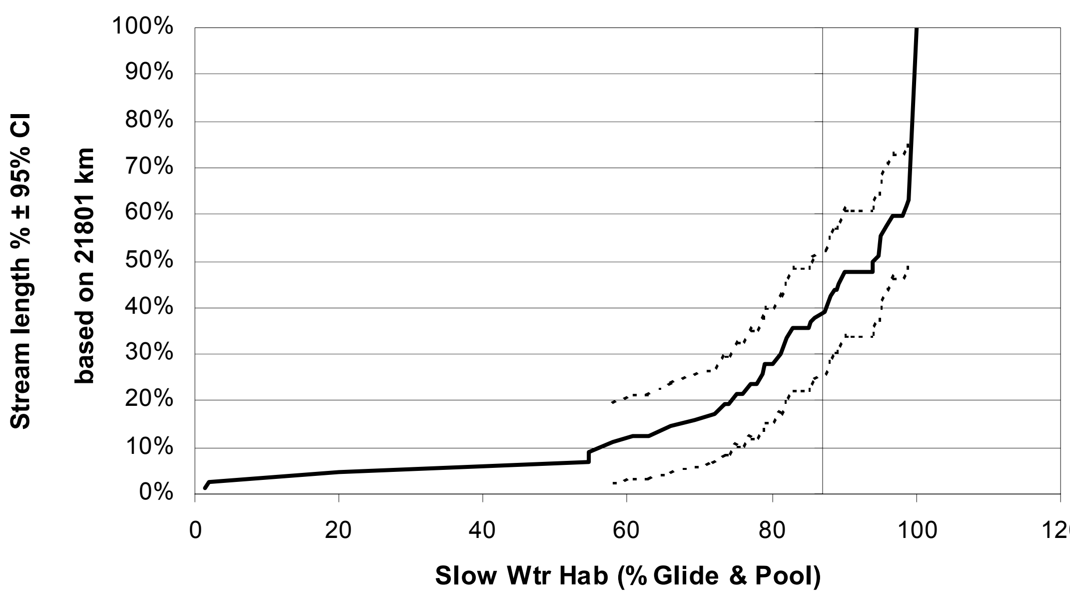
## Residual pools >100 cm deep (number/reach)

| | | |
|---|---|---|
| **Random** | **21801 km** | **89% of km =0; all values ≤ 4** |
| **Reference** | **30/30 meas** | **median = 0** |

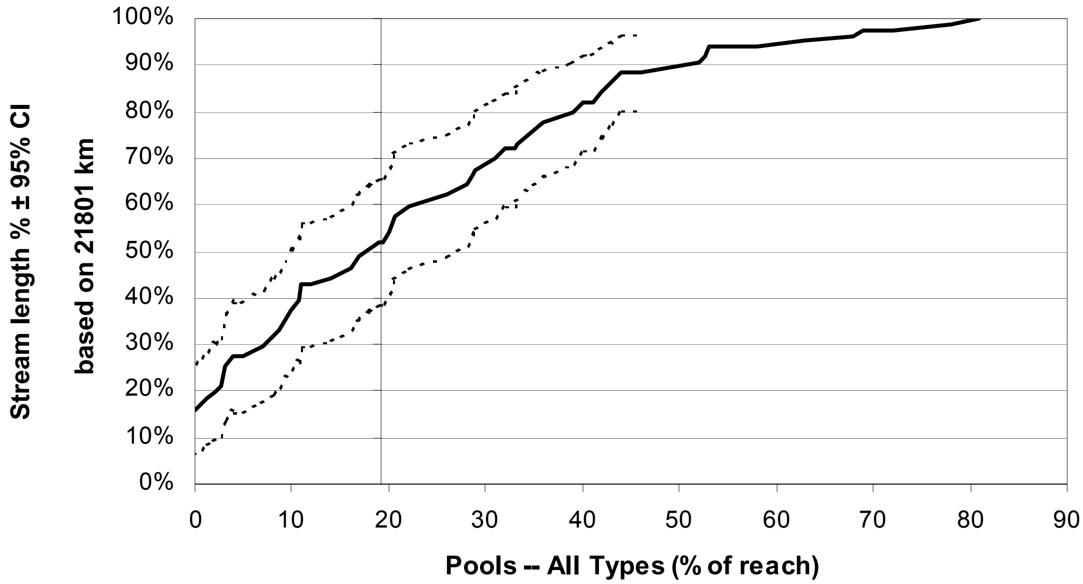
## Mean vert. profile area of RPs (m2/pool)



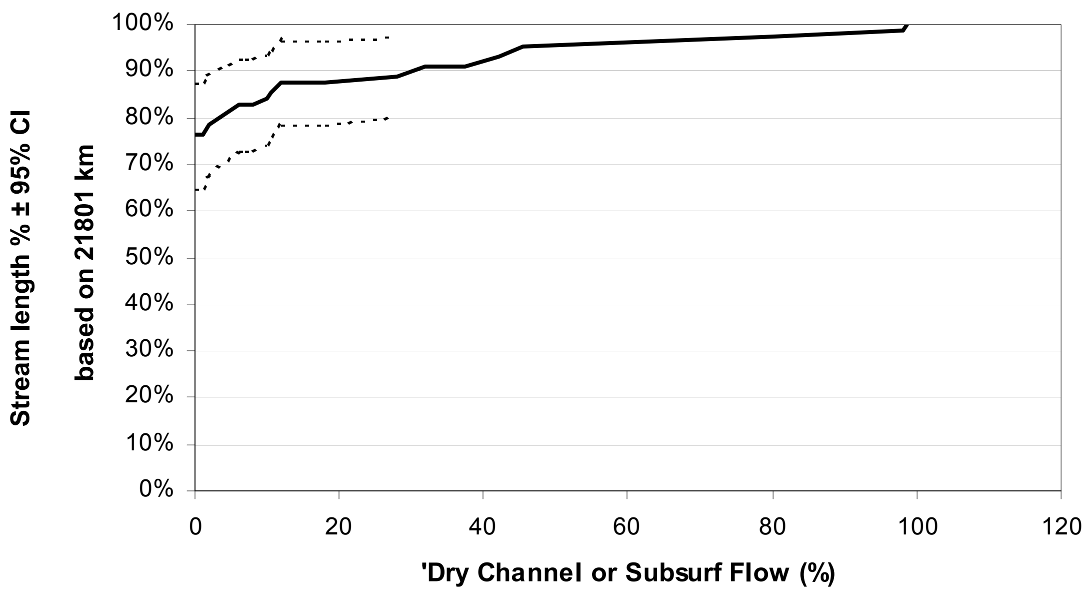

## Slow Wtr Hab (% Glide & Pool)



## Pools -- All Types (% of reach)

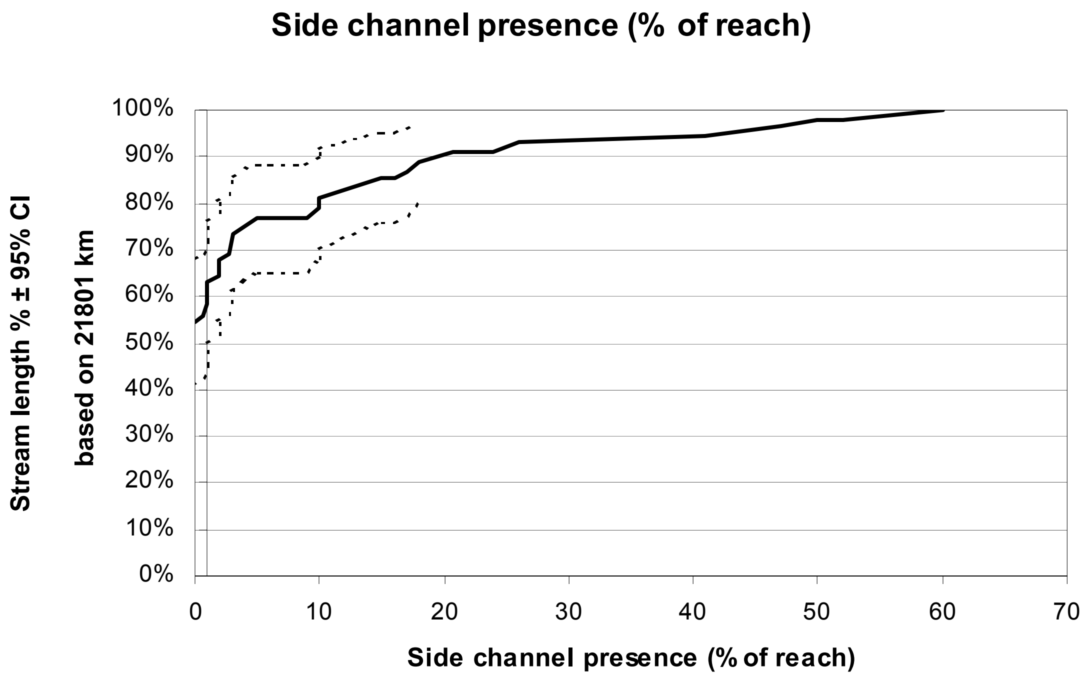



## 'Dry Channel or Subsurf Flow (%)

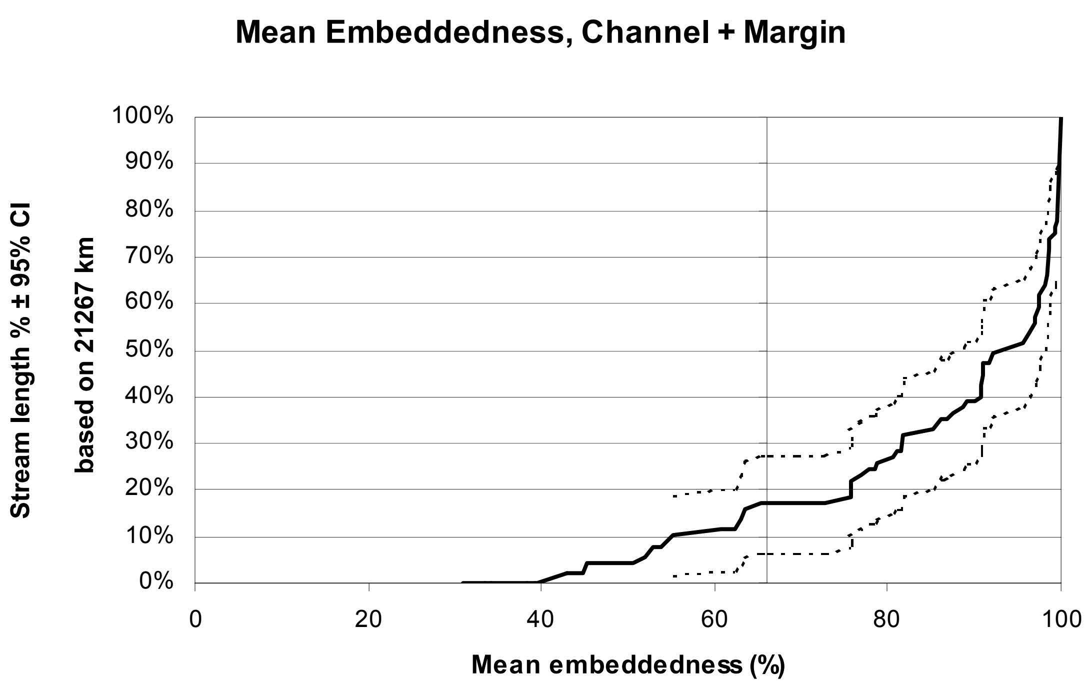



## Falls (% of reach)

| | | |
|---|---|---|
| **Random** | **21801 km** | **all values 0%** |
| **Reference** | **30/30 meas** | **median = 0%** |

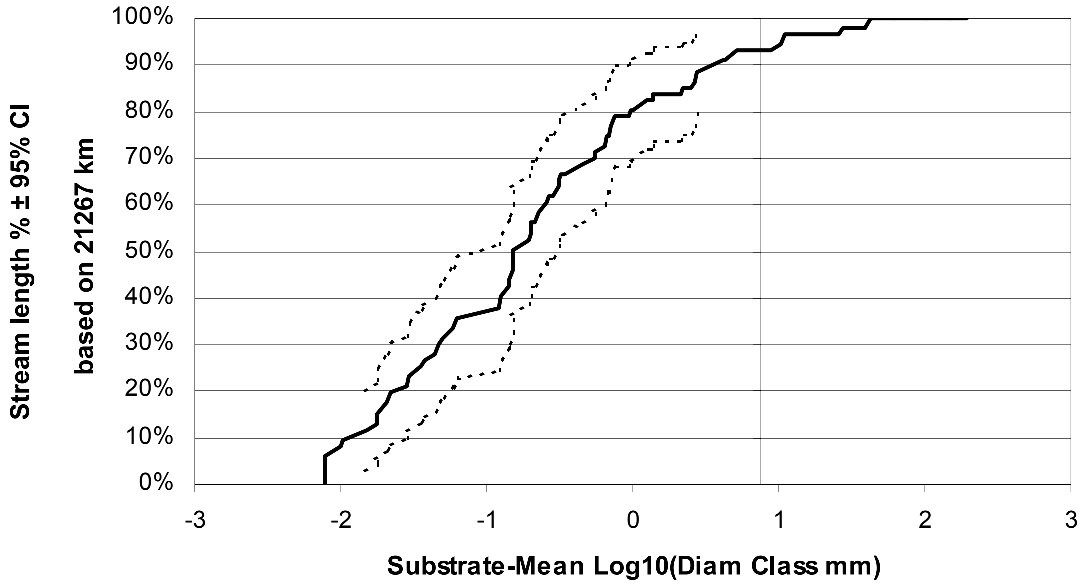


Side channel presence (% of reach)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Stream length % ± 95% CI
based on 21801 km
0
10
20
30
40
50
60
70
Side channel presence (% of reach)

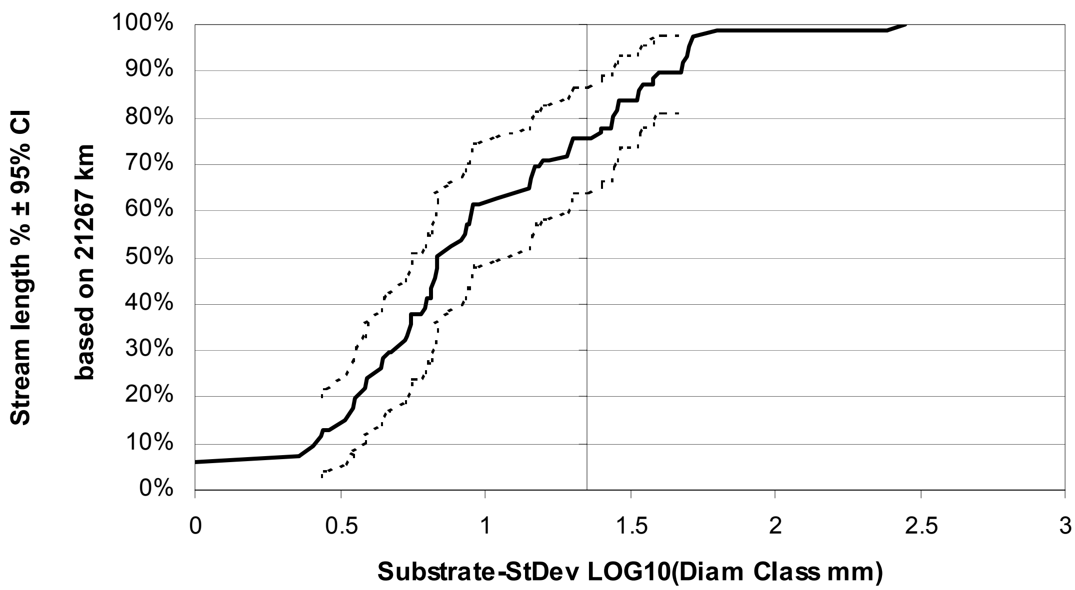



Mean Embeddedness, Channel + Margin
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Stream length % ± 95% CI
based on 21267 km
0
20
40
60
80
100
Mean embeddedness (%)

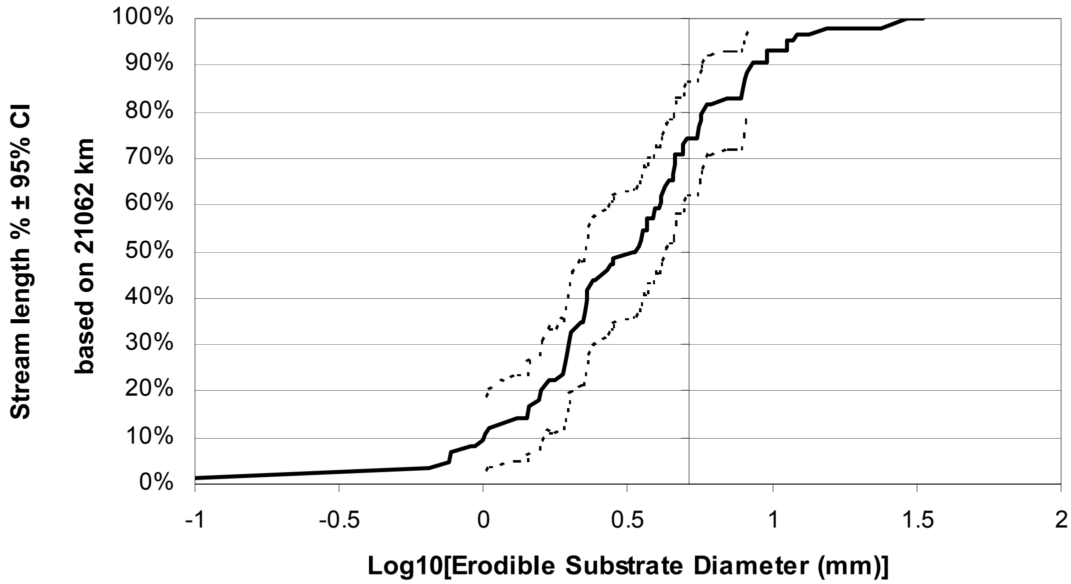
## Mean Substrate Diameter



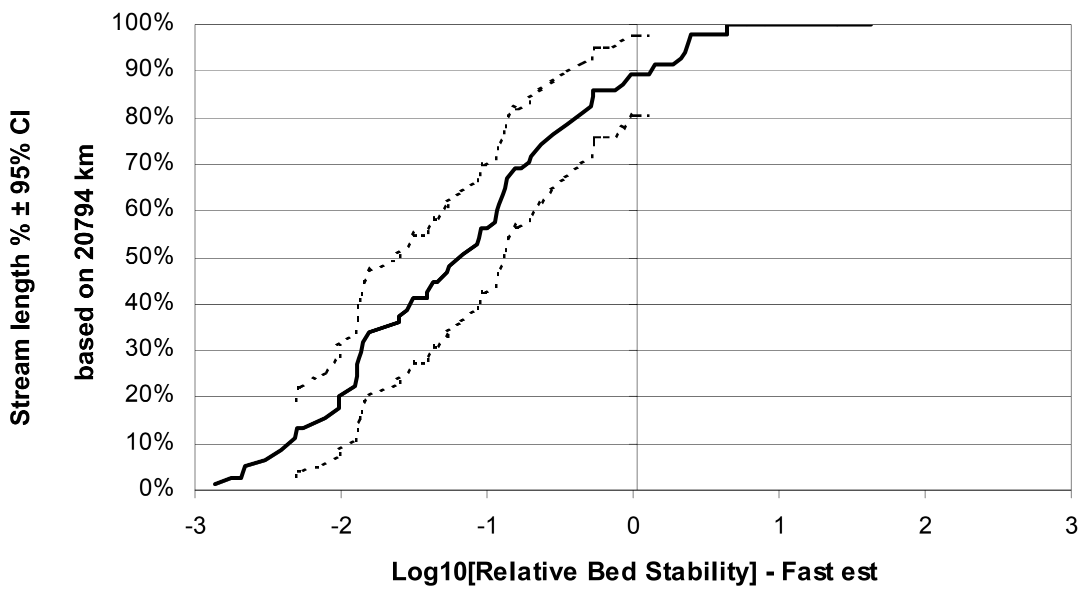

## Standard Deviation of Substrate Diameter



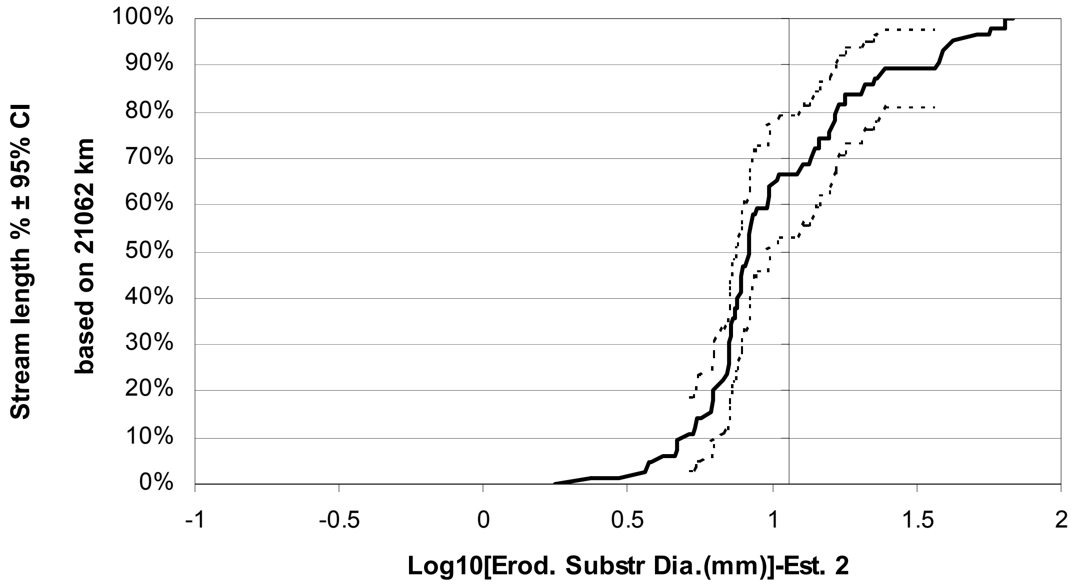
## Erodible Substrate Diameter - Fast est.



