Imagine the result

Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009 – 2013

Tennessee Valley Authority
Ash Recovery Project
Kingston, Tennessee

October 2014

140820-TNTVA-RPT-234

ARCADIS

Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009 – 2013

Tennessee Valley Authority
Kingston Ash Release

Amber Stojak
Staff Environmental Scientist

Suzanne Walls
Project Ecologist

Prepared for:
Tennessee Valley Authority

Prepared by:
ARCADIS U.S., Inc.
114 Lovell Road
Suite 202
Knoxville
Tennessee 37934
Tel 865 675 6700
Fax 865 675 6712

Our Ref.:
TNTVAKIP.DSR2

Date:
October 7, 2014

This document is intended only for the use of the individual or entity for which it was prepared and may contain information that is privileged, confidential and exempt from disclosure under applicable law. Any dissemination, distribution or copying of this document is strictly prohibited.

Table of Contents

1. Introduction **1-1**

2. Fish **2-1**

2.1 Fish Community 2-1

2.2 Fish Reproduction 2-2

2.3 Fish Bioaccumulation 2-3

2.4 Fish Health 2-4

3. Benthic Invertebrates **3-1**

3.1 Benthic Invertebrate Community 3-1

3.2 Sediment Toxicity Tests 3-2

3.3 Benthic Invertebrate Bioaccumulation 3-3

4. Tree Swallows **4-1**

4.1 Tree Swallow Reproduction 4-1

4.2 Tree Swallow Bioaccumulation 4-2

5. Data Quality Assurance/Quality Control Results **5-1**

5.1 Analytical Data Review 5-1

5.2 Data Quality Summary 5-1

6. References **6-1**

Tables

2-1 Largemouth Bass Fillet Summary Statistics in 2013
2-2 Largemouth Bass Ovary Summary Statistics in 2013
2-3 Largemouth Bass Liver Summary Statistics in 2013
2-4 Bluegill Sunfish Fillet Summary Statistics in 2013
2-5 Bluegill Sunfish Ovary Summary Statistics in 2013
2-6 Bluegill Sunfish Liver Summary Statistics in 2013
2-7 Redear Sunfish Fillet Summary Statistics in 2013
2-8 Redear Sunfish Ovary Summary Statistics in 2013
2-9 Redear Sunfish Liver Summary Statistics in 2013
3-1 Benthic Invertebrate Community Results for the Emory River: 2009-2013
3-2 Benthic Invertebrate Community Results for the Clinch and Tennessee Rivers: 2009-2013
3-3 Snail (Non-Depurated) Summary Statistics in 2013
3-4 Mayfly Nymph (Non-Depurated) Summary Statistics in 2013
3-5 Mayfly Nymph (Depurated) Summary Statistics in 2013
3-6 Mayfly Adult Summary Statistics in 2013
4-1 Tree Swallow Egg Summary Statistics for 2013
4-2 Tree Swallow Egg Summary Statistics for 2014
5-1 Analytical Data Review for 2013
5-2 Data Quality Review for 2013

Figures

1-1 River Reaches
2-1 Fish Community Survey: Reservoir Fish Assemblage Index Scores, 2001-2013
2-2 Black Bass Catch Rates: 2002-2013
2-3 Selenium Concentrations in Bluegill Sunfish, Redear Sunfish, and Largemouth Bass Fillets
2-4 Selenium Concentrations in Redear Sunfish Fillets, 2010-2013
2-5 Fish Health Condition Indices
3-1 Benthic Invertebrate Community Population Density: 2009-2013
3-2 Benthic Invertebrate Community Average Taxa Richness: 2009-2013
3-3 Selenium Concentrations in Depurated Snail Tissue: 2009-2013
3-4 Selenium Concentrations in Depurated Mayfly Nymph Tissue: 2009-2013
3-5 Selenium Concentrations in Mayfly Adult Tissue: 2009-2013
4-1 Reproductive Metrics in Tree Swallows, 2013-2014
4-2 Selenium Concentrations in Tree Swallow Eggs: 2009-2014