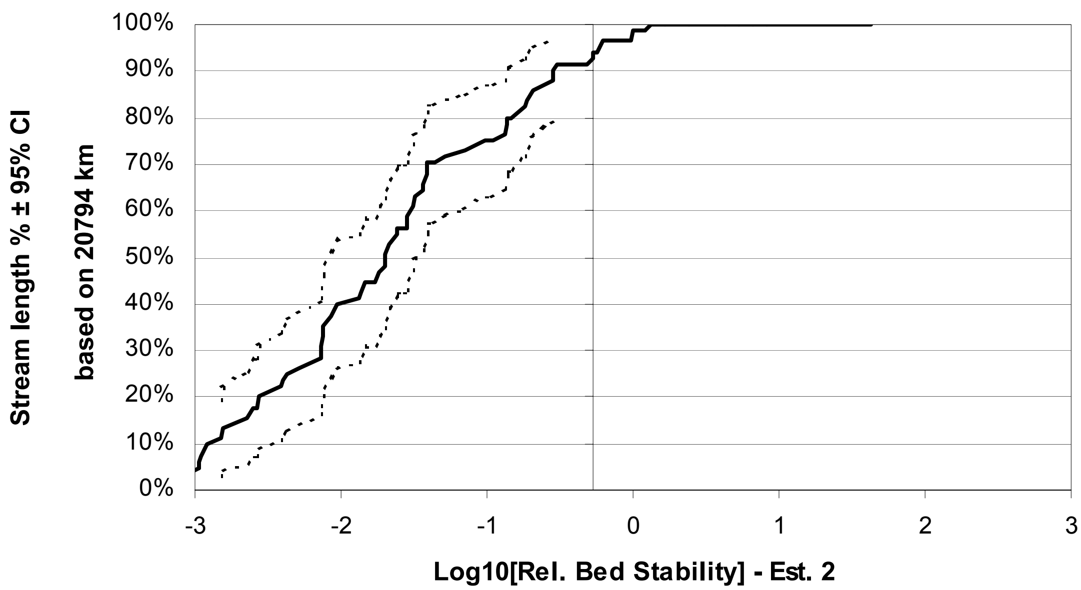

## Relative Bed Stability - Fast est.



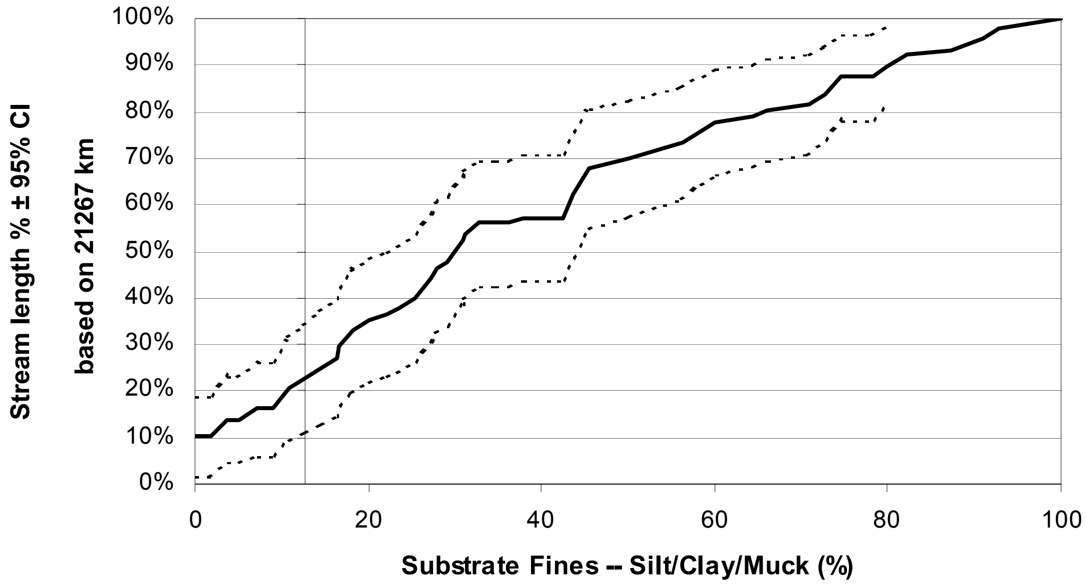
## Erodible Substrate Diameter - Est. 2



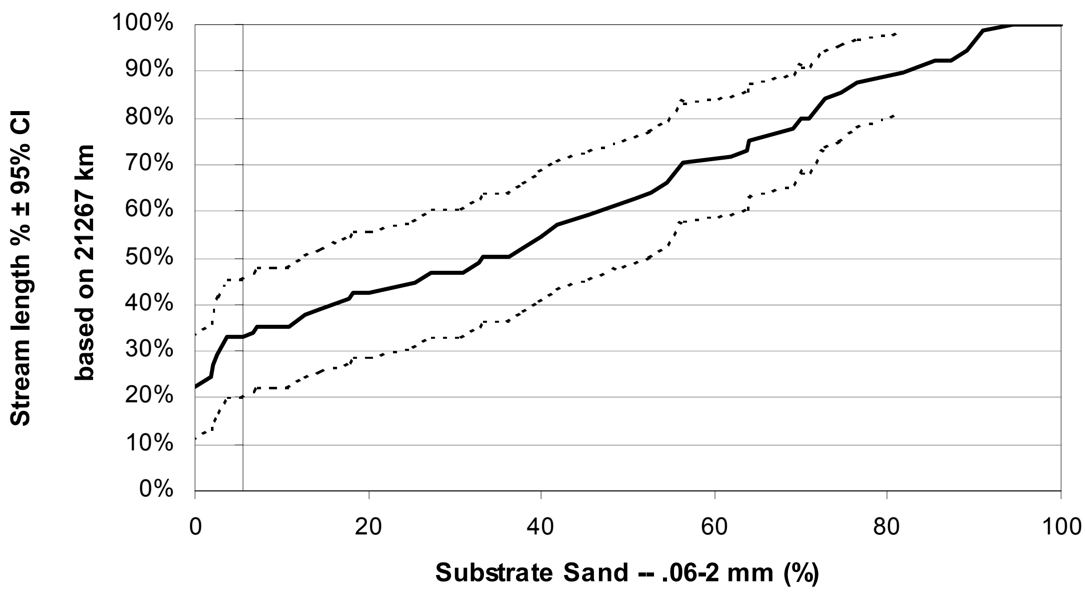

## Relative Bed Stability - Est 2



## Substrate Fines -- Silt/Clay/Muck (%)




## Substrate Sand -- .06-2 mm (%)



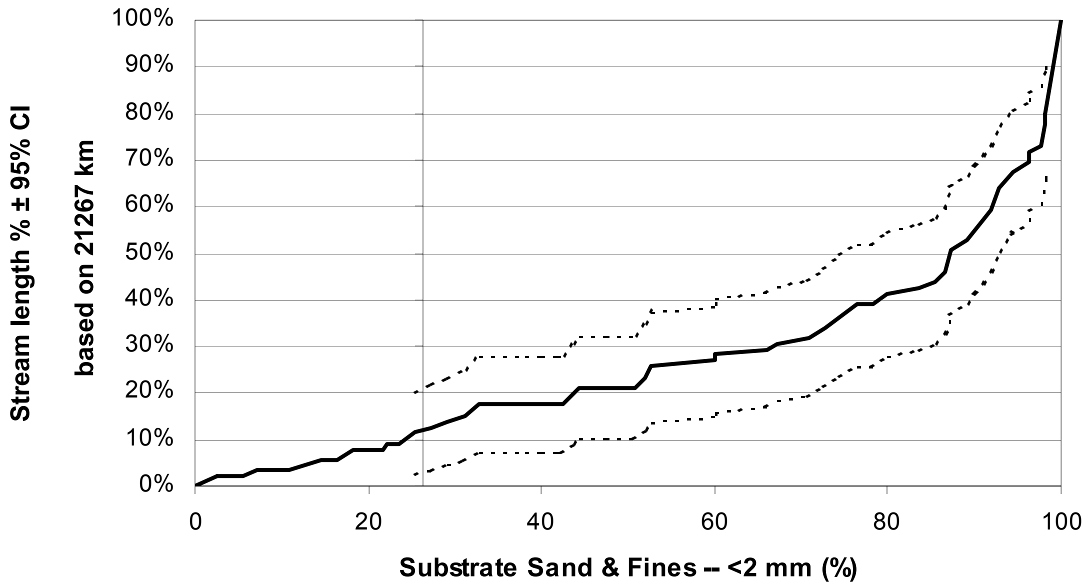

## Substrate Hardpan

| | | |
|---|---|---|
| **Random** | **21801 km** | **98% of values <4%; all values ≤10%** |
| **Reference** | **30/30 meas** | **median = 0%** |

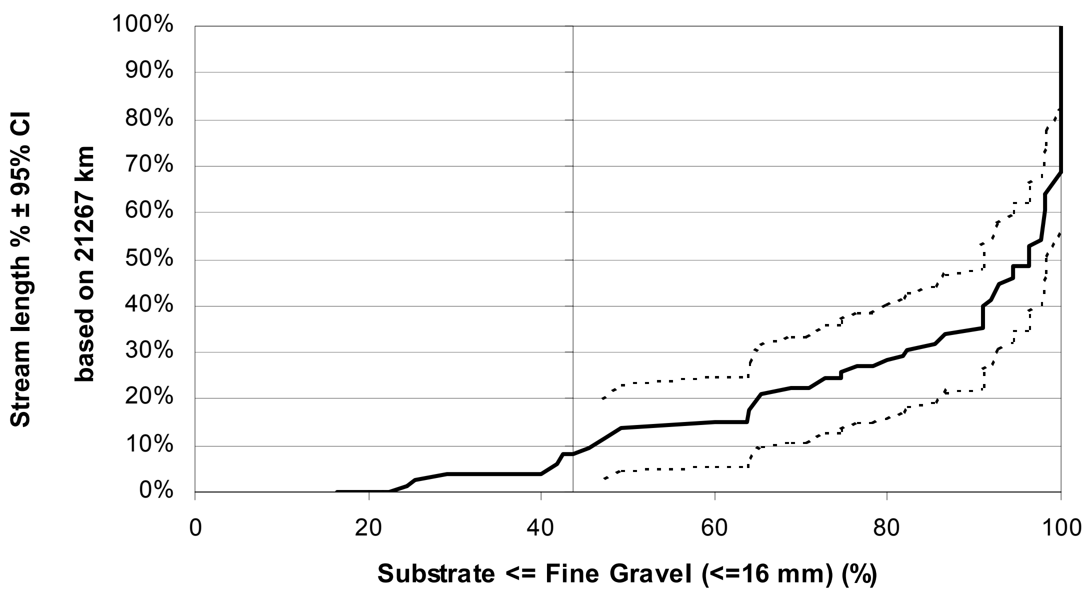
## Substrate Concrete

| | | |
|---|---|---|
| **Random** | **21801 km** | **all values 0%** |
| **Reference** | **30/30 meas** | **median = 0%** |

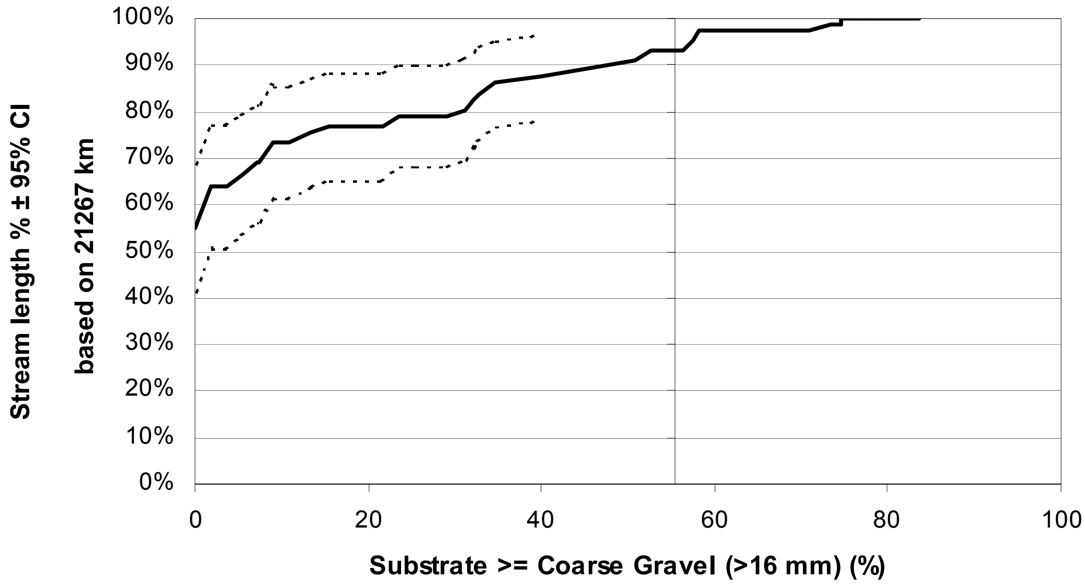
### Substrate Sand & Fines -- <2 mm (%)




### Substrate <= Fine Gravel (<=16 mm) (%)



## Substrate >= Coarse Gravel (>16 mm) (%)




## Substrate Bedrock

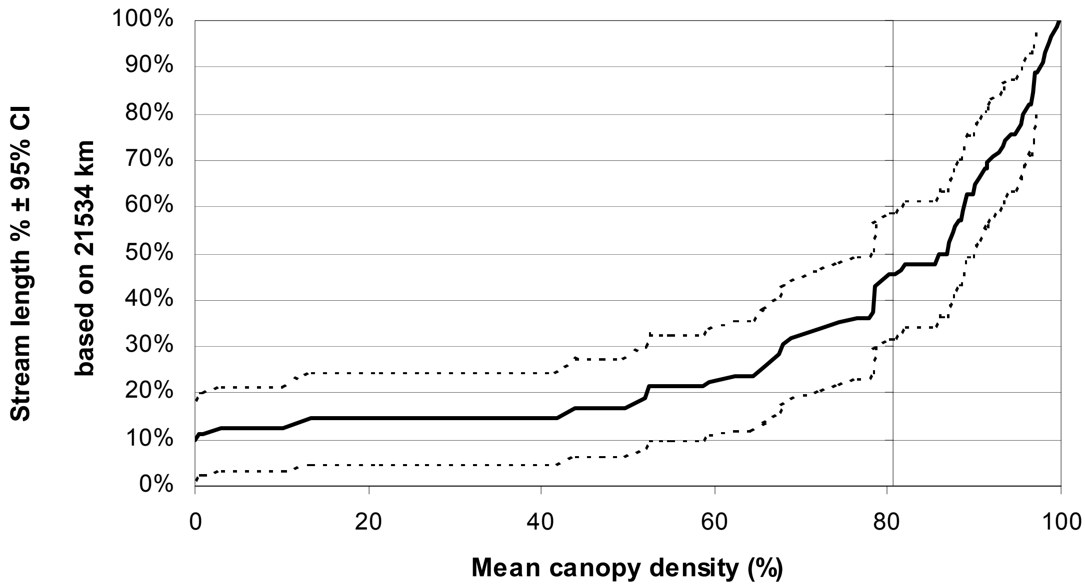
| | | |
|---|---|---|
| **Random** | **21801 km** | **86% of values 0%; all values ≤10%** |
| **Reference** | **30/30 meas** | **median = 0%** |

## Substrate Wood or Detritus -- (%)

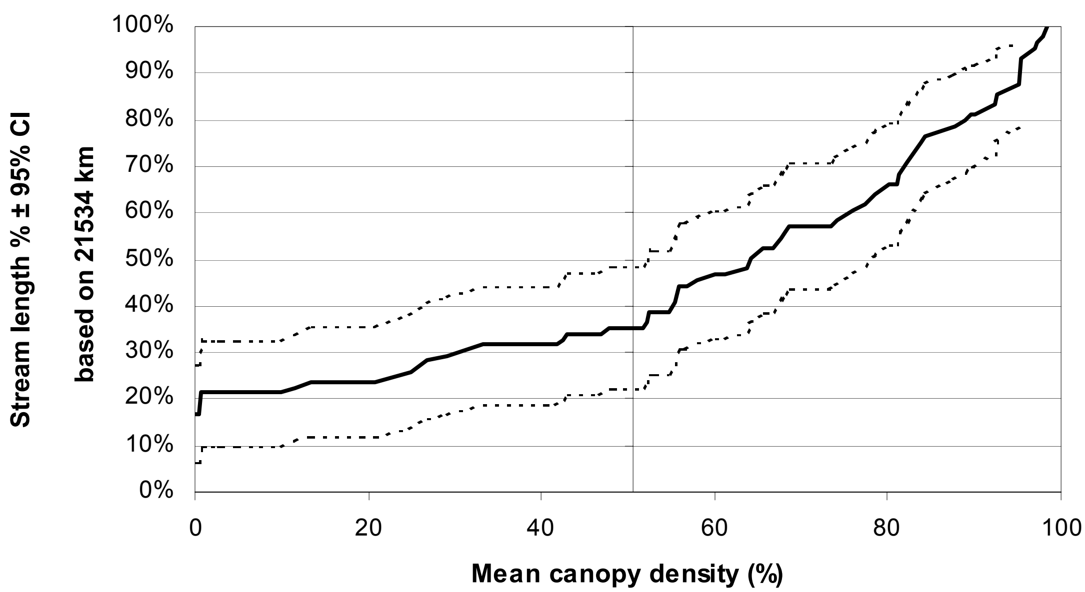

**Reference site median value (based on 30/30 sites) = 0%.**

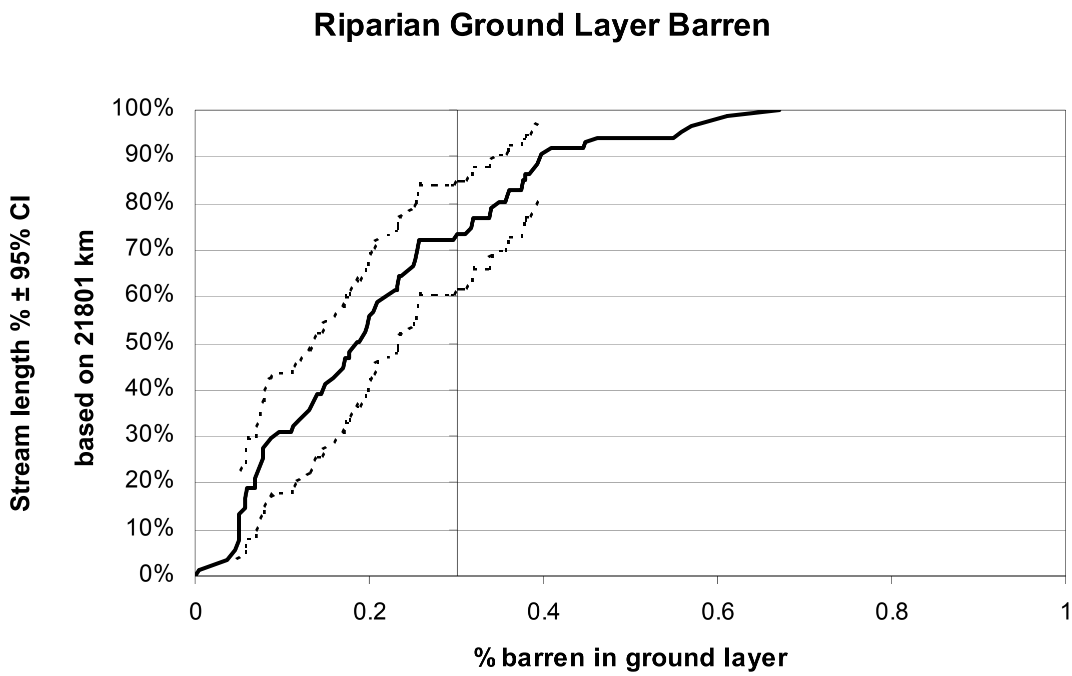
## PHYSICAL HABITAT: RIPARIAN COVER, RIPARIAN DISTURBANCE, FISH COVER, and LARGE WOODY DEBRIS

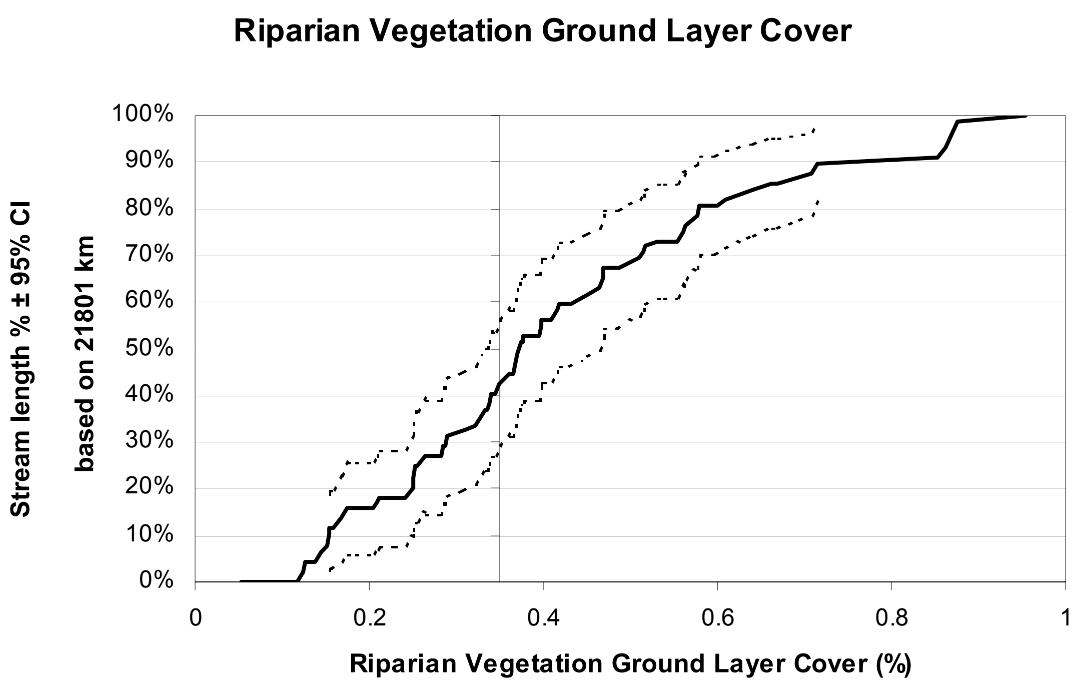
### Mean Bank Canopy Density



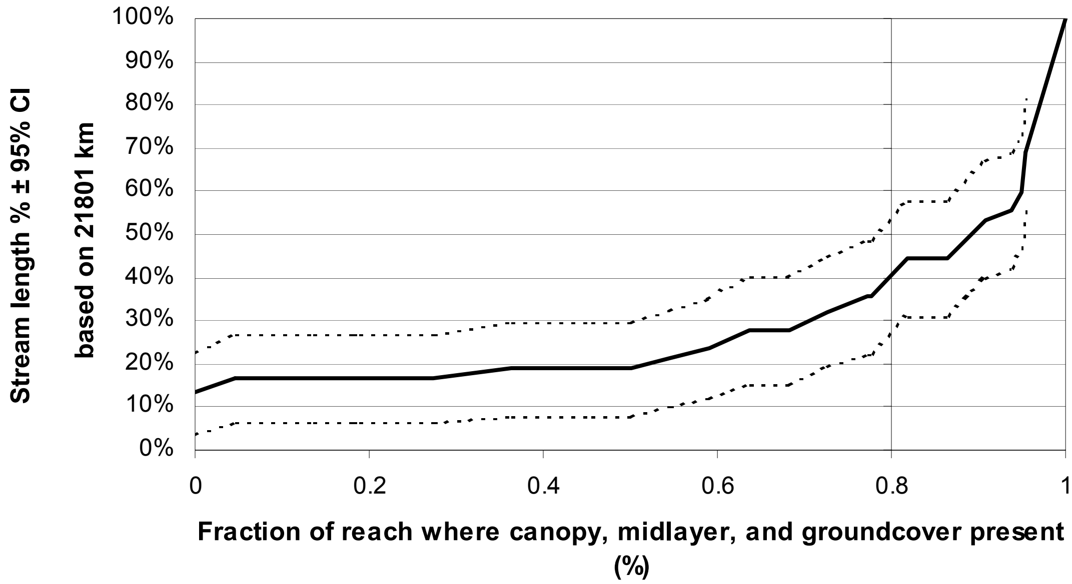

### Mean Mid-channel Canopy Density



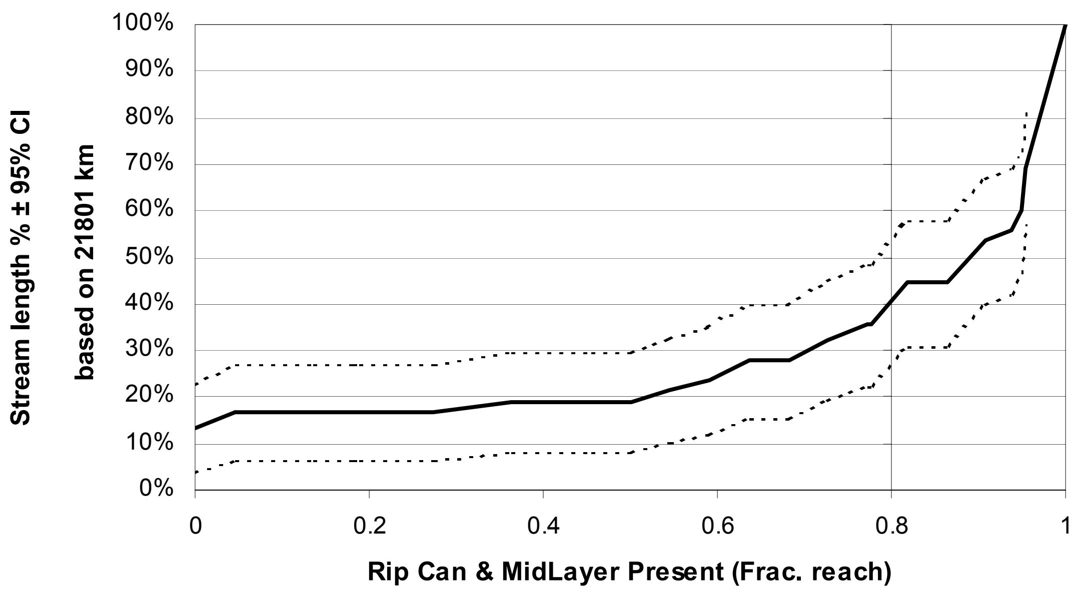

Riparian Ground Layer Barren
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.2
0.4
0.6
0.8
1
% barren in ground layer


Riparian Vegetation Ground Layer Cover
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.2
0.4
0.6
0.8
1
Riparian Vegetation Ground Layer Cover (%)

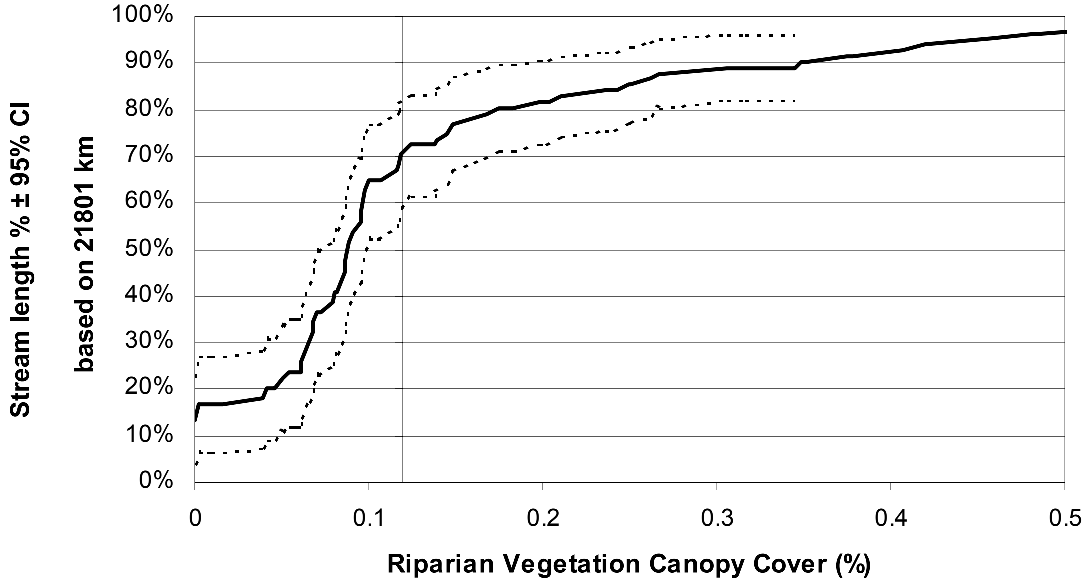
## Presence of Riparian Canopy + Midlayer + Ground




## Rip Can & MidLayer Present (Frac. reach)

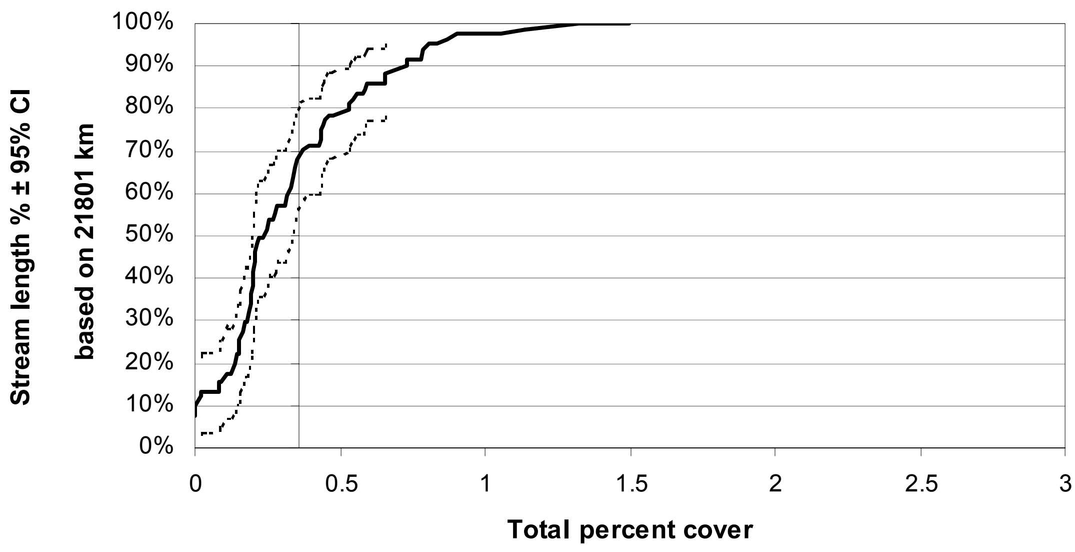


## Riparian Vegetation Canopy Cover

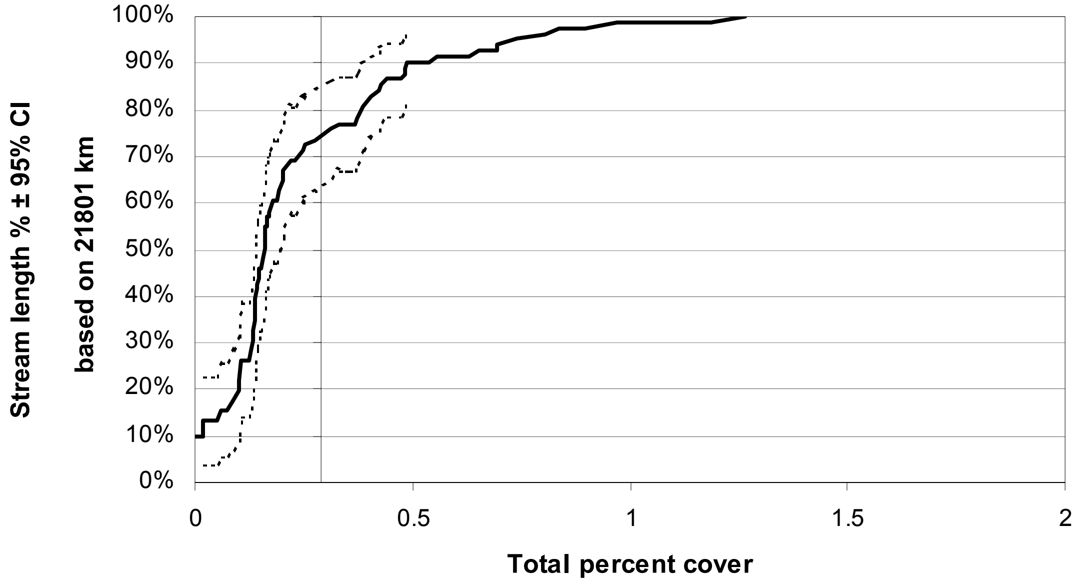



**Outlier values of 0.53–0.76 (representing less than 3% of km) not shown.**

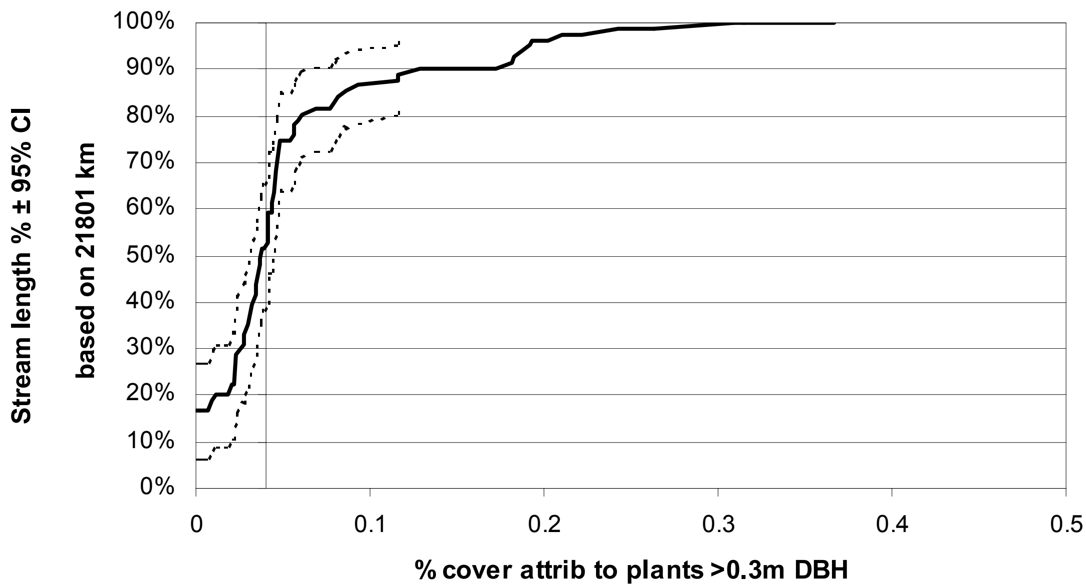
## Riparian Vegetation Canopy + Midlayer + Groundlayer Woody Cover



## Riparian Vegetation Canopy + Midlayer Woody Cover

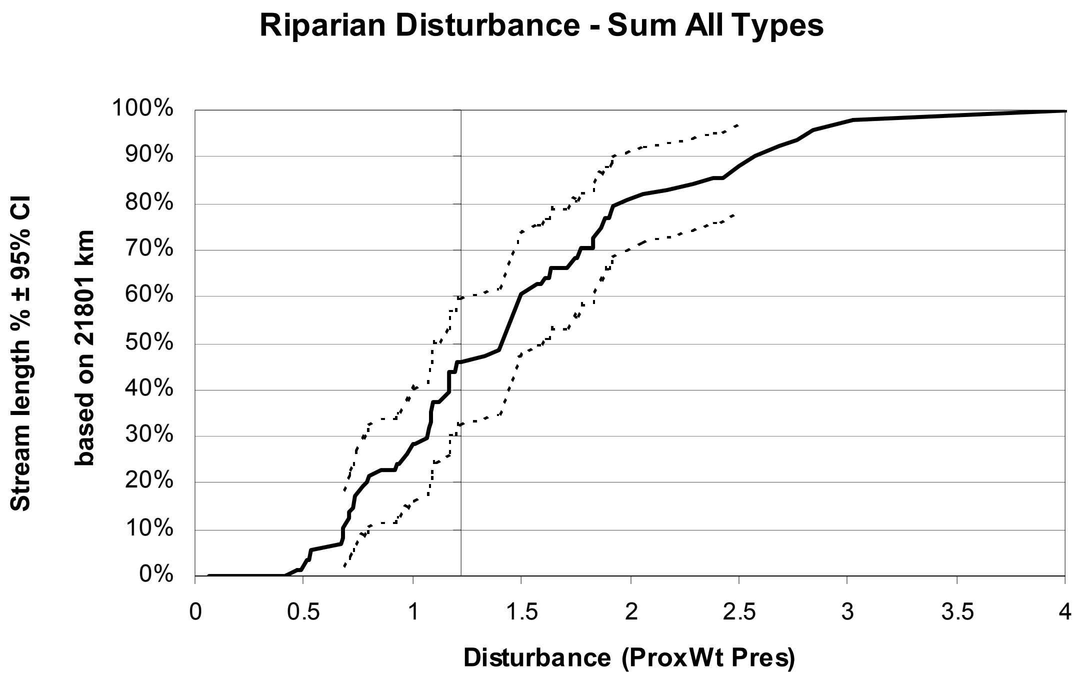


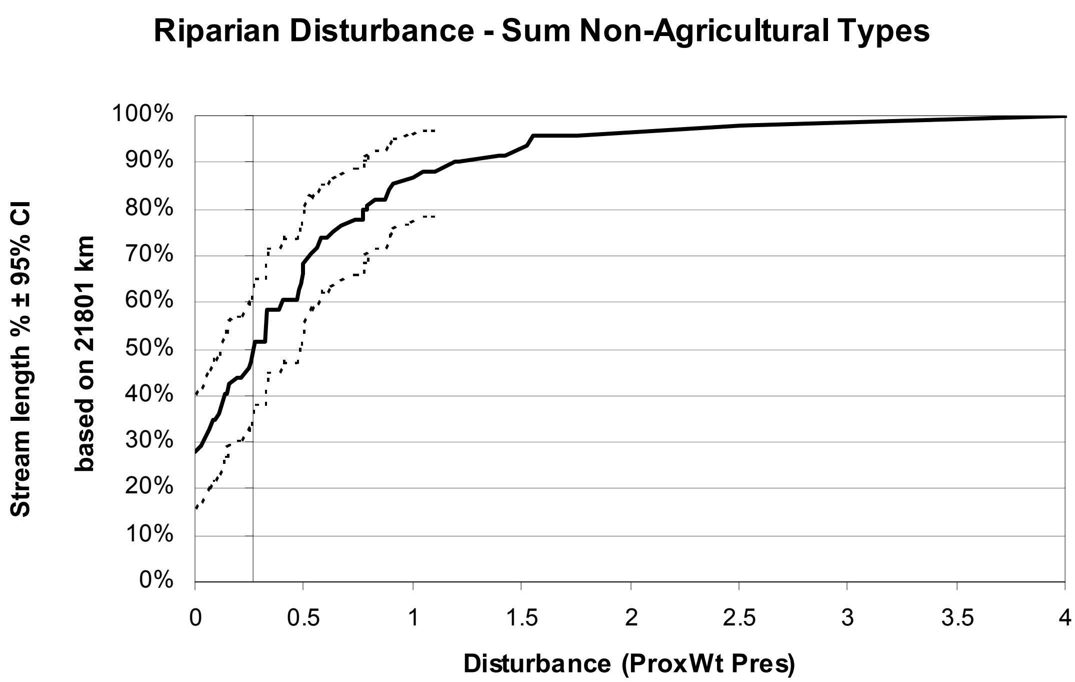

## Riparian Canopy >0.3m DBH

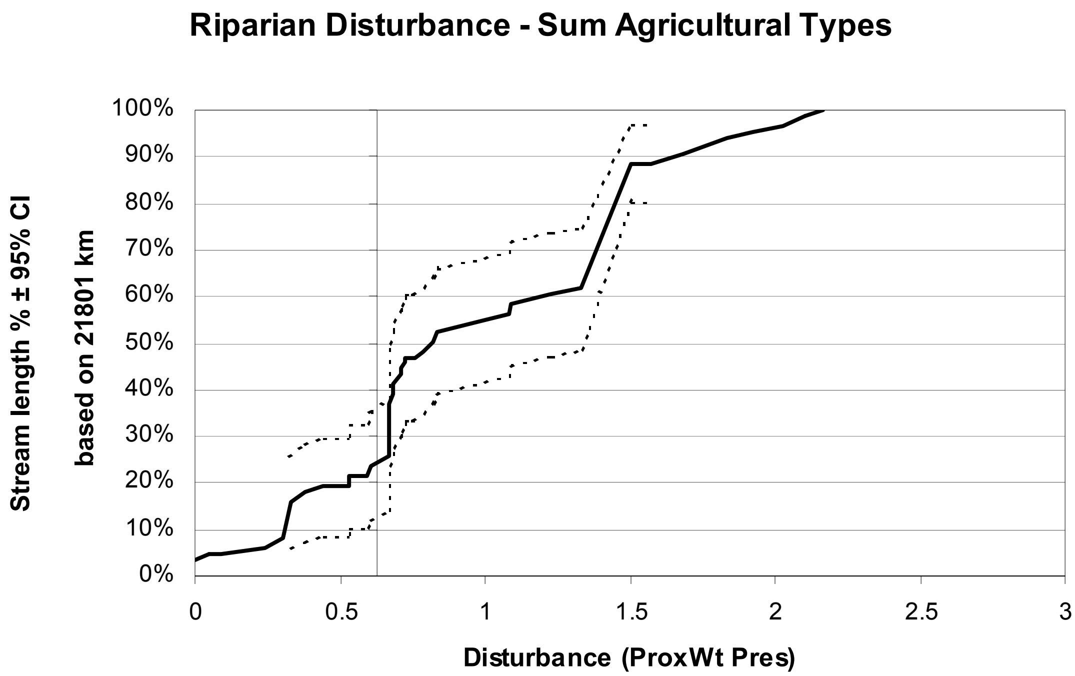


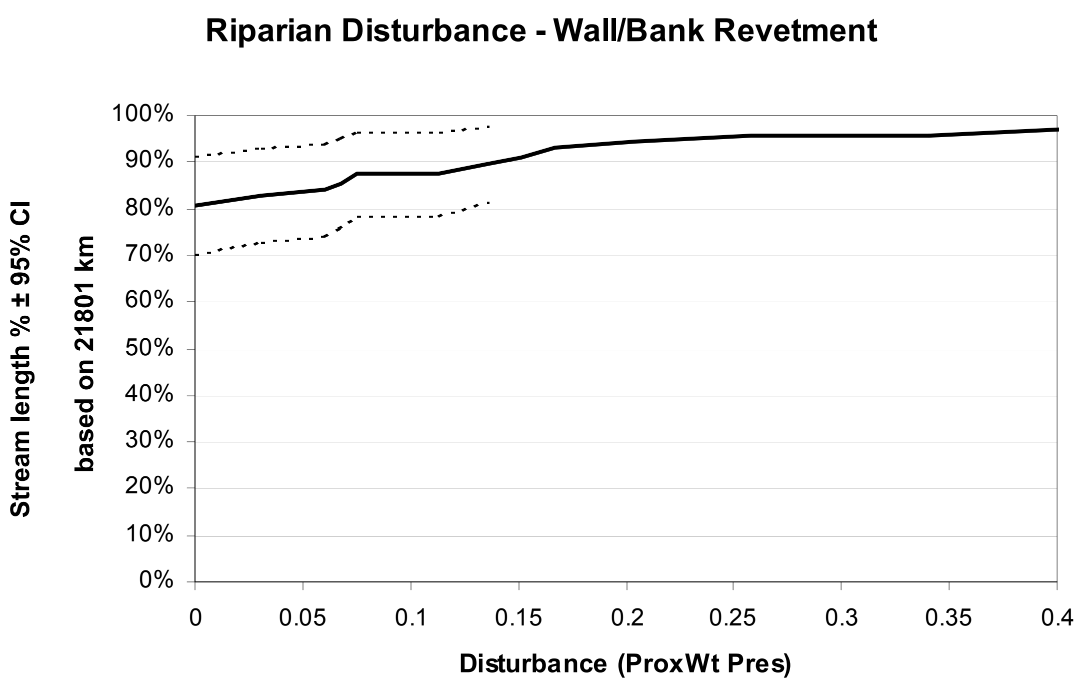

## Riparian Vegetation Coniferous Cover

| | | |
|---|---|---|
| **Random** | **21801 km** | **all values ≤ 0.9%** |
| **Reference** | **30/30 meas** | **median = 0%** |