Appendices

A 2013 Fish Community Survey Results

Acronyms and Abbreviations

%	percent
BERA	Baseline Ecological Risk Assessment
COPECs	constituents of potential ecological concern
CRM	Clinch River Mile
DQOs	data quality objectives
dw	dry weight
EDDs	electronic data deliverables
ERM	Emory River Mile
KIF	Kingston Fossil Plant
LERM	Little Emory River Mile
MDL	method detection limits
mg/kg	milligram per kilogram
ORNL	Oak Ridge National Laboratory
QAPP	Quality Assurance Project Plan
QC	quality control
RFAI	Reservoir Fish Assemblage Index
site	Tennessee Valley Authority Kingston Fossil Plant Release Site in Roane County, Tennessee
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
USEPA	U.S. Environmental Protection Agency

1. Introduction

In August 2012, a Baseline Ecological Risk Assessment (BERA) (ARCADIS 2012a) was approved by the U.S. Environmental Protection Agency (USEPA). The BERA evaluated the potential ecological effects on biota from ash residuals in the river system at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) Release Site, in Roane County, Tennessee (the site, Figure 1-1). The BERA focused primarily on data collected post-dredging. The BERA was developed in support of the *Kingston Ash Recovery Project, Non-Time Critical Removal Action, River System Engineering Evaluation/Cost Analysis* (TVA 2012), which evaluated alternatives for restoration of the river system impacted by the December 22, 2008 ash release.

Monitoring for some ecological receptors is ongoing. The purpose of this report is to quantitatively assess the most recent dataset (i.e., 2013), and when possible, to evaluate temporal trends in constituent concentrations from 2009 through 2013. A preliminary analysis of 2014 data was also included if these data were available. Consistent with the results of the BERA and the focus of the Long Term Monitoring Program, only data for selenium and arsenic are discussed for each receptor. This report evaluates data from 2009 through 2013 for the following biota:

- Fish
- Benthic invertebrates
- Tree swallows.

The overall conclusions presented here do not change the risk management recommendations provided in the BERA (ARCADIS 2012a). The data included in this report were reported by analytical laboratories and validated via a quality assurance/quality control review as specified in the *Quality Assurance Project Plan for the Tennessee Valley Authority Kingston Ash Recovery Project, Revision 1* (QAPP) (TVA 2010). A summary of the data validation process and data quality results are presented in the final chapter of this report.

2. Fish

Many species of fish were selected for evaluation in the BERA because they represent various feeding guilds and are ubiquitous in the Emory, Clinch, and Tennessee River locations near the site. Fish may be exposed to ash-related constituents through their gills, ingestion of sediment and water, consumption of aquatic prey, and maternally transferring constituents to eggs. Exposure to ash-related constituents may lead to bioaccumulation over time which may then affect the health of the community.

The main study objectives were to 1) compare community metric results among locations and across 5 years; 2) evaluate fish reproductive condition among locations and years; 3) compare concentrations of metals and metalloids in fish tissues; 4) evaluate fish health condition among locations and years; and 5) relate concentrations measured at the study sites to reference area concentrations and literature-derived effects values, when available.

2.1 Fish Community

Historically, fish communities have been studied in the Tennessee and Clinch Rivers. Monitoring of the Emory River fish community began in 2009 after the ash release. A detailed description of the sampling locations and collection methods can be found in *Evaluation of the Fish Community in the Vicinity of the Kingston Fossil Plant, 2001 – 2010* (Baker 2011a) and *Evaluation of 2012 Fish Community Survey Results for the Kingston Fossil Plant Ash Recovery Project* (Appendix A in ARCADIS 2013).