Riparian Disturbance - Sum All Types
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.5
1
1.5
2
2.5
3
3.5
4
Disturbance (ProxWt Pres)

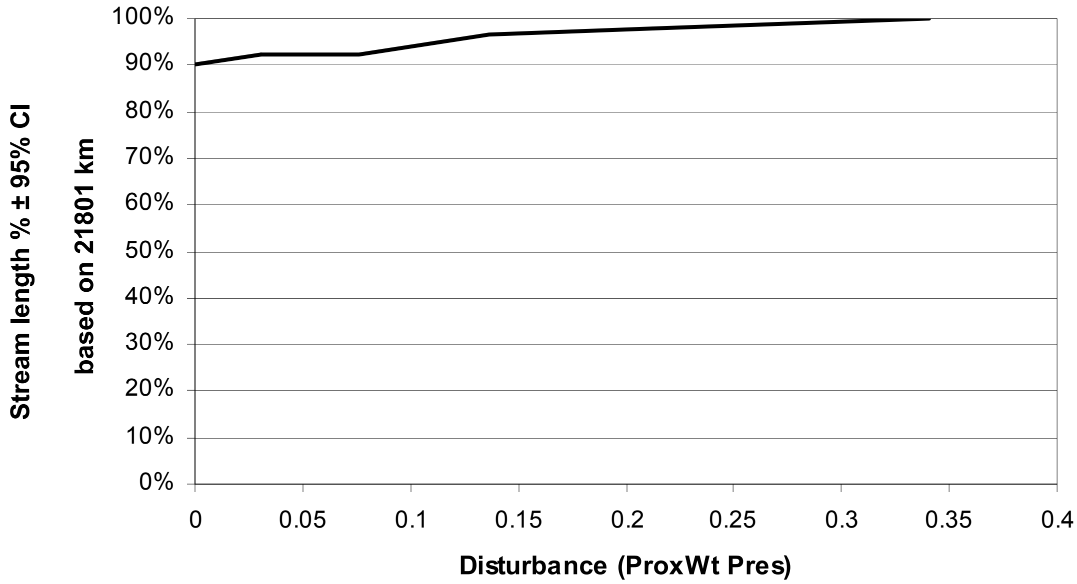

Riparian Disturbance - Sum Non-Agricultural Types
Stream length % ± 95% CI
based on 21801 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.5
1
1.5
2
2.5
3
3.5
4
Disturbance (ProxWt Pres)



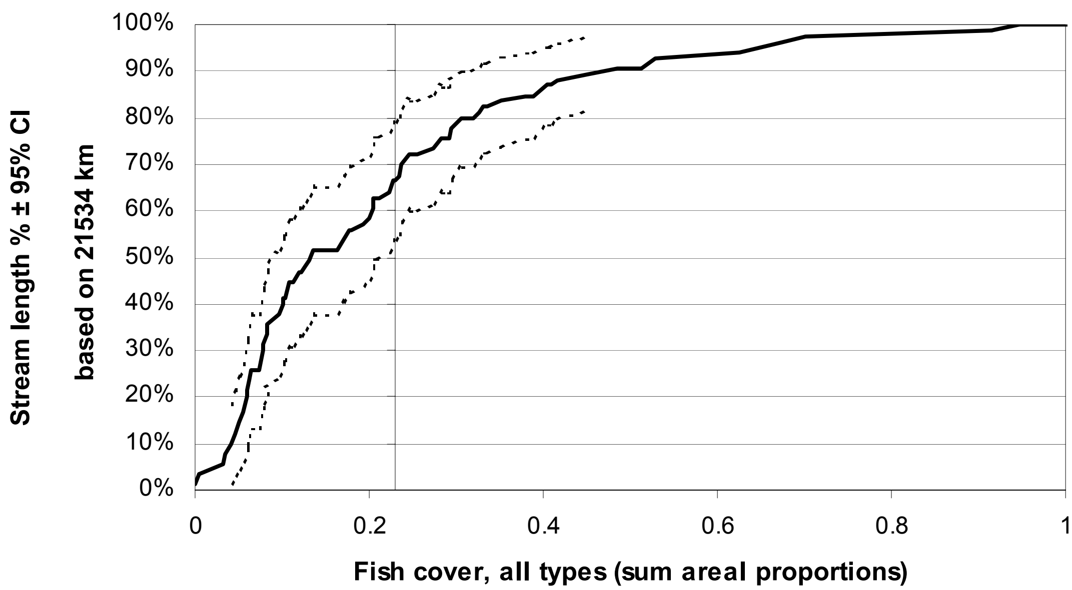




**Outlier values of 0.44–0.75 (representing less than 5% of km) not shown. Note scale. Reference site median value (based on 30/30 sites) = 0%.**

## Riparian Disturbance - Pipes

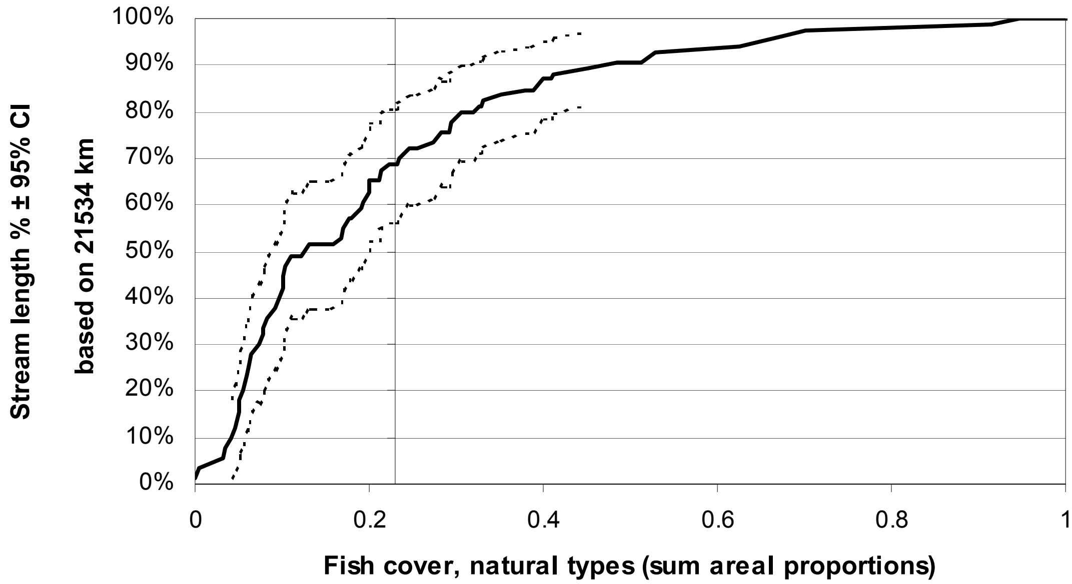



## Fish Cover - All Types



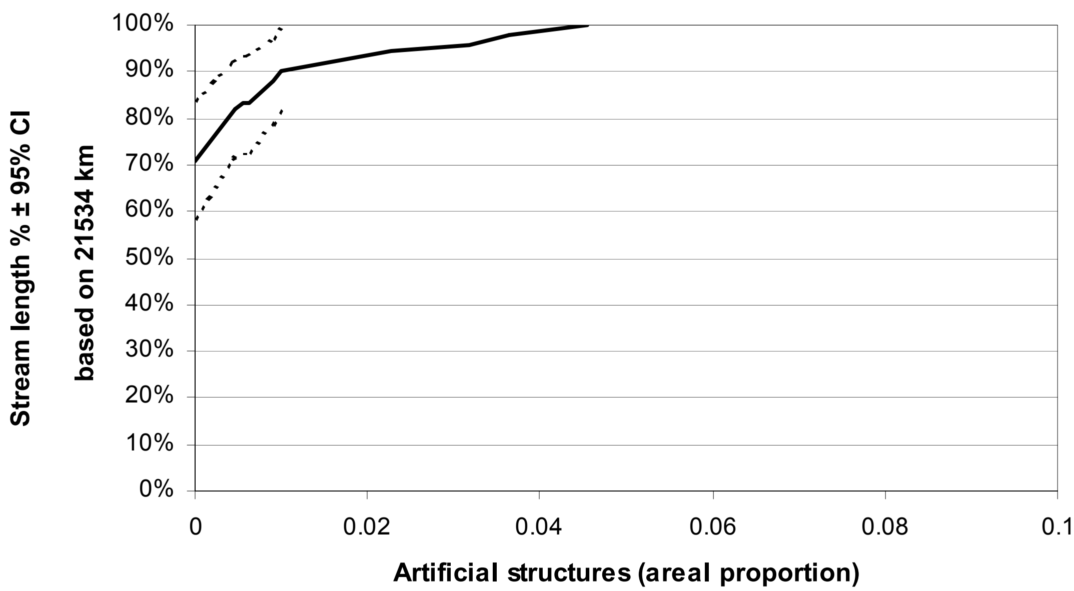

**Outlier values of 0.94–1.1 (representing less than 2% of km) not shown.**

## Fish Cover - Natural Types



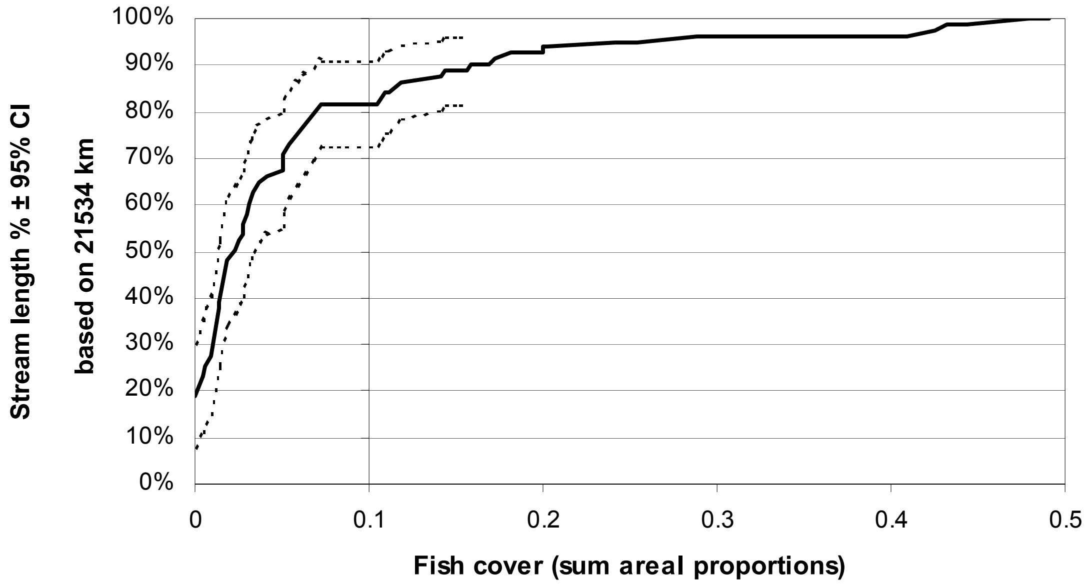

**Reference site median value (based on 30/30 sites) = 0%.**

## Fish Cover - Artificial Structures

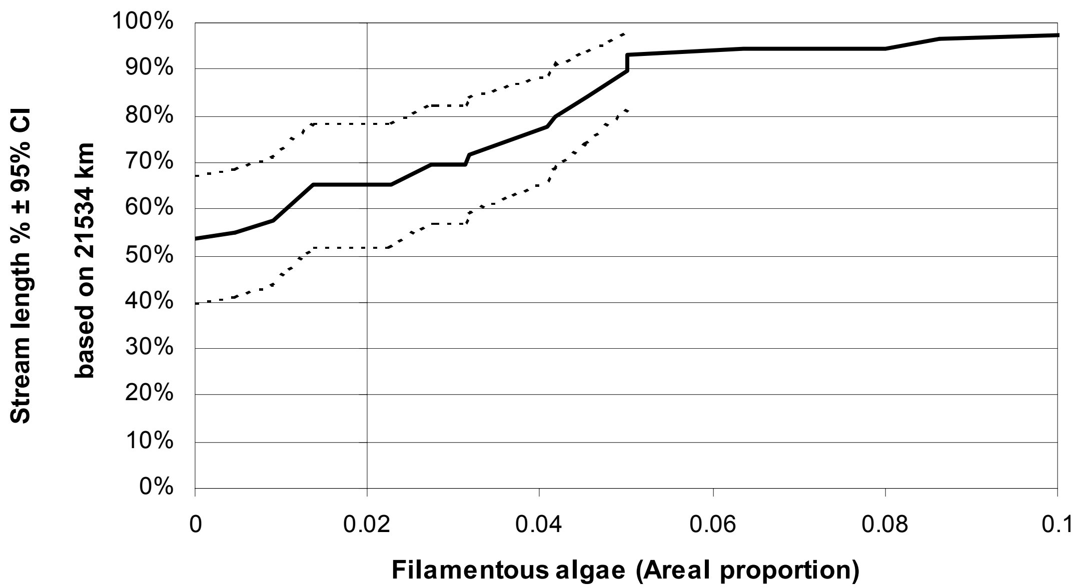



**Reference site median value (based on 30/30 sites) = 0%.**

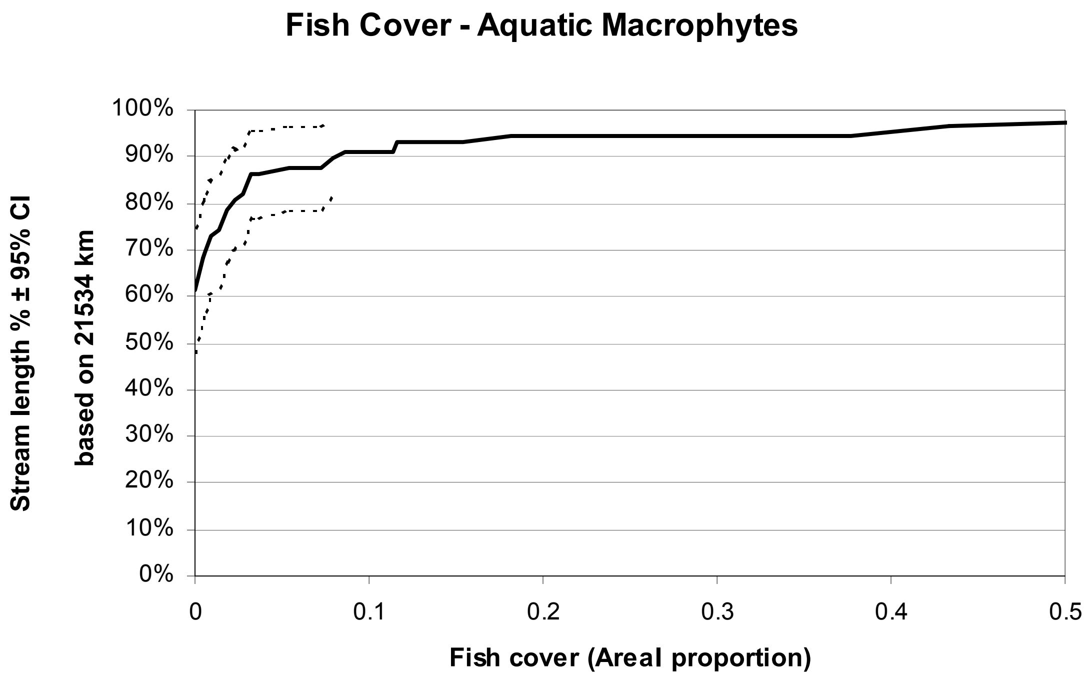
## Fish Cover - LWD, RCK, UCB or HUM



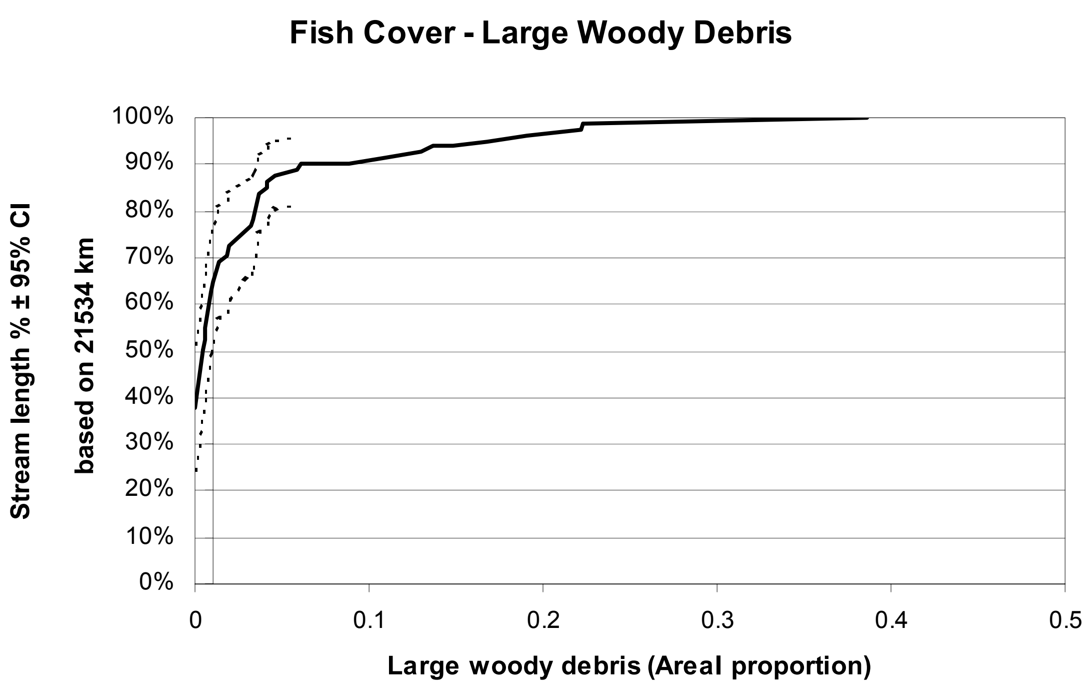

## Fish Cover - Filamentous Algae




**Outlier values of 0.18–0.57 (representing less than 3% of km) not shown. Note scale.**

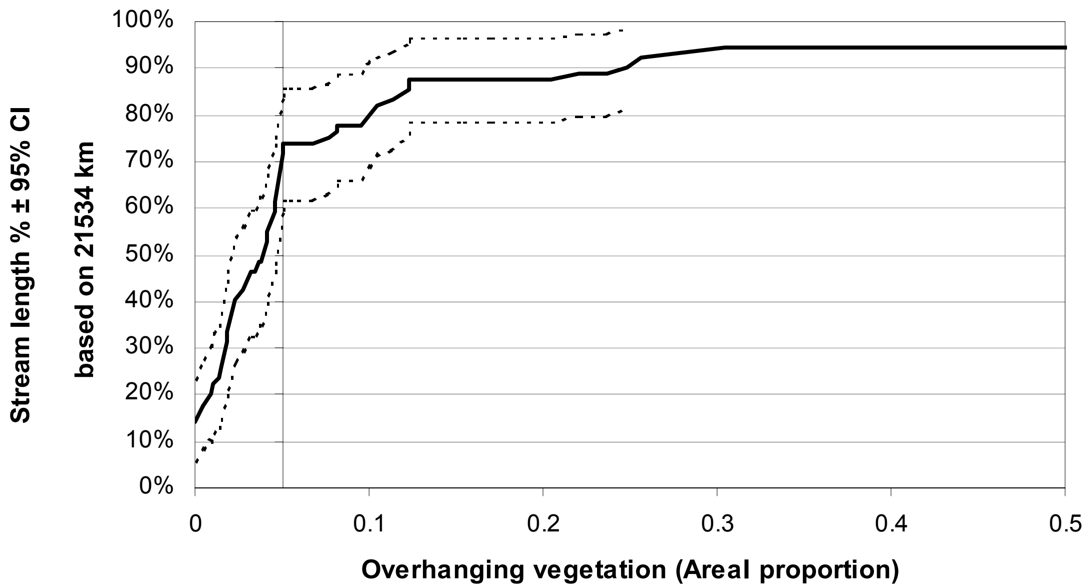



**Outlier values of 0.63–0.66 (representing less than 3% of km) not shown.**
**Reference site median value (based on 30/30 sites) = 0%.**



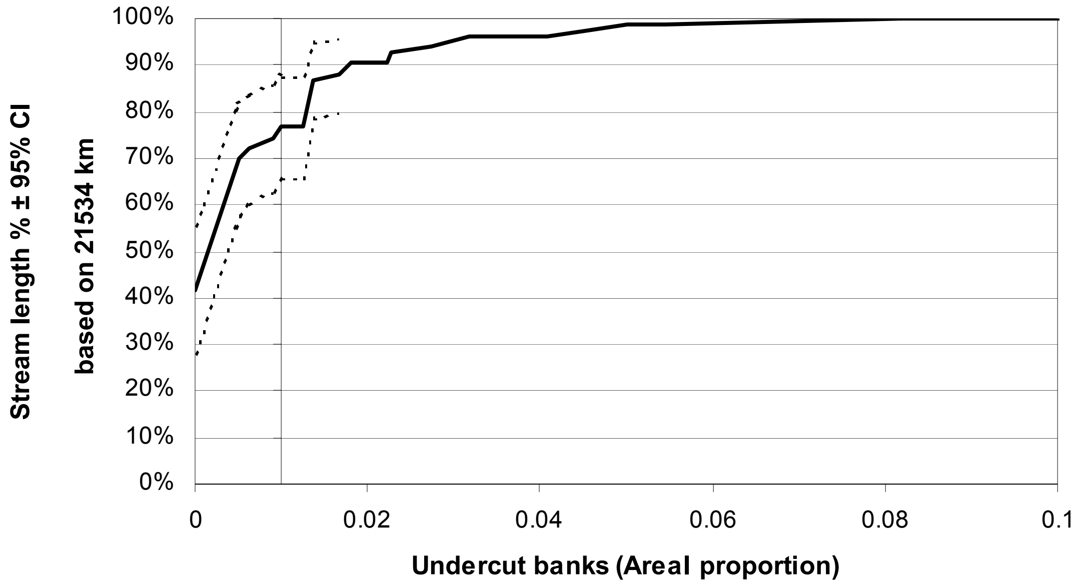
## Fish Cover - Brush & Small Debris


## Fish Cover - Overhanging Vegetation



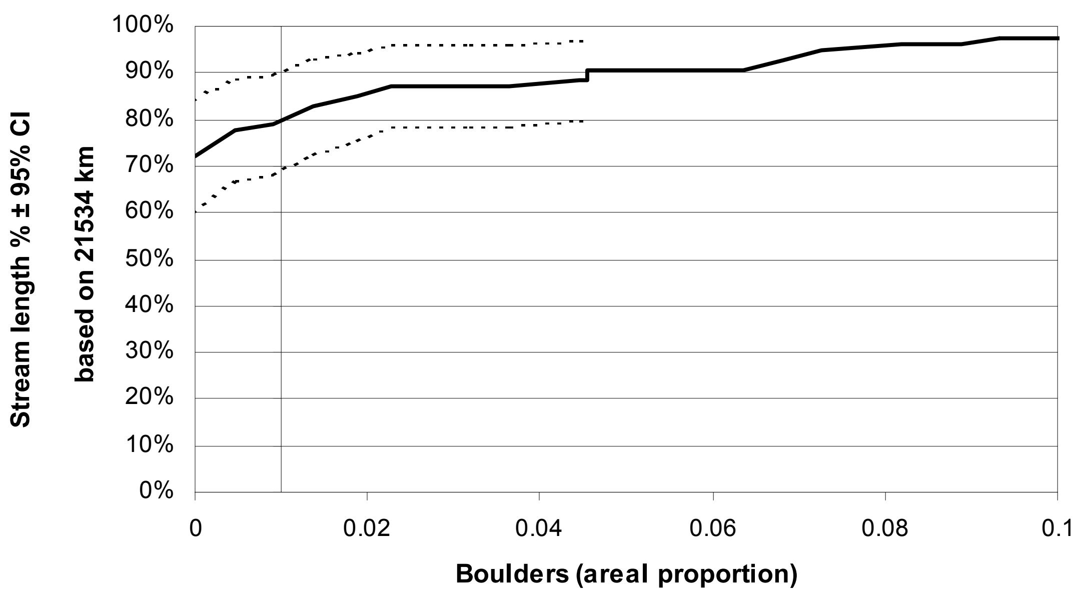

**Outlier values of 0.51–0.88 (representing less than 6% of km) not shown.**

## Fish Cover - Undercut Banks



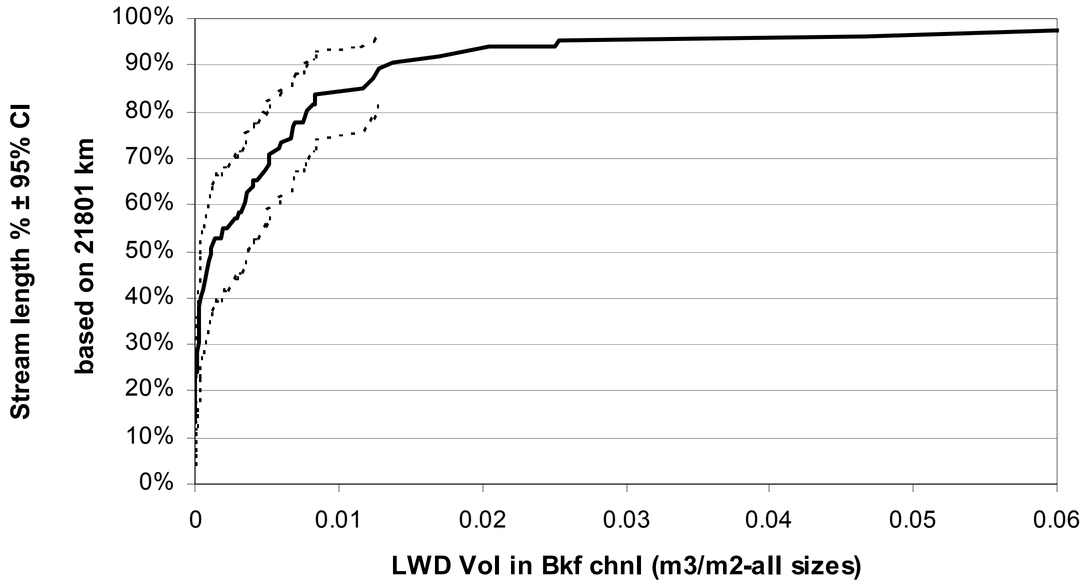

**Note scale.**

## Fish Cover - Boulders



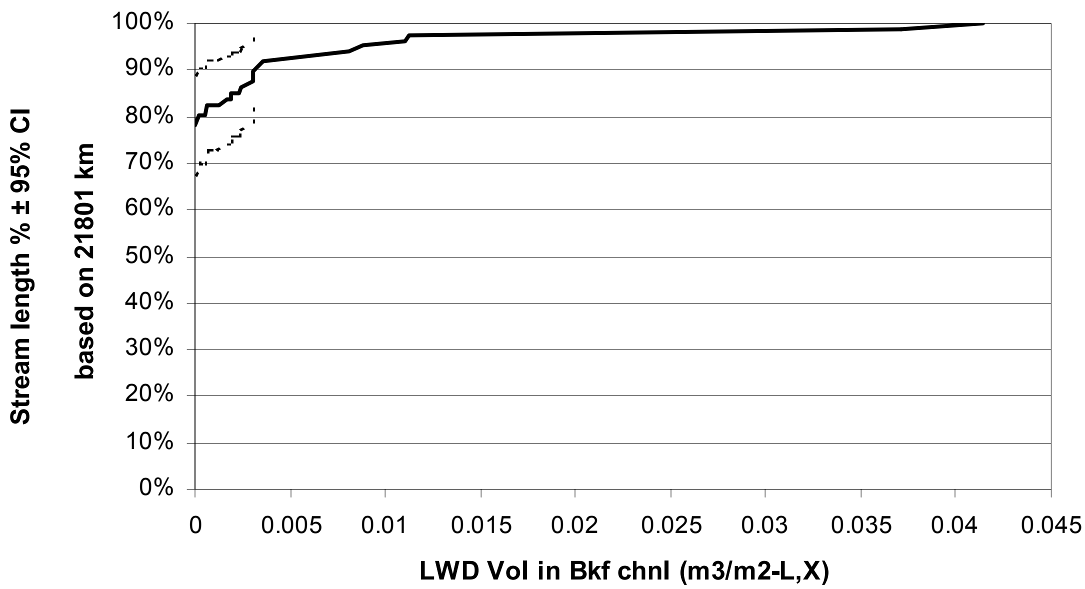

**Outlier values of 0.14–0.47 (representing less than 4% of km) not shown. Note scale.**

## LWD Vol in Bkf chnl (m3/m2-all sizes)



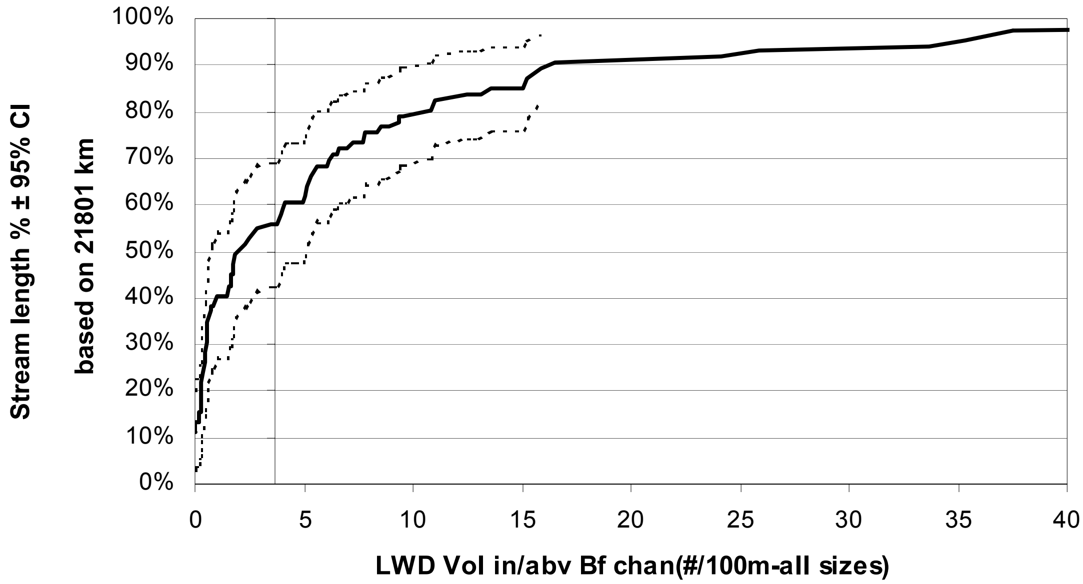

**Outlier values of 0.08 and 0.14 (representing less than 3% of km) not shown.**
**Reference site median value (based on 30/30 sites) = 0.**

## LWD Vol in Bkf chnl (m3/m2-L,X)



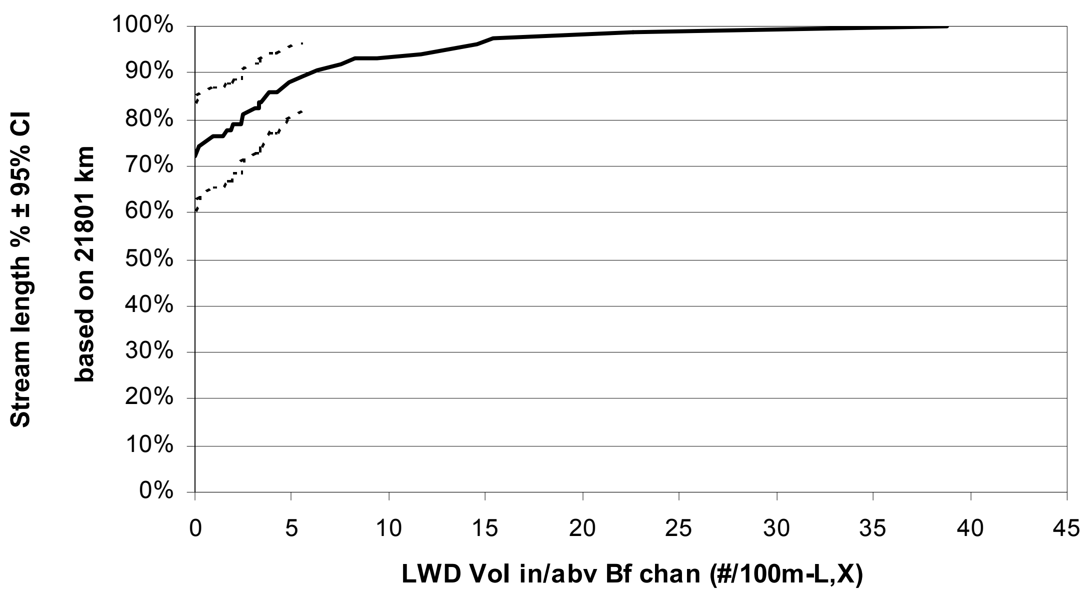

**Reference site median value (based on 30/30 sites) = 0%.**

## LWD Vol in/abv Bf chan(#/100m-all sizes)




**Outlier values of 60.0–87.4 (representing less than 2% of km) not shown.**

## LWD Vol in/abv Bf chan (#/100m-L,X)




**Reference site median value (based on 30/30 sites) = 0%.**

**Appendix L. Fish species collected from 30 reference sites and 55 random sites.** (Note that data from sites KES022 and KES037 are not included.). Some species are named as Endangered (ENDANG), Threatened (THREAT), or Species in need of conservation (SINC), based on state listings (Kansas Department of Wildlife and Parks 2005; Kansas Department of Wildlife and Parks 2005). Several species are marked as INTRO (not originally native in Kansas), based on distribution information from Cross and Collins (1995), NatureServe, and other sources.

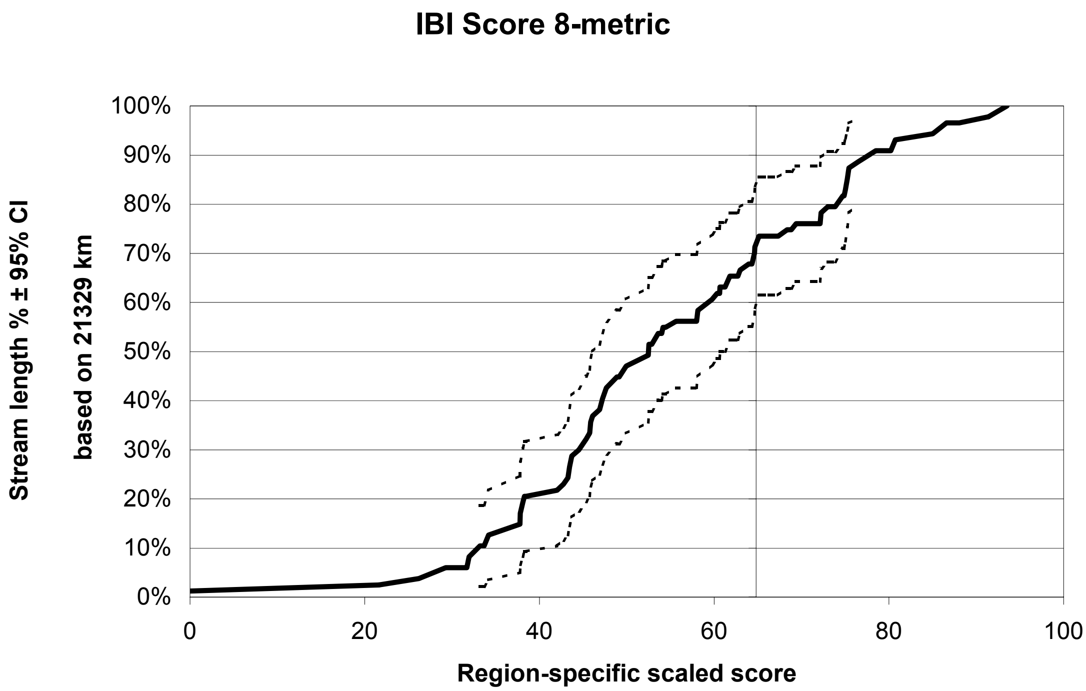
| SCIENTIFIC NAME (common name) | STATUS | REFERENCE | RANDOM | Grand Total |
|---|---|---|---|---|
| Ambloplites rupestris (rock bass) | INTRO | 1 | | 1 |
| Ameiurus melas (black bullhead) | | 11 | 20 | 31 |
| Ameiurus natalis (yellow bullhead) | | 15 | 14 | 29 |
| Aplodinotus grunniens (freshwater drum) | | 3 | 5 | 8 |
| Campostoma anomalum (central stoneroller) | | 27 | 36 | 63 |
| Carassius auratus (goldfish) | | 1 | | 1 |
| Carpiodes carpio (river carpsucker) | | 7 | 9 | 16 |
| Carpiodes cyprinus (quillback) | | 1 | 3 | 4 |
| Catostomus commersoni (white sucker) | | 7 | 10 | 17 |
| Cottus carolinae (banded sculpin) | SINC | 1 | | 1 |
| Cyprinella camura (bluntface shiner) | | 5 | | 5 |
| Cyprinella lutrensis (red shiner) | | 27 | 40 | 67 |
| Cyprinella spiloptera (spotfin shiner) | SINC | 1 | | 1 |
| Cyprinus carpio (common carp) | INTRO | 15 | 17 | 32 |
| Dorosoma cepedianum (gizzard shad) | | 7 | 11 | 18 |
| Erimystax x-punctatus (gravel chub) | SINC | 1 | | 1 |
| Etheostoma blennioides (greenside darter) | SINC | 2 | | 2 |
| Etheostoma cragini (Arkansas darter) | THREAT | 2 | 2 | 4 |
| Etheostoma flabellare (fantail darter) | | 2 | | 2 |
| Etheostoma nigrum (Johnny darter) | | | 3 | 3 |
| Etheostoma spectabile (orangethroat darter) | | 23 | 24 | 47 |
| Etheostoma stigmaeum (speckled darter) | SINC | 1 | | 1 |
| Etheostoma whipplei (redfin darter) | | 1 | 1 | 2 |
| Etheostoma zonale (banded darter) | SINC | 1 | | 1 |
| Fundulus notatus (blackstripe topminnow) | | 6 | 5 | 11 |
| Fundulus zebrinus (plains killifish) | | 6 | 10 | 16 |
| Gambusia affinis (western mosquitofish) | | 6 | 20 | 26 |
| Ictalurus punctatus (channel catfish) | | 17 | 16 | 33 |
| Ictiobus bubalus (smallmouth buffalo) | | 7 | 4 | 11 |
| Ictiobus cyprinellus (bigmouth buffalo) | | 1 | 2 | 3 |
| Labidesthes sicculus (brook silverside) | | 7 | 3 | 10 |
| Lepisosteus osseus (longnose gar) | | 4 | 4 | 8 |
| Lepisosteus platostomus (shortnose gar) | | 2 | | 2 |
| Lepomis cyanellus (green sunfish) | | 28 | 42 | 70 |
| Lepomis cyanellus X macrochirus (bluegill X green sunfish) | | 4 | 1 | 5 |
| Lepomis gulosus (warmouth) | | 1 | | 1 |
| Lepomis humilis (orangespotted sunfish) | | 17 | 17 | 34 |
| Lepomis macrochirus (bluegill) | | 23 | 21 | 44 |

| **SCIENTIFIC NAME (common name)** | **STATUS** | **REFERENCE** | **RANDOM** | **Grand Total** |
|---|---|---|---|---|
| Lepomis megalotis (longear sunfish) | | 19 | 12 | 31 |
| Luxilus cardinalis (cardinal shiner) | | 2 | | 2 |
| Luxilus cornutus (common shiner) | | 4 | 4 | 8 |
| Lythrurus umbratilis (redfin shiner) | | 10 | 9 | 19 |
| Macrhybopsis storeriana (silver chub) | ENDANG | | 1 | 1 |
| Micropterus punctulatus (spotted bass) | | 6 | 1 | 7 |
| Micropterus salmoides (largemouth bass) | | 21 | 29 | 50 |
| Minytrema melanops (spotted sucker) | SINC | 1 | 1 | 2 |
| Morone americana (white perch) | INTRO | | 2 | 2 |
| Morone chrysops (white bass) | | 3 | 3 | 6 |
| Moxostoma erythrurum (golden redhorse) | SINC | 7 | 3 | 10 |
| Moxostoma macrolepidotum (shorthead redhorse) | | 9 | 1 | 10 |
| Nocomis asper (redspot chub) | THREAT | 1 | | 1 |
| Nocomis biguttatus (hornyhead chub) | THREAT | 1 | | 1 |
| Notemigonus crysoleucas (golden shiner) | | 5 | 8 | 13 |
| Notropis atherinoides (emerald shiner) | | 2 | 4 | 6 |
| Notropis boops (bigeye shiner) | | 2 | | 2 |
| Notropis rubellus (rosyface shiner) | | 4 | | 4 |
| Notropis stramineus (sand shiner) | | 19 | 26 | 45 |
| Notropis topeka (Topeka shiner) | THREAT | 1 | 1 | 2 |
| Notropis volucellus (mimic shiner) | | 3 | 1 | 4 |
| Noturus exilis (slender madtom) | | 9 | 4 | 13 |
| Noturus flavus (stonecat) | | 6 | 5 | 11 |
| Noturus nocturnus (freckled madtom) | | 2 | | 2 |
| Percina caprodes (logperch) | | 11 | 4 | 15 |
| Percina copelandi () | | 1 | | 1 |
| Percina copelandi (channel darter) | | 1 | | 1 |
| Percina phoxocephala (slenderhead darter) | | 7 | 4 | 11 |
| Phenacobius mirabilis (suckermouth minnow) | | 16 | 22 | 38 |
| Phoxinus erythrogaster (southern redbelly dace) | | 2 | 1 | 3 |
| Pimephales notatus (bluntnose minnow) | | 17 | 15 | 32 |
| Pimephales promelas (fathead minnow) | | 11 | 34 | 45 |
| Pimephales tenellus (slim minnow) | | 1 | 1 | 2 |
| Pimephales vigilax (bullhead minnow) | | 3 | 8 | 11 |
| Polyodon spathula (paddlefish) | | | 1 | 1 |
| Pomoxis annularis (white crappie) | | 6 | 9 | 15 |
| Pomoxis nigromaculatus (black crappie) | | 1 | 1 | 2 |
| Pylodictis olivaris (flathead catfish) | | 11 | 9 | 20 |
| Semotilus atromaculatus (creek chub) | | 14 | 26 | 40 |
| Semotilus atromaculatus (fathead minnow) | | 1 | | 1 |
| **Grand Total** | | **531** | **590** | **1121** |

**Appendix M. Fish community characteristics of reference sites.** This table shows summary statistics for the reference sites.