Fish were collected using boat electrofishing and gill netting. Fifteen 300-meter runs were completed along area ranges. Area ranges consisted of Emory River Mile (ERM) 1.7 to ERM 4.5 (mid-point ERM 2.5), Clinch River Mile (CRM) 0.0 to 2.4 (mid-point CRM 1.5) and CRM 3.8 to 5.3 (mid-point CRM 4.4). Fish were identified to species, tallied, and examined for diseases, deformities, or any other anomalies (Baker 2011a). Total numbers of species were evaluated using TVA's Reservoir Fish Assemblage Index (RFAI) methodology as part of their National Pollutant Discharge Elimination System permit renewal requirements. The RFAI uses metrics from four categories (species richness and composition, abundance, and fish heath). RFAI scores are ranked and assigned ratings (very poor, poor, fair, good, and excellent) (Baker 2011a). A summary of the results are presented in Appendix A.

The RFAI results for the Emory River in the immediate area of the ash release (ERM 2.5) rated "good" during the five annual surveys following the spill, while the Clinch River (CRM 1.5 and CRM 4.4) rated "fair" to "good" (Figure 2-1). Results for species richness metrics were similar during pre-spill and post-spill surveys. The number of indigenous species collected at the sites over the years indicated "moderate" to "good" representation of indigenous species. No apparent differences were noted between pre- and post-spill surveys for composition metrics (i.e., percent dominance by one species); however, slight differences were observed in trophic composition metrics, with improved scores (lower composition) for

"percent omnivores" in CRM 4.4. Slight increases were also observed in the "percent of tolerant individuals" at CRM 4.4 and ERM 2.5, resulting in reduced scores for these locations, but the opposite was observed at CRM 1.5 where the percent of tolerant individuals decreased.

Respective to historical results at KIF, the number of fish collected in electrofishing samples was highest at sites in 2009 and 2010, but still remained in the moderate to low range. Catch rates of black bass in 2013 were slightly lower at ERM 2.5 and CRM 2.5 compared to 2012, but were similar to pre-spill collections (Figure 2-2). Largemouth bass relative weights in 2013 were also similar to previous years for both locations for fish 8 to 11 inches and 12 to 14 inches long. In addition, the average number of fish collected per run in electrofishing samples at CRM 4.4 in both 2011 and 2012 was low; however, the catch rates increased in 2013 and were similar to pre-spill averages.

Percentages of fish with anomalies were elevated in 2009 and again in 2011; however, these percentages returned to pre-spill conditions in most areas during the 2012 summer and fall sampling and remained low in 2013. Given year-to-year variability in the incidence of anomalies and the fact that parasite loads in 2011 and 2012 were highest at sampling locations in the Clinch upstream of the Emory River, there is no clear evidence that the increases are ash related.

Overall, the 2013 RFAI results for each location were within the range of expected variation based on historical results and the inherent variability in sampling reservoir fish communities. Collectively, the RFAI results for the five sample years indicate fish assemblages near KIF continue to be representative of those observed prior to the spill and, likewise, are representative of those expected in transition zones within upper mainstream reservoirs, indicating no apparent relation to the ash release.

2.2 Fish Reproduction

Oak Ridge National Laboratory (ORNL) conducted fish reproductive studies that focused on assessing the health and condition of fish ovaries. A detailed description of the sampling locations and collection methods can be found in *Evaluating the Effects of the Kingston Fly Ash Release on Fish Reproduction: Spring 2009 – 2010 Studies* (Greeley et al. 2012) and *Preliminary Evaluation of 2012 ORNL Results: Fish Reproduction Studies* (Appendix B in ARCADIS 2013).

The ovary was chosen because it provides a route for maternal transfer of metals and metalloids to the developing eggs. Similar to previous years, fish in 2013 were collected by electrofishing from two reference locations (ERM 8.0 and CRM 8.0) and three impacted locations (ERM 3.0, ERM 0.9, and CRM 1.5). Largemouth bass, bluegill sunfish, and redear sunfish were collected in the spring of 2013, during their pre-spawning stage of reproductive development. After collection and transport to ORNL, fish were euthanized, ovaries were measured, and ovary weight, analysis of ovary stage, oocyte (immature developing

eggs) condition, and estimates of fecundity were recorded. The gonadosomatic index or size of the gonad compared with the body size was also used as in indicator of fish reproductive status (Greeley et al. 2012).