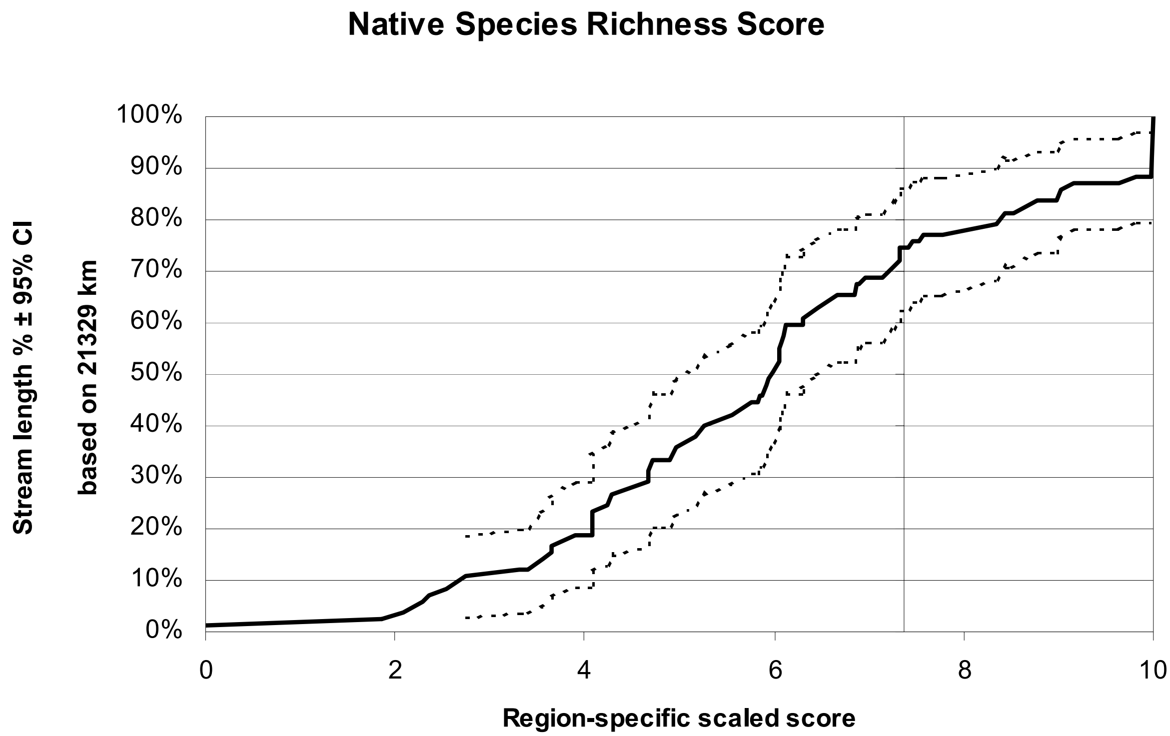
| code | analyte | n | min | p25 | p50 | p75 | max | mean | stdev |
|---|---|---|---|---|---|---|---|---|---|
| natsp | Native Species Richness Score (0-10) | 30 | 0 | 5.93 | 7.37 | 8.52 | 10.00 | 7.13 | 2.24 |
| natfam | Native Family Richness Score (0-10) | 30 | 0 | 5.95 | 7.49 | 8.96 | 10.00 | 7.41 | 2.13 |
| nindiv | No. Indiv. Score (0-10) | 30 | 0 | 2.99 | 5.36 | 7.86 | 10.00 | 5.72 | 2.88 |
| sensit | Sensit. Spp. Rich. Score (0-10) | 30 | 0 | 0.00 | 4.19 | 7.49 | 10.00 | 4.00 | 3.93 |
| tolrnt | % Tolerants Score (0-10) | 30 | 0 | 1.36 | 4.41 | 8.60 | 10.00 | 4.90 | 3.59 |
| smbenth | Ntv Sm. Benth. Spp. Rich. Score (0-10) | 30 | 0 | 4.07 | 6.59 | 8.32 | 10.00 | 6.19 | 2.80 |
| benthic | Native Benth. Spp. Rich. Score (0-10) | 30 | 0 | 3.16 | 5.02 | 7.35 | 10.00 | 5.24 | 2.59 |
| wcolumn | Ntv Wtr. Col. Spp. Rich. Score (0-10) | 30 | 0 | 4.76 | 6.28 | 7.84 | 10.00 | 6.30 | 2.41 |
| wcolspcl | Ntv Wtr. Col. Spec. Spp. Score (0-10) | 30 | 0 | 1.33 | 4.04 | 7.05 | 10.00 | 4.39 | 3.39 |
| sunfish | Ntv Centrarchid Spp. Rich. Score (0-10) | 30 | 0 | 3.31 | 4.84 | 7.13 | 10.00 | 5.02 | 2.24 |
| minnow | Ntv Cyprinid Spp. Rich. Score (0-10) | 30 | 0 | 4.55 | 5.56 | 8.18 | 10.00 | 5.99 | 2.53 |
| longlive | Ntv. Long-lived Spp. Rich. Score (0-10) | 30 | 0 | 5.29 | 6.61 | 8.66 | 10.00 | 6.71 | 2.36 |
| alien | % Non-natives Score (0-10) | 30 | 0 | 9.15 | 9.59 | 9.90 | 10.00 | 8.95 | 2.19 |
| troph | No. Trophic Strat. Score (0-10) | 30 | 0 | 6.73 | 8.88 | 10.00 | 10.00 | 8.36 | 2.17 |
| carn | % Carnivores Score (0-10) | 30 | 0 | 0.96 | 3.26 | 6.07 | 10.00 | 4.14 | 3.56 |
| insinv | % Insectivores+Invertivores Score (0-10) | 30 | 0 | 5.78 | 8.11 | 10.00 | 10.00 | 7.30 | 3.25 |
| insect | % Insectivores Score (0-10) | 30 | 0 | 3.60 | 5.66 | 10.00 | 10.00 | 6.16 | 3.58 |
| herbiv | % Herbivores+Micro. Omniv. Score (0-10) | 30 | 0 | 10.00 | 10.00 | 10.00 | 10.00 | 8.80 | 2.72 |
| omni | % Macrophagic Omnivores Score (0-10) | 30 | 0 | 8.85 | 10.00 | 10.00 | 10.00 | 8.57 | 2.90 |
| omnihb | % Omniv. + Herbiv. Score (0-10) | 30 | 0 | 5.15 | 9.22 | 10.00 | 10.00 | 7.57 | 3.13 |
| repro | No. Reprod. Strat. Score (0-10) | 30 | 0 | 8.00 | 8.00 | 8.57 | 10.00 | 7.68 | 2.05 |
| tolrepr | % Tolerant Spawners Score (0-10) | 30 | 0 | 3.96 | 6.41 | 8.82 | 10.00 | 6.25 | 3.13 |
| gravel | % Cln. Subs. Spawners Score (0-10) | 30 | 0 | 3.96 | 6.40 | 8.82 | 10.00 | 6.25 | 3.13 |
| ibi1 | IBI Score (0-100)--MAHA metrics+longlive | 30 | 0 | 63.99 | 68.38 | 73.29 | 84.99 | 65.75 | 15.44 |
| ibi4 | IBI based on S:N and resp. (10 metrics) | 30 | 0 | 58.70 | 63.99 | 69.57 | 85.43 | 61.78 | 16.16 |
| ibi5 | IBI Score (13 metrics) | 30 | 0 | 59.31 | 65.54 | 71.34 | 83.20 | 62.79 | 15.36 |
| ibi6 | IBI score (12 metrics) | 30 | 0 | 60.68 | 66.16 | 70.01 | 81.80 | 62.82 | 15.52 |
| ibi7 | IBI score (11 metrics) | 30 | 0 | 59.16 | 65.02 | 70.12 | 83.62 | 61.89 | 15.93 |
| ibi8 | IBI score (8 metrics) | 30 | 0 | 54.19 | 64.78 | 71.35 | 88.06 | 60.61 | 17.55 |

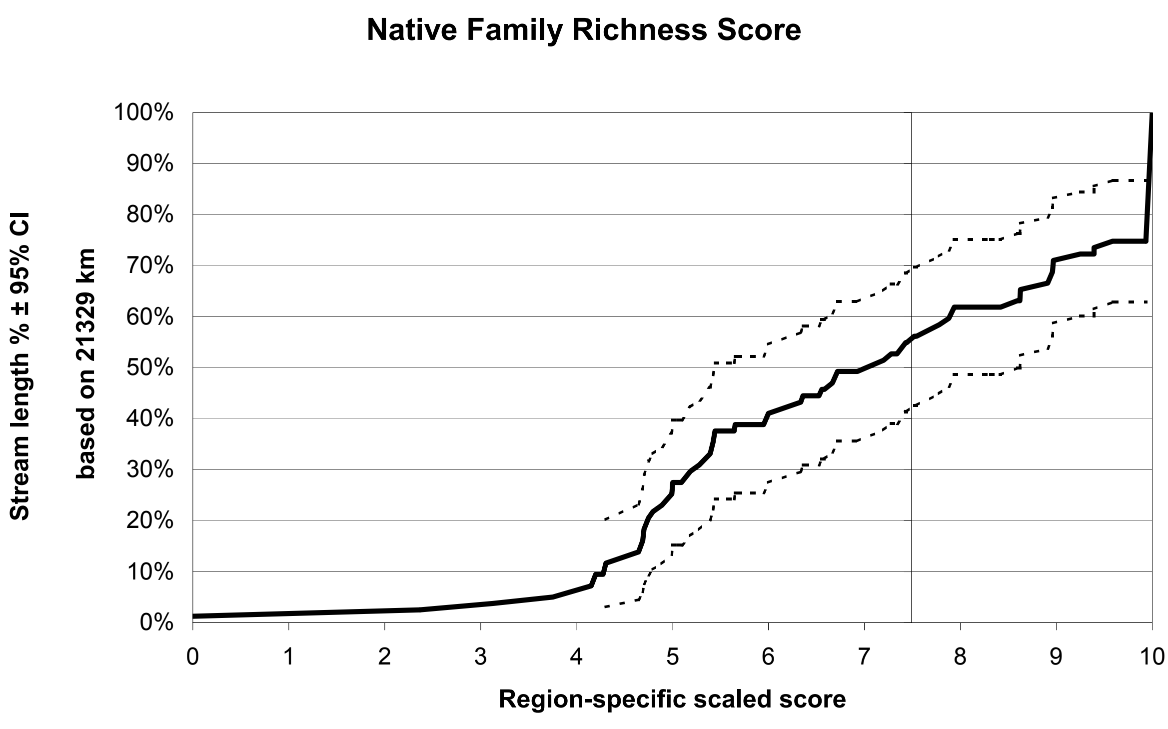
**Appendix N. Fish community metrics and indices of biotic integrity.**



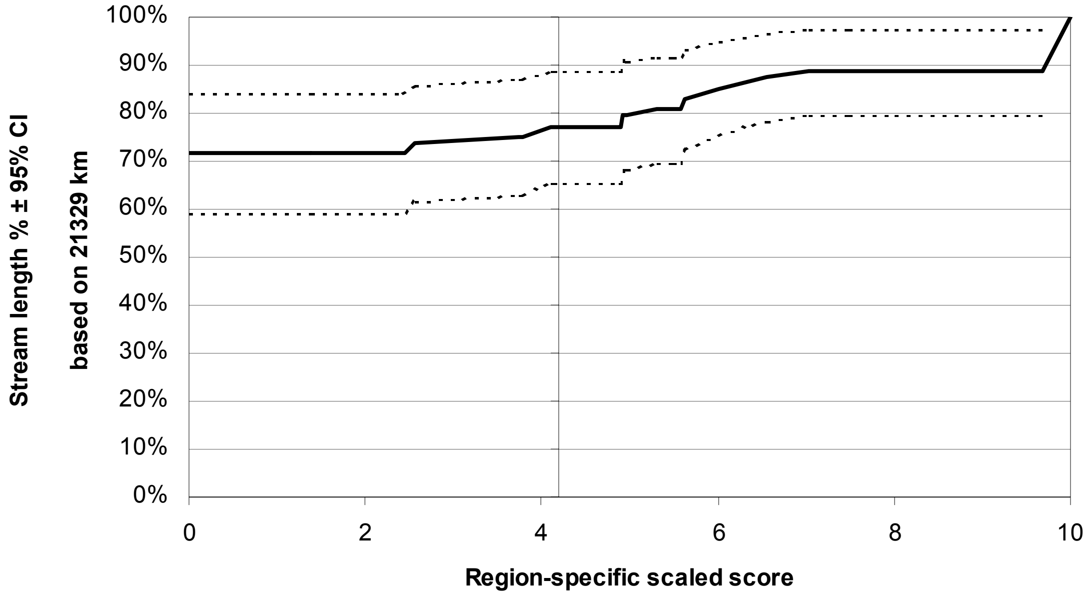

| Metric | 12-m IBI | 11-m IBI | 8-m IBI |
|---|---|---|---|
| 1. Native Species Richness | X | X | X |
| 2. Native Family Richness | X | X | X |
| 3. Number of Individuals Collected | X | X | – |
| 4. Sensitive Species Richness | X | X | X |
| 5. Proportion of Tolerant Individuals | X | X | X |
| 6. Number of Native Benthic Species | X | X | X |
| 7. Number of Native Water Column Species | X | X | – |
| 8. Number of Long-lived species | X | X | X |
| 9. Proportion of Individuals of Introduced Species | X | X | X |
| 10. Proportion of Individuals as Carnivores | X | X | X |
| 11. Proportion of Individuals as Insectivores and Invertivores | X | – | – |
| 12. Proportion of Individuals as Omnivores and Herbivores | X | X | – |

**Metrics included in the 8-metric IBI:**

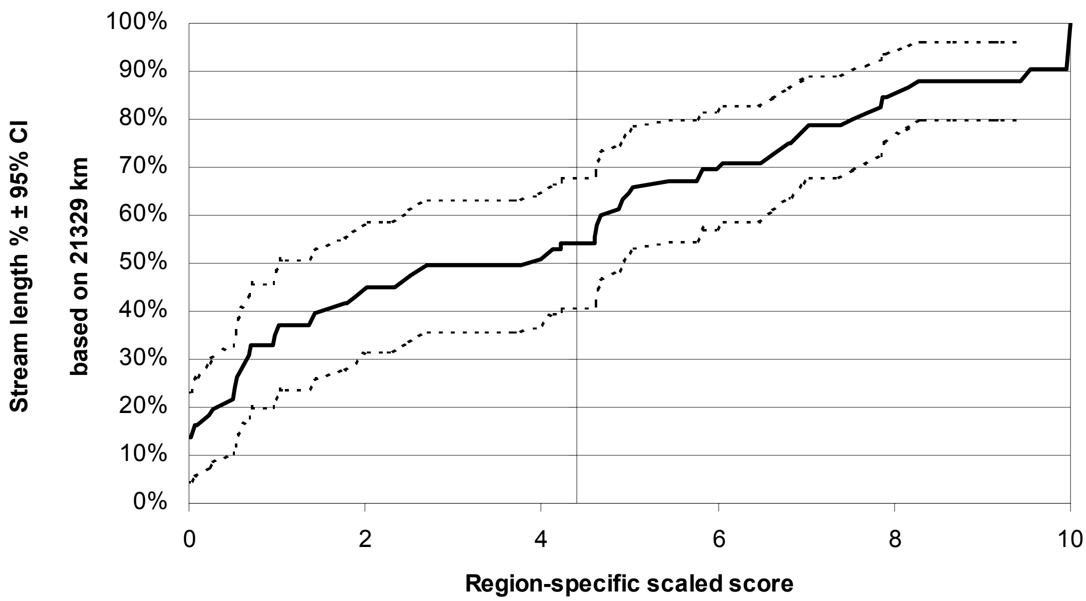


## Sensitive Species Richness Score

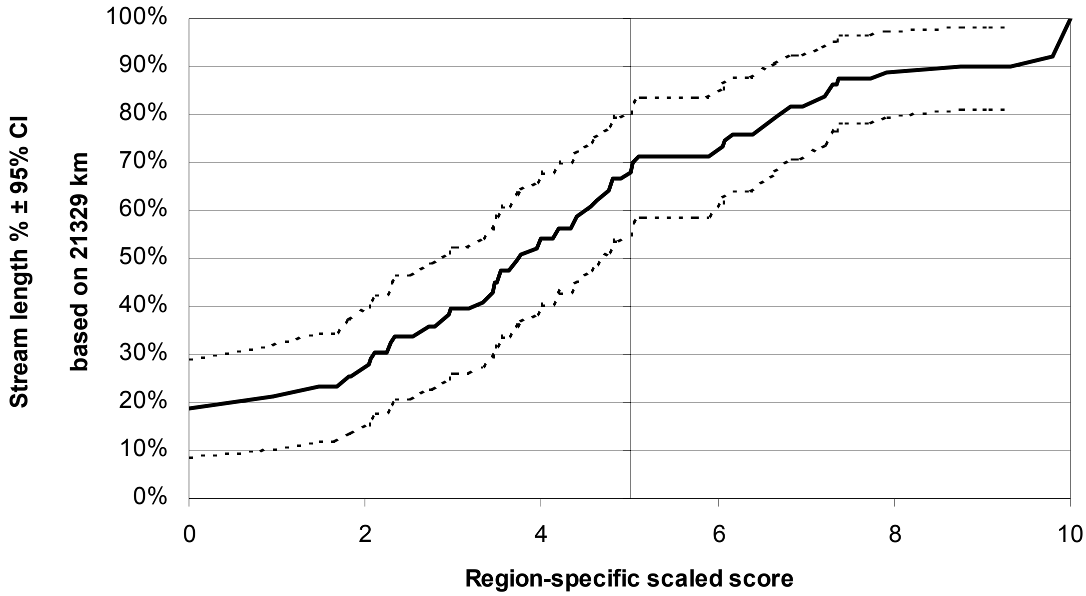



## Tolerants Score

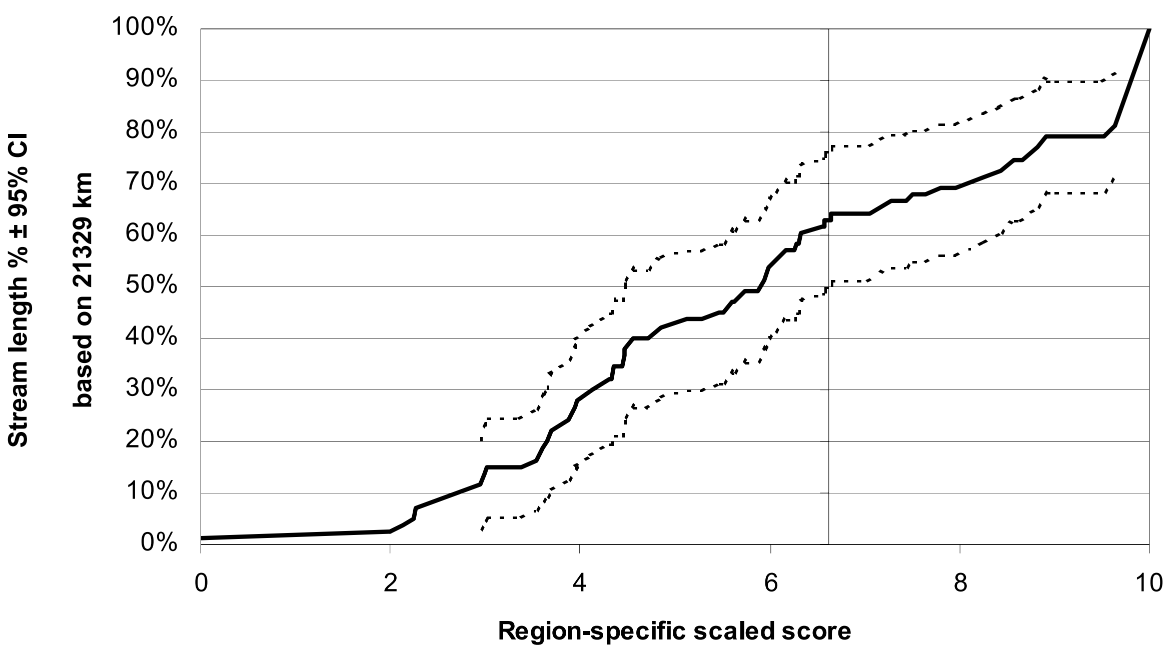



s

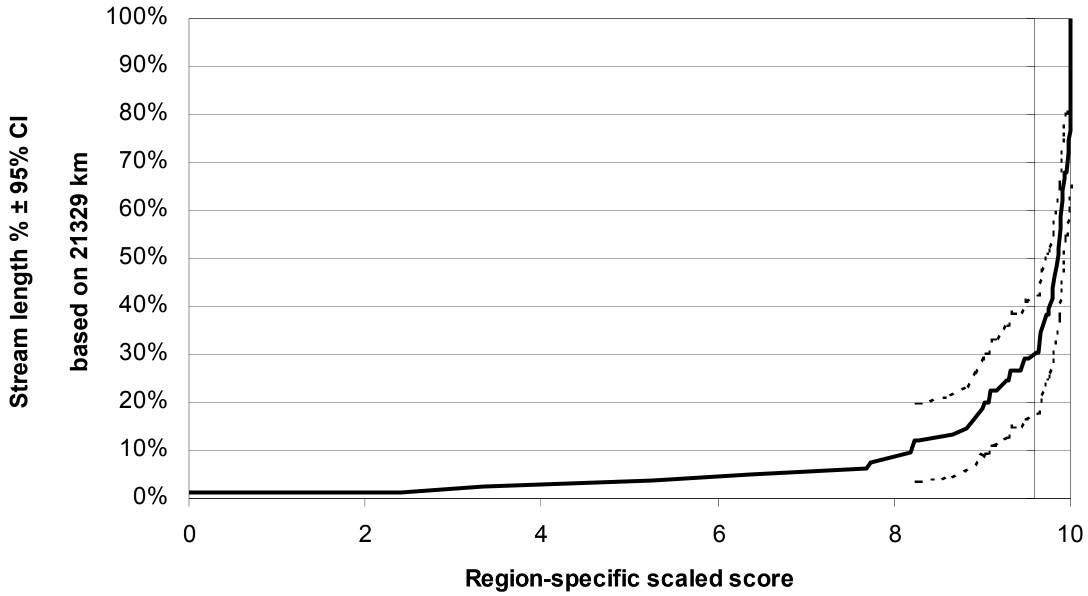
## Native Benthic Species Richness Score