Similar to previous years, preliminary evaluation of the 2013 gross morphological appearance of fish and ovary samples indicate no adverse effects in female fish reproduction. All female fish collected were reproductively mature, based on visual inspection of the ovaries and oocytes.

2.3 Fish Bioaccumulation

A detailed description of the sampling locations and collection methods can be found in *Fish Bioaccumulation Studies Associated with the Kingston Fly Ash Spill, Spring 2009 – Fall 2010* (Adams et al. 2012), *Trace Element Concentrations in Fish: 2010* (ARCADIS 2012b), and in *Preliminary Evaluation of 2012 ORNL Results: Fish Bioaccumulation* (Appendix C in ARCADIS 2013*)*.

Bioaccumulation of metals and metalloids were measured in fillets of largemouth bass, bluegill sunfish, and redear sunfish. Spring sampling was conducted in April and May in conjunction with the fish health and reproductive studies. Fish were collected from three upstream references (ERM 8.0, LERM 2.0, and CRM 8.0), and three impacted locations (ERM 3.0, ERM 0.9, and CRM 1.5). Fish fillets were sent to Pace Analytical Services, Inc. for analysis of 26 metals and metalloids (Adams et al. 2012). A preliminary analysis of the spatial and temporal trends for selenium, arsenic, and mercury concentrations in fish fillets were evaluated. A more detailed report is anticipated by December 2014. Concentrations of arsenic, mercury, and selenium in fish tissues collected in 2013 are presented in Tables 2-1 through 2-9 and discussed below.

Post-spill selenium concentrations in all three species' fillets have been higher in individuals collected from impacted locations compared to the reference locations (Figure 2-3). Redear sunfish continued to show the highest selenium concentrations compared to other species, which most likely reflects differences in diet. Mean concentrations of selenium in fillets in redear sunfish were similar in 2013 compared to previous years (Figure 2-4). The only exception to this trend occurred in redear sunfish at ERM 0.9, where spring 2013 mean concentrations were higher than in 2011 and 2012; however, when standard deviation is considered, this difference is not statistically significant. Overall, concentrations of selenium in all species remain below the USEPA proposed ambient water quality criterion of 7.91 milligram per kilogram (mg/kg) (whole-body, dry weight [dw]) in all years of study.

In general, arsenic concentrations in 2013 were higher at ash-impacted sites compared to reference locations at ERM 8.0 and LERM 2.0. Impacted concentrations were comparable to concentrations from the reference location at CRM 8.0, which may be elevated due to possible inputs from Department of Energy facilities (Appendix C in ARCADIS 2013) or from Bull Run Fossil Plant. Arsenic concentrations in fillets of all three species at impacted sites ranged from 0.12 to 1.48 mg/kg, while reference concentrations ranged from 0.07 to 1.30 mg/kg (Tables 2-1, 2-4, and 2-7). Similar to selenium results, redear sunfish had the highest

concentrations of arsenic in fillets of the fish evaluated. In 2013, arsenic concentrations in redear sunfish were similar or slightly lower than concentrations in 2012. The lowest concentrations were observed at ERM 8.0, and the highest concentrations were found at CRM 1.5. No apparent temporal trends were found when 2013 data were compared to previous years.

Mercury is a legacy constituent not related to the ash release, but is the focus of fish consumption advisories for the Emory River. While some individual concentrations were found above the USEPA human health fish consumption criterion for methyl mercury in fish fillets (0.3 mg/kg wet weight), those concentrations were found at impacted (ERM 0.9, ERM 3.0, and CRM 1.5) and the reference locations (ERM 8.0). All mean concentrations of mercury were below the mercury consumption criteria (Tables 2-1, 2-4, and 2-7).

2.4 Fish Health

A detailed description of the sampling locations and collection methods can be found in *Fish Health Studies Associated with the Kingston Fly Ash Spill, Spring 2009 – Fall 2010* (Adams and Fortner 2012) and in *Preliminary Evaluation of 2012 ORNL Results: Fish Health* (Appendix D in ARCADIS 2013).

The fish health study was conducted by ORNL in conjunction with the reproduction and bioaccumulation studies. The three primary species collected (largemouth bass, bluegill sunfish, and redear sunfish) were the same as in the bioaccumulation and reproductive studies, at the same locations. Only female fish were collected in the spring (in conjunction with the reproductive study) and both males and females were collected in the fall. Blood samples from the fish were collected immediately after electroshocking and were stored on ice. Condition indices, bioenergetic and hematological responses, histopathological indicators, indicators of carbohydrate-protein metabolism, organ dysfunction responses, and measures of electrolyte homeostasis were all measured and calculated.

While a rigorous statistical analysis is still forthcoming by ORNL, 2013 results were evaluated graphically to see if temporal or spatial patterns were apparent for individual metrics. When spring and fall samples were graphed separately (Figure 2-5), natural variation was observed in a number of parameters (i.e., alkaline phosphatase and calcium). In addition, a number of parameters differ by species (i.e., amylase, globulin, and total bilirubin). Glucose levels in bass, and to a lesser extent bluegill sunfish, were elevated and more variable at the spill sites in 2010 and 2011 compared to the references sites, indicating potential ash-related stress. Evaluation of the 2013 data indicated that glucose levels are now similar to reference locations. Creatinine levels in bass were elevated in 2009 and 2010 at ERM 0.9, but appear to be similar to reference sites in 2013. Additional histopathology results are still being evaluated. To date, no differences leading to adverse effects in fish health have been identified from any of the fish condition indices (Figure 2-5). A more detailed report is anticipated by December 2014.

3. Benthic Invertebrates

Benthic invertebrates are found living within or on top of sediments in the Emory, Clinch, and Tennessee Rivers. Benthic invertebrates in these rivers consist of mostly oligochaetes (aquatic worms), chironomids (larval midges), burrowing mayfly nymphs, and also crustaceans (crayfish and amphipods), bivalves (mussels and clams), snails, larval flies, leeches, and mites. Because of their close association with the sediments and water, they have the potential for bioaccumulation of metals and metalloids. They may also transfer these constituents to their fish and wildlife consumers. Snails and mayflies serve as a useful receptor in order to understand exposure and potential effects of these constituents on the benthic invertebrate community.

The main study objectives in 2013 were to assess impacts to the benthic community by 1) comparing community metric results among sites and across 5 years; 2) comparing tissue concentrations of metals and metalloids in snails, mayfly nymphs, and mayfly adults for evaluating differences among sites and years; and finally 3) relating concentrations measured at the study sites to reference area concentrations and literature derived effects values, when available. A brief discussion of each objective is presented in the subsections below.

3.1 Benthic Invertebrate Community

Benthic invertebrate community evaluations in November and December 2013 were conducted on the Emory, Clinch, and Tennessee Rivers, similar to previous years. A detailed description of the sampling locations and collection methods can be found in *Evaluation of Benthic Macroinvertebrate Communities in the Vicinity of TVA's Kingston Fossil Plant, 2009-2010* (Baker 2011b).

In 2013, nine transect locations on the Emory River (ERM 6.0, ERM 5.0, ERM 4.1, ERM 3.5, ERM 3.0, ERM 2.6, ERM 2.2, ERM 1.0, and ERM 0.7), six transect locations on the Clinch River (CRM 8.7, CRM 6.0, CRM 4.0, CRM 3.0, CRM 1.5, and CRM 0.5), and one transect location on the Tennessee River (Tennessee River Mile [TRM] 560.8) were selected for monitoring. Ten grab samples were collected from each transect and benthic invertebrates within each sample were identified to the lowest possible taxon. The total number of taxa were tallied and used to generate benthic invertebrate community metrics in order to assess the overall health of the benthic invertebrate community. Population density, taxa richness, number of organisms, number of taxa, percent oligochaetes and chironomids, and many other types of metrics were used to assess the community spatially and temporally. Details on how these metrics are calculated are presented in *Evaluation of Benthic Macroinvertebrate Communities in the Vicinity of TVA's Kingston Fossil Plant, 2009-2010* (Baker 2011b). At each sample location, water depth was also recorded along with a physical description of the sediment in the sample in order to estimate: percent ash, grain size, and substrate type. In addition to the benthic invertebrate community data collections, sediment chemistry data (percent ash, metals, total organic carbon, and the percent sand, silt, clay, or gravel) were also collected

from the Emory River. The purpose of the co-located data collections was to better interpret the various factors potentially influencing the benthic invertebrate community.