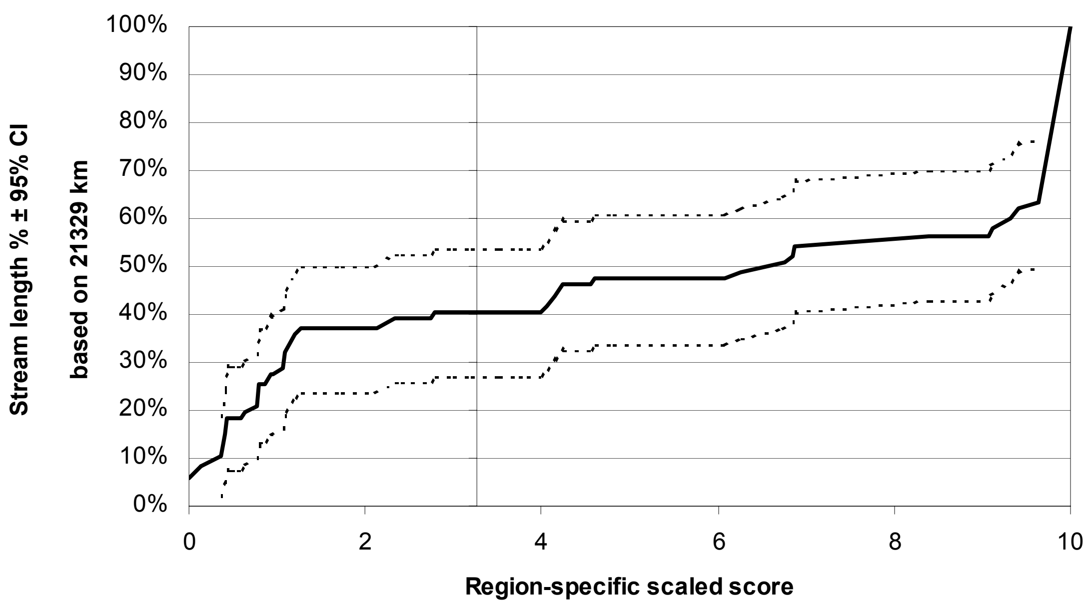

## Native Longlived Species Richness Score



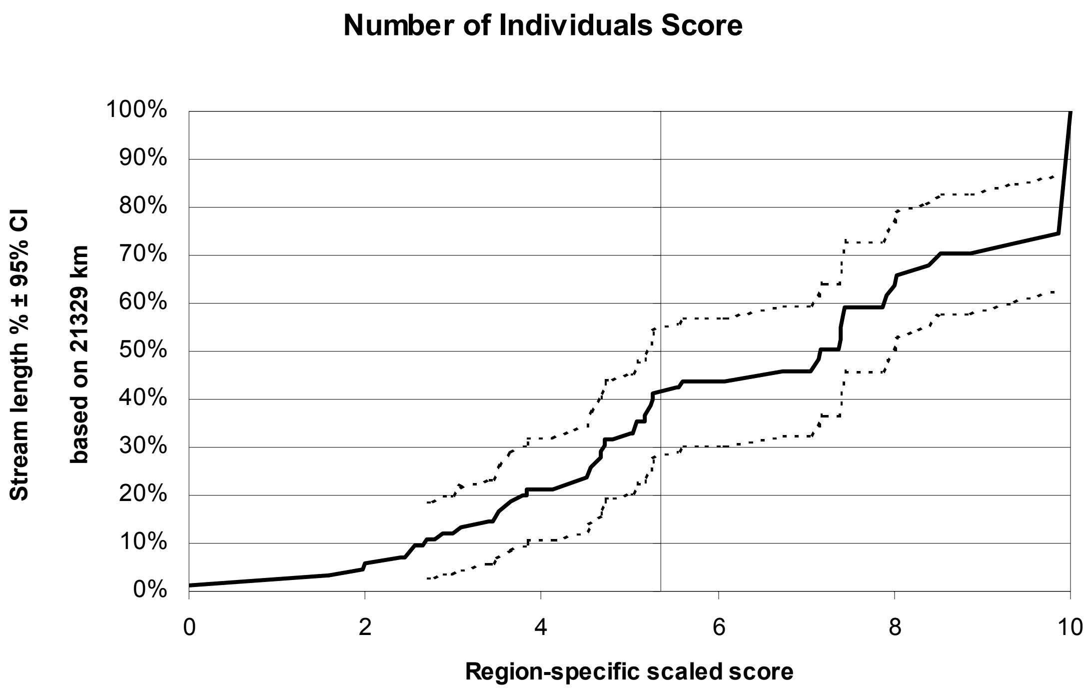
## Percent Nonnatives Score

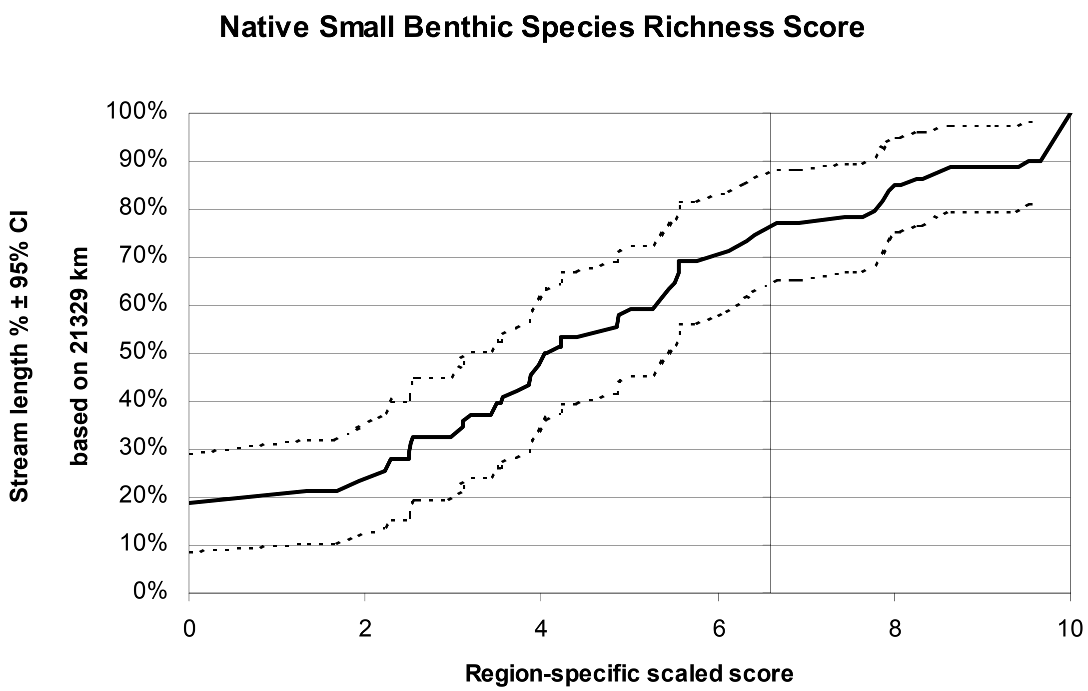



## Percent Carnivores Score

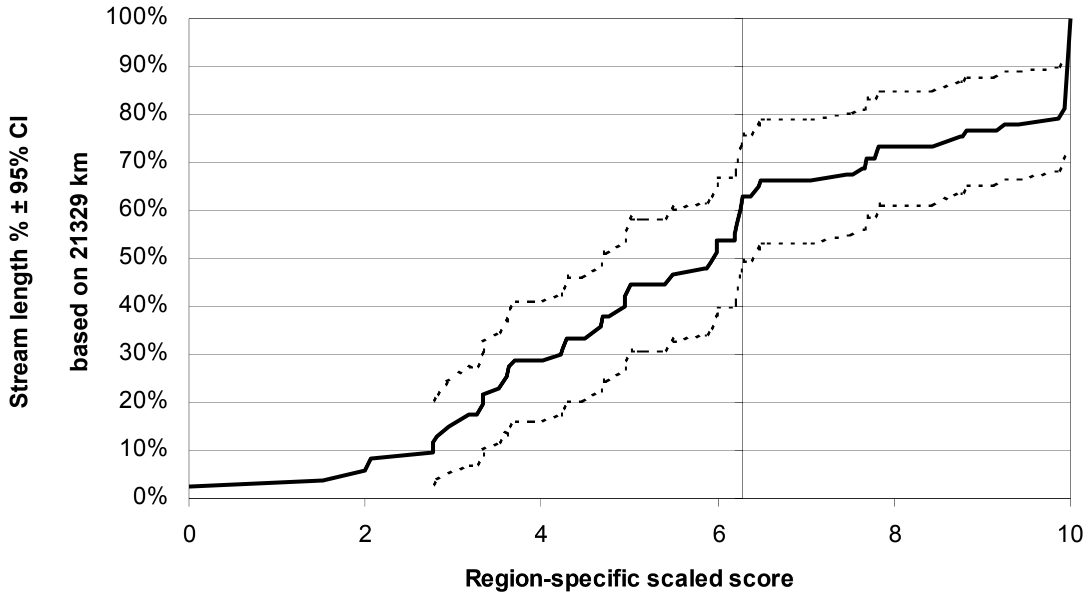


**Metrics calculated but not included in the IBI:**

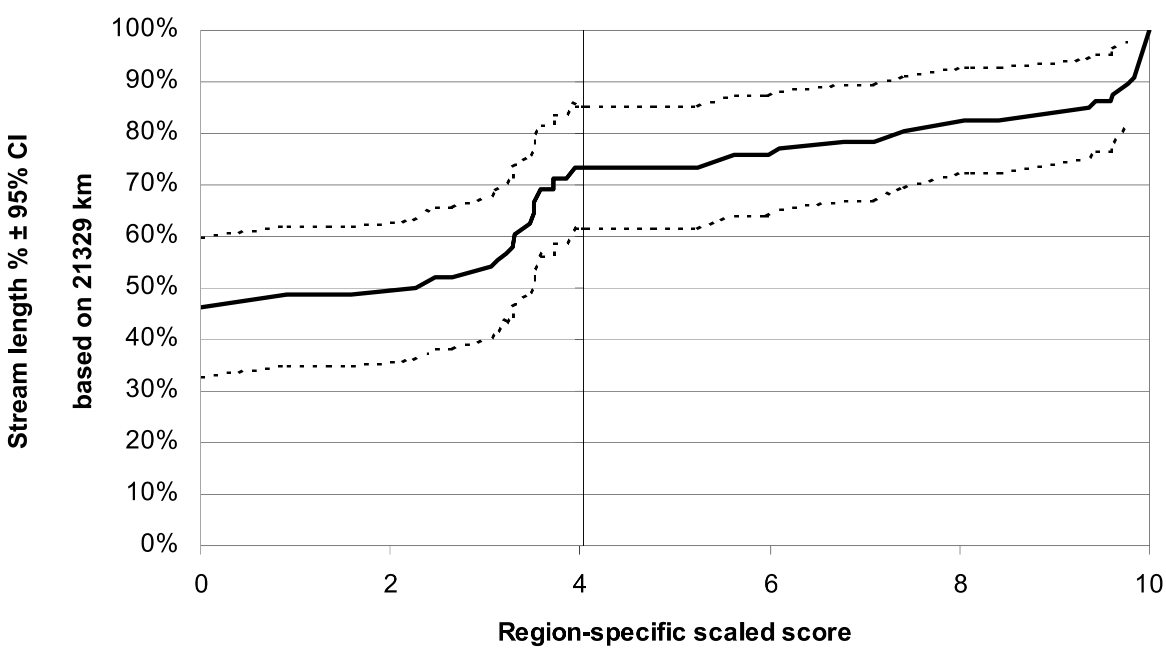


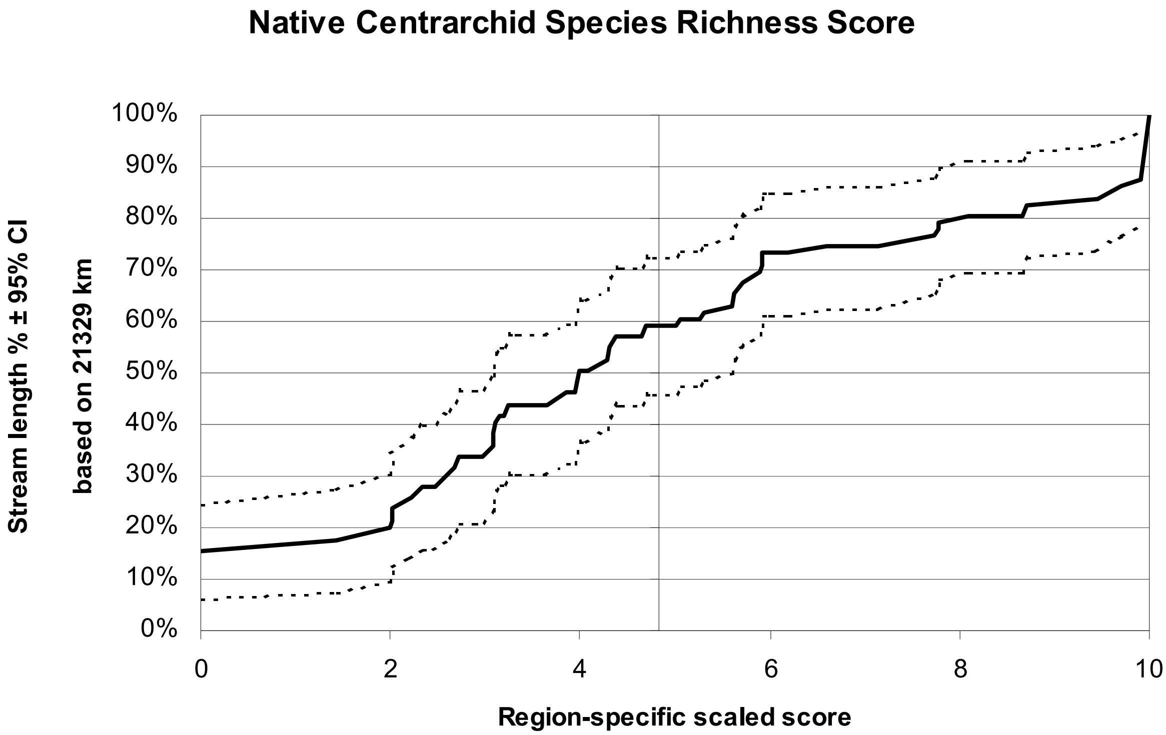



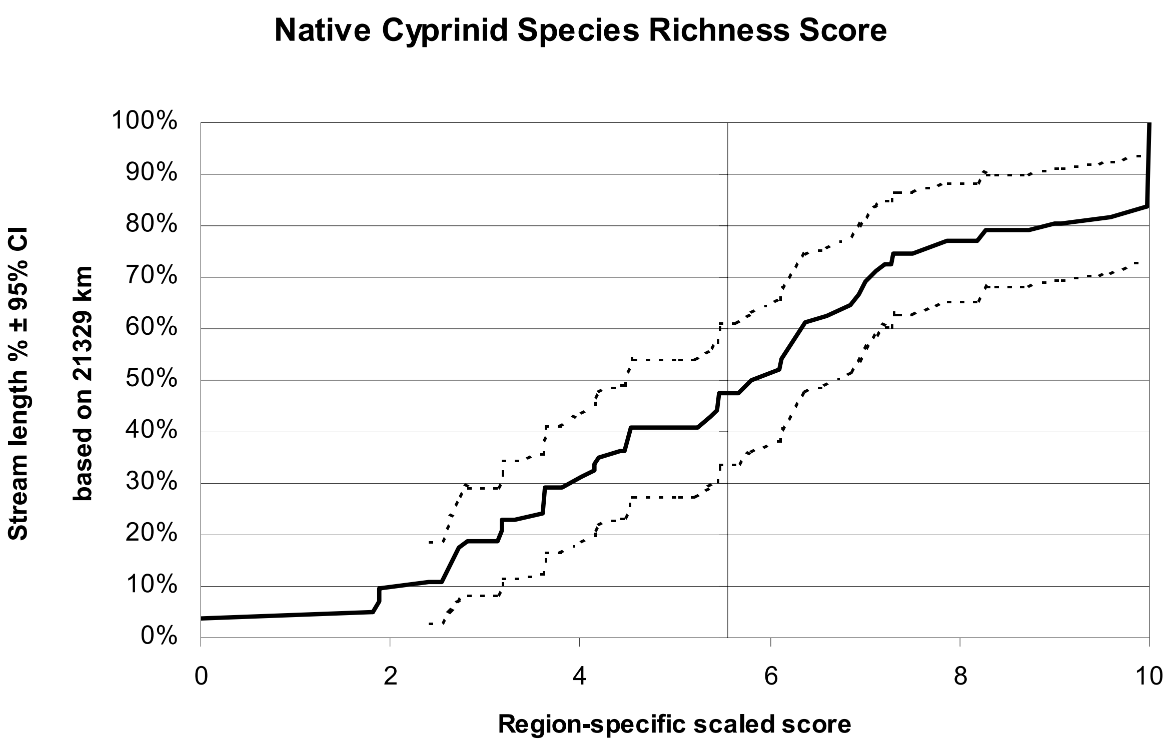
## Native Water Column Species Richnesss Score



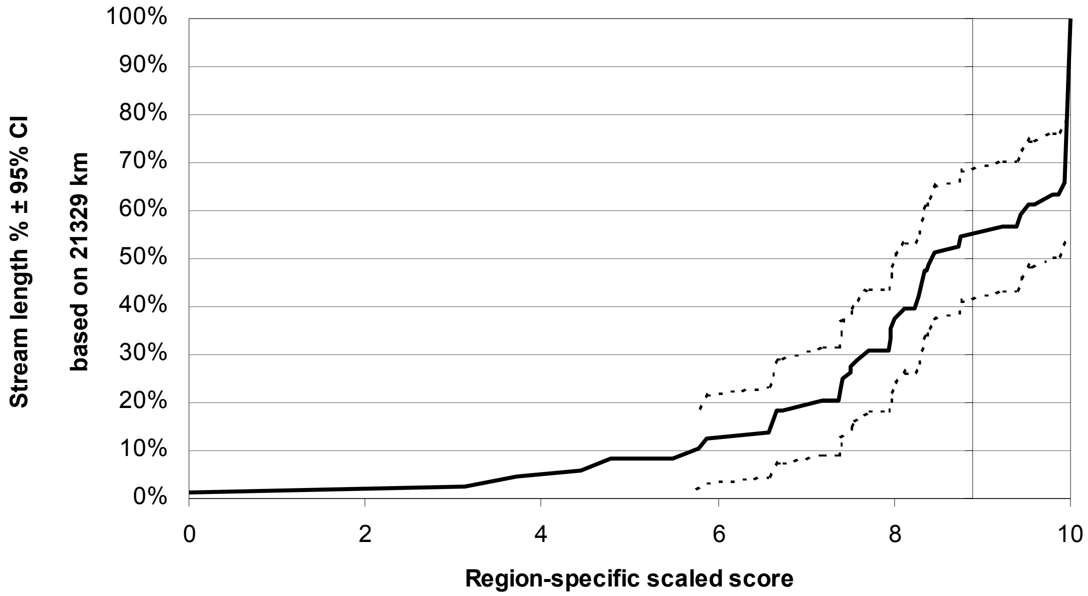

## Native Water Column Spec Species Score



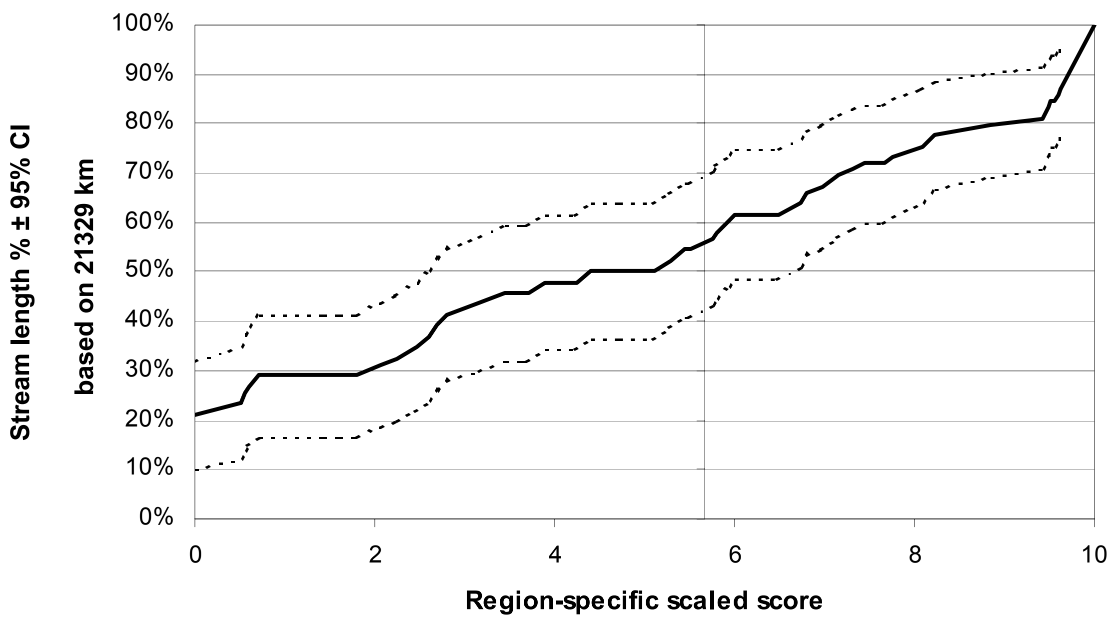

Native Centrarchid Species Richness Score
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Stream length % ± 95% CI
based on 21329 km
0
2
4
6
8
10
Region-specific scaled score


Native Cyprinid Species Richness Score
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Stream length % ± 95% CI
based on 21329 km
0
2
4
6
8
10
Region-specific scaled score