Variations in November/December 2013 Emory River benthic community abundance (Figure 3-1; Table 3-1), composition, and diversity (Figure 3-2) among sites were consistent with the variation seen in previous years. These differences were related more to a temporal variation when comparing across the 5 years, or are a reflection of spatial heterogeneity when comparing amongst sites. The differences seen across the past 5 years of data were also observed between the reference sites, which is another reflection of natural variability. The results of the community analysis from the Clinch and Tennessee Rivers (Table 3-2) are consistent with previous years and do not suggest any adverse impacts from the ash release.

3.2 Sediment Toxicity Tests

Laboratory bioassays (toxicity testing) in which benthic invertebrate species are exposed to sediment samples in the laboratory were conducted in November 2013 on the Emory and Clinch Rivers. A detailed description of the sampling locations and collection methods can be found in *Emory and Clinch River Sediment Chemistry and Toxicity Testing Data Analysis Report* (ARCADIS 2014) and in *Final Report: Hyalella azteca 10-day Whole Sediment Toxicity Test Results for Tennessee Valley Authority-Kingston Monitoring and Analysis Project: Clinch River and Emory River Sediment Samples* (GLEC 2014).

The Emory River was sampled at two locations, one as a site-related sample (ERM 1.0), and the other as a background “reference” (ERM 6.0). The Clinch River was sampled at two locations, one as a site-related sample (CRM 3.0), and the other as a background “reference” (CRM 6.0). Locations were sampled on both the left and right descending banks; however, substrate not conducive to the dredge sampling (e.g., bedrock bottoms or hard packed clay) often restricted the sampling to one bank. The sediment samples were homogenized into one sample for each location and analyzed for ash content, metals and mercury, total organic carbon, pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and one 5-gallon bucket of remaining sediment was sent to the toxicity laboratory. Surface water samples were also collected in “reference” areas, ERM 6.0 and CRM 8.0, for use in the sediment toxicity tests with all sample locations. Water was collected from 0.5 meter above the bottom and analyzed for inorganic constituents, ammonia, alkalinity, dissolved organic carbon, hardness (as calcium carbonate), total suspended solids, and pH.

Sediment toxicity tests were conducted at Great Lakes Environmental Center located in Traverse City, Michigan. The collected sediment samples from ERM 1.0, ERM 6.0, CRM 3.0, and CRM 8.0 were used in 10-day whole sediment toxicity tests to evaluate effects on survival and growth of *Hyalella azteca*. The site-related sediment samples were assessed as whole 100% site sediment, along with a dilution series of 20%, 40%, 60%, and 80%. Dilutions were made using the reference sediments from ERM 6.0 and CRM 8.0, respectively. Reference sediments were also tested at 100% sediment. Surface water from the

reference locations at ERM 6.0 and CRM 8.0 was used as overlying water in the exposures. Survival and growth results were statistically evaluated, comparing results of the impacted site to the results of the reference site for each river. Laboratory control samples were also evaluated.

Control and reference locations all met test acceptability with survival measured over 80%. The Emory River concentrations of five dilutions (20%, 40%, 60%, 80%, and 100%) were statistically compared to the performance of the reference sample (ERM 6.0). ERM 1.0 samples had no statistically significant reduction ($p \geq 0.05$) in *Hyalella azteca* survival, dry weight (average), or biomass (weight of surviving organisms divided by number of organisms at test start) after 10 days of exposure to the sediment treatments relative to the reference sample.