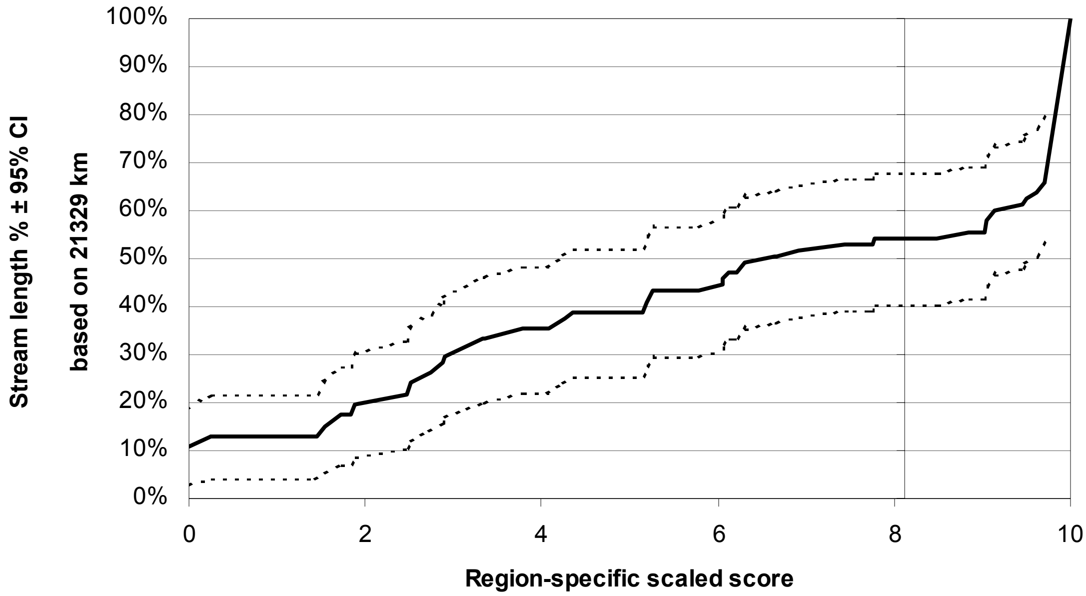
## Number of Trophic Strata Score



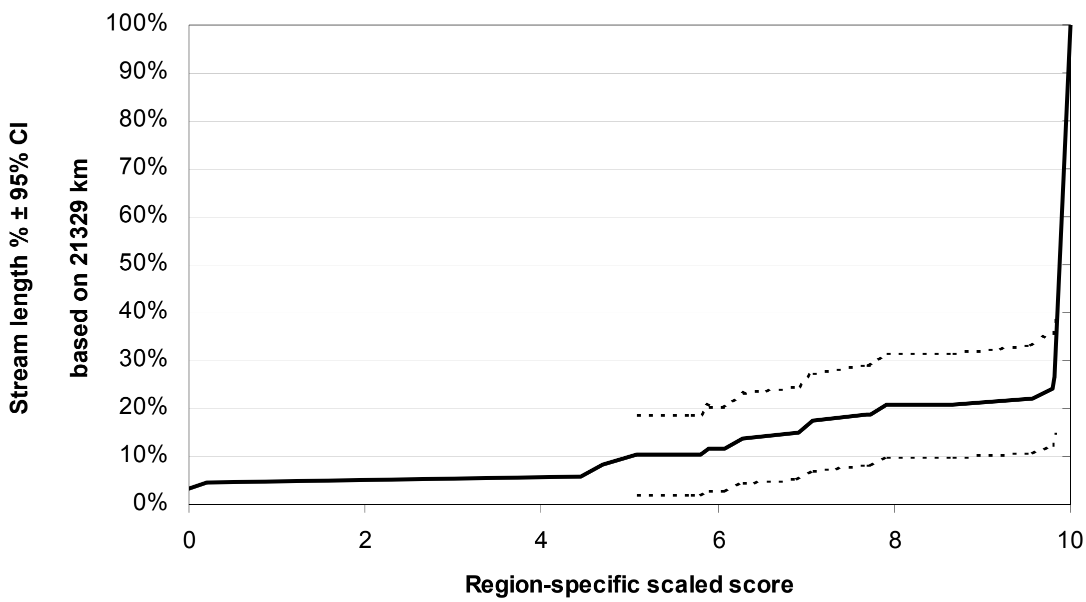

## Percent Insectivores Score



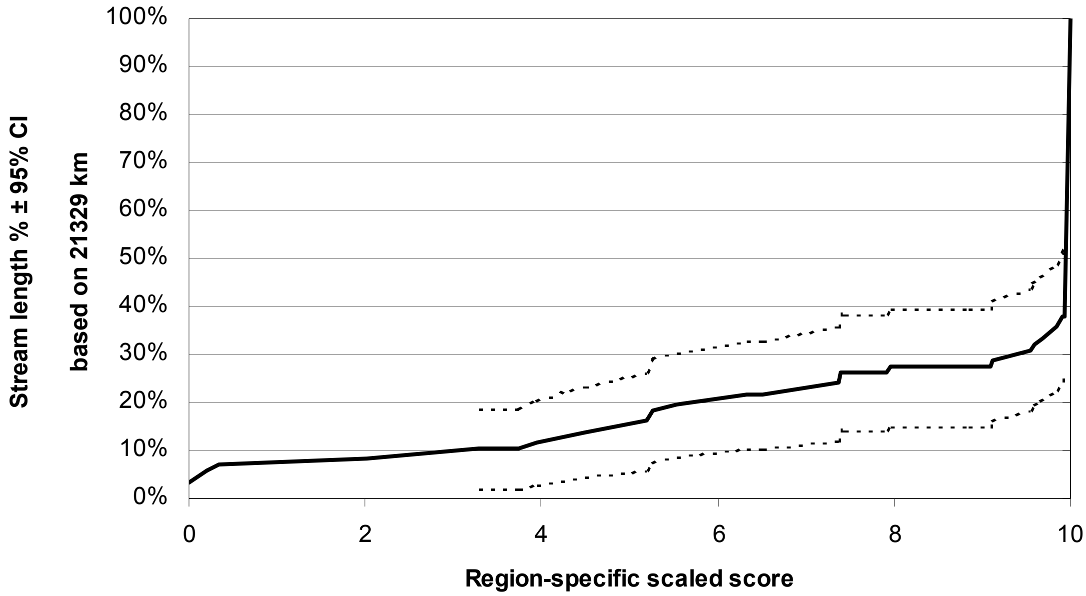
## Percent Insectivores - Invertivores Score



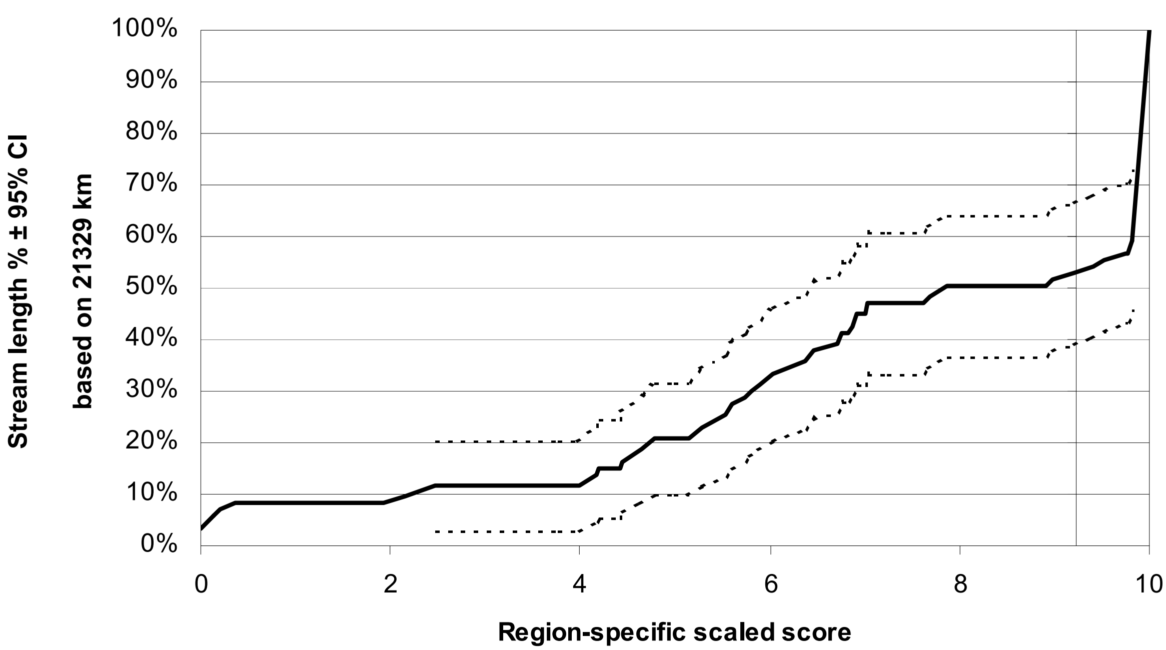

## Percent Herbivores - Micro - Omnivores Score



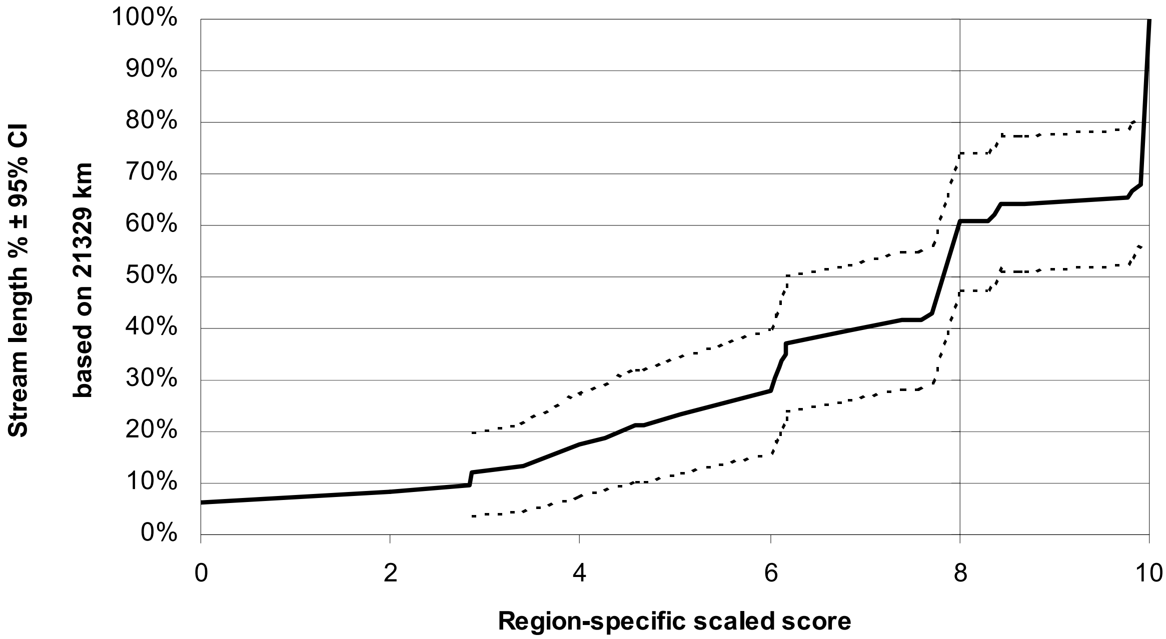
## Percent Macrophagic Omnivores Score



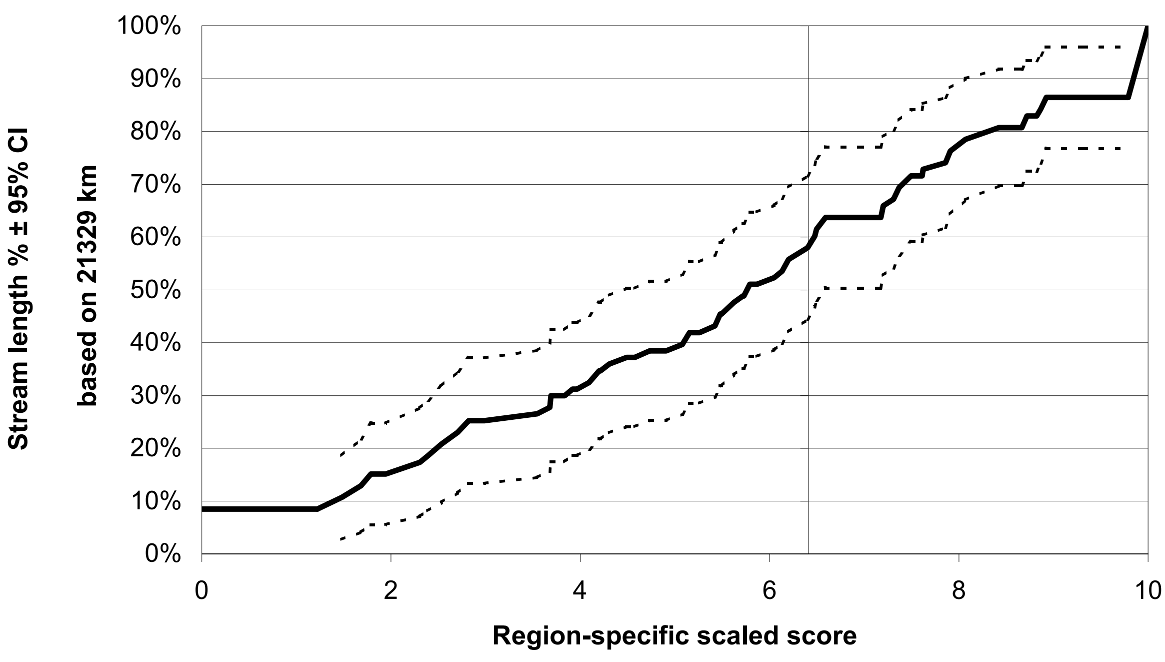

## Percent Omnivores - Herbivores Score

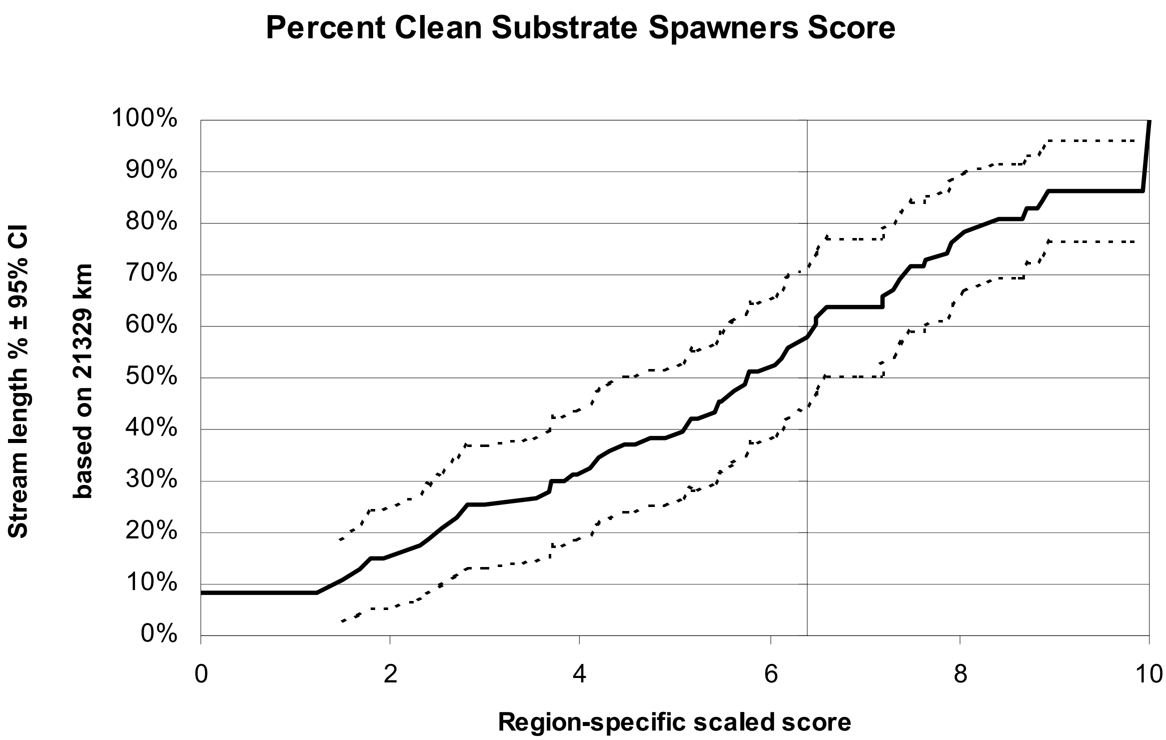


## No Repro Strata Score




## Percent Tolerant Spawners Score




Percent Clean Substrate Spawners Score
Stream length % ± 95% CI
based on 21329 km
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
2
4
6
8
10
Region-specific scaled score

**Appendix O. Measures examined for correlations.** Type of variable: F = fish, P = physical habitat, W = water chemistry.

| Type | Abbr. | Label |
|---|---|---|
| F | numspec | Total number of species in sample |
| F | numnatsp | Number of native species in sample |
| F | numfamly | Total number of families in sample |
| F | numnatfm | Number of native families in sample |
| F | nssen | No. of sensitive spp. in sample |
| F | psen | Prop. of sensitive indiv. in sample |
| F | nsnsen | No. of native sensitive spp. in sample |
| F | pnsen | Prop. of ntv sensitive indiv. in sample |
| F | nstole | No. of tolerant spp. in sample |
| F | ptole | Prop. of tolerant indiv. in sample |
| F | nsntole | No. of native toleerant spp. in sample |
| F | pntole | Prop. of ntv tolerant indiv. in sample |
| F | nslunk | No. of long-lived spp. in sample |
| F | plunk | Prop. long-lived indiv. in sample |
| F | nsnlunk | No. native long-lived spp. in sample |
| F | pnlunk | Prop. native long-lived indiv. in sample |
| F | nsintro | No. non-native spp. in sample |
| F | numintro | No. non-native indiv. in sample |
| F | pintro | Prop. non-native indiv. in total sample |
| F | pnativ | Prop. native indiv. in total sample |
| F | ntroph | No. Trophic Strategies (all spp.) |
| F | nntroph | No. Trophic Strategies (ntv spp.) |
| F | epcarn | Exp. Prop. Carnivores |
| F | epinsiv | Exp. Prop. Ins-inv. |
| F | epmac | Exp. Prop. mac. omni. |
| F | ephbmic | Exp. Prop. Herb.+ mic. omni. |
| F | affin | Trophic Model Affinity (all spp.) |

| Type | Abbr. | Label |
|---|---|---|
| F | natsp | Native Species Richness Score (0-10) |
| F | natfam | Native Family Richness Score (0-10) |
| F | nindiv | No. Indiv. Score (0-10) |
| F | sensit | Sensit. Spp. Rich. Score (0-10) |
| F | tolrnt | % Tolerants Score (0-10) |
| F | smbenth | Ntv Sm. Benth. Spp. Rich. Score (0-10) |
| F | benthic | Native Benth. Spp. Rich. Score (0-10) |
| F | wcolumn | Ntv Wtr. Col. Spp. Rich. Score (0-10) |
| F | wcolspcl | Ntv Wtr. Col. Spec. Spp. Score (0-10) |
| F | sunfish | Ntv Centrarchid Spp. Rich. Score (0-10) |
| F | minnow | Ntv Cyprinid Spp. Rich. Score (0-10) |
| F | longlive | Ntv. Long-lived Spp. Rich. Score (0-10) |
| F | alien | % Non-natives Score (0-10) |
| F | troph | No. Trophic Strat. Score (0-10) |
| F | carn | % Carnivores Score (0-10) |
| F | insinv | % Insectivores+Invertivores Score (0-10) |
| F | insect | % Insectivores Score (0-10) |
| F | herbiv | % Herbivores+Micro. Omniv. Score (0-10) |
| F | omni | % Macrophagic Omnivores Score (0-10) |
| F | omnihb | % Omniv. + Herbiv. Score (0-10) |
| F | repro | No. Reprod. Strat. Score (0-10) |
| F | tolrepr | % Tolerant Spawners Score (0-10) |
| F | gravel | % Cln. Subs. Spawners Score (0-10) |
| F | ibi1 | IBI Score (0-100)--MAHA metrics+longlive |
| F | ibi4 | IBI based on S:N and resp. (10 metrics) |
| F | ibi5 | IBI Score (13 metrics) |
| F | ibi6 | IBI score (12 metrics) |

| Type | Abbr. | Label |
|---|---|---|
| F | ibi7 | IBI score (11 metrics) |
| F | ibi8 | IBI score (8 metrics) |
| P | XBKF_W | Bankfull Width--Mean (m) |
| P | XBKF_H | Bankfull Height-Mean (m) |
| P | XINC_H | Channel Incision Ht.-Mean (m) |
| P | xgb | Rip Ground Layer Barren (Cover) |
| P | XCMGW | Rip Veg Canopy+Mid+Ground Woody Cover |
| P | xcdenbk | Mean Bank Canopy Density (%) |
| P | XEMBED | Mean Embeddedness--Channel+Margin (%) |
| P | xfc_ucb | Fish Cvr-Undercut Banks (Areal Prop) |
| P | xfc_all | Fish Cvr-All Types (Sum Areal Prop) |
| P | xfc_nat | Fish Cvr-Natural Types (Sum Areal Prop) |
| P | xfc_big | Fish Cvr-LWD,RCK,UCBorHUM(Sum Area Prop) |
| P | w1_hall | Rip Dist--Sum All Types (ProxWt Pres) |
| P | w1_hnoag | Rip Dist--Sum NonAg Types (ProxWt Pres) |
| P | w1_hag | Rip Dist--Sum Agric Types (ProxWt Pres) |
| P | lrbs_bw5 | Log10[Rel. Bed Stability] - Est. 2 |
| P | rpgt75 | Resid Pools >75cm deep (number/reach) |
| P | lsubd_sd | Substrate-StDev LOG10(Diam Class mm) |
| P | PCT_FN | Substrate Fines -- Silt/Clay/Muck (%) |
| P | PCT_SA | Substrate Sand -- .06-2 mm (%) |
| P | PCT_HP | Substrate Hardpan -- (%) |
| P | pct_RC | Substrate Concrete (%) |
| P | PCT_SAFN | Substrate Sand & Fines -- <2 mm (%) |
| P | PCT_SFGF | Substrate <= Fine Gravel (<=16 mm) (%) |
| P | PCT_BIGR | Substrate >= Coarse Gravel (>16 mm) (%) |
| P | PCT_BDRK | Substrate Bedrock (%) |
| P | PCT_ORG | Substrate Wood or Detritus -- (%) |
| P | xdepth | Thalweg Mean Depth (cm) |
| P | sddepth | Std Dev of Thalweg Depth (cm) |

| Type | Abbr. | Label |
|---|---|---|
| P | xwidth | Wetted Width -- Mean (m) |
| P | pct_pool | Pools -- All Types (% of reach) |
| P | XCM | Rip Veg Canopy+Mid Layer Cover |
| P | pfc_ohv | Overhang. Veg. Presence (% Rch) |
| P | pfc_ucb | Undercut Bank Presence (% Rch) |
| P | PCT_RI | Riffle (% of reach) |
| W | WF01 | Temperature (Deg C), REMAP Field Parameters |
| W | WF04 | Flow (CFS), REMAP Field Parameters |
| W | WF05 | pH (SU), REMAP Field Parameters |
| W | WG03 | Alkalinity (bicarbonate, mg/L), in Water |
| W | WG11 | Total Nitrogen (mg/L), by Calculation |
| W | WG12 | Chloride (mg/L), in Water |
| W | WG17 | Dissolved Oxygen (mg/L), REMAP Field Parameters |
| W | WG30 | Turbidity (NTU) |
| W | WG31 | Hardness (as CaCO3, mg/L), in Water by Calculation |
| W | WM30 | Lead in Water by AA (Lead, ug/L) |
| W | WM32 | Selenium (ug/L), in Water by AA |
| W | WM34 | Mercury (ug/L), in Water |
| W | WM50 | Selenium, Dissolved (ug/L), in Water by AA |
| W | WM63 | Lead, Dissolved (ug/L), in Water by AA |
| W | WM68 | Mercury, Dissolved (ug/L), in Water by AA |
| W | WT01 | Ammonia, as Nitrogen (mg/L), in Water by Automated Distillation |
| W | WT02 | Nitrate+Nitrite, as Nitrogen (mg/L), in Water |
| W | WT03 | Total Kjeldahl Nitrogen (mg/L), in Water, Colorimetric |
| W | WT04 | Total Phosphorus(mg/L), in Water, Colorimetric |
| W | WT12 | Sulfate (mg/L), in Water |