Similarly, the Clinch River concentrations of all five dilutions (20%, 40%, 60%, 80%, and 100%) were statistically compared to the performance of the reference sample (CRM 8.0). CRM 3.0 samples had no statistically significant reduction ($p \geq 0.05$) in *Hyalella azteca* survival, dry weight (average), or biomass (weight of surviving organisms divided by number of organisms at test start) after 10 days of exposure to the sediment treatments relative to the reference sample.

3.3 Benthic Invertebrate Bioaccumulation

Benthic invertebrate bioaccumulation evaluations in 2013 were conducted on the Emory, Clinch, and Tennessee Rivers, similar to previous years. A detailed description of the collection methods can be found in *Evaluation of Invertebrate Bioaccumulation of Fly Ash Contaminants in the Emory, Clinch, and Tennessee Rivers, 2009-2010* (Smith 2012) and in *Preliminary Evaluation of 2012 ORNL Results: Invertebrate Bioaccumulation* (Appendix F in ARCADIS 2013). Similar to previous years, mayfly adults and nymphs (*Hexagenia bilineata*) and a species of snail (*Pleurocera canaliculatum*) were collected for evaluation.

In 2013, five locations on the Emory River (ERM 6.0, ERM 4.0, ERM 3.0 (adult mayflies only), ERM 2.5, and ERM 1.0), one location on the Little Emory River (LERM 1.0), three locations on the Clinch River (CRM 6.0, CRM 3.5, and CRM 1.5), and two locations on the Tennessee River (TRM 566.3 and TRM 572.5) were selected for collections of snails and mayfly nymphs. Mayfly adults were collected opportunistically as close to core locations on the Emory, Clinch, and Tennessee Rivers as possible. Snails and mayfly nymphs were separated into depurated and non-depurated samples, and adult mayflies were separated by sex. All samples were analyzed for 13 metals and metalloids (arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, selenium, strontium, titanium, V, and Zn. A preliminary analysis of the spatial and temporal trends for selenium and arsenic concentrations in benthic invertebrate tissues was conducted for this report. A more detailed evaluation will be published by December 2014. Concentrations of arsenic and selenium in benthic invertebrate tissues collected in 2013 are presented in Tables 3-3 through 3-6.

Selenium concentrations in depurated snails collected at most 2013 locations were similar or slightly less than concentrations seen in 2012 data. All selenium concentrations were below the USEPA tissue monitoring endpoint concentration of 7 mg/kg dw. While concentrations remained somewhat elevated at Emory and Clinch River locations downstream of the release, there were no definitive temporal changes or trends between 2013 and previous years (Figure 3-3).

Selenium concentrations in depurated and non-depurated mayfly nymphs were also similar between 2013 and the previous year of data. Both groups of nymphs exhibited similar spatial trends in all years, with highest concentrations at ERM 1.0 and then decreasing concentrations progressively with increasing distance downstream from the Emory River (Figure 3-4). All concentrations were below the USEPA tissue monitoring endpoint (7 mg/kg dw). Selenium concentrations in 2013 mayfly adults were similar or less than concentrations in 2012. As for nymphs, the highest concentrations of selenium in adults were found at ERM 1.0 with progressively decreasing concentrations as distance downstream increased. Although mean concentrations at ERM 1.0 in mayfly adults remain near the tissue monitoring endpoint, they were significantly reduced from 2011 (Figure 3-5).

The highest concentrations of arsenic in snails were generally found in the Clinch River at CRM 6.0 (reference), CRM 3.5, and CRM 1.5. Arsenic concentrations in 2013 snails and mayflies (nymphs and adults) were all well below the USEPA tissue monitoring endpoint range (34 to 83 mg/kg). Concentrations were similar to those seen in 2012. Furthermore, concentrations of arsenic in mayfly nymphs were similar within each location in all years.

4. Tree Swallows

Tree swallows (*Tachycineta bicolor*) were selected as a representative aerial-feeding insectivorous bird species for the site. Tree swallows are a breeding migratory resident in Tennessee, inhabiting standing cavities of dead trees, bluebird boxes, or other artificial structures (Nicholson 1997; Robinson 1990), and foraging 100 to 200 meters around their nest during the breeding season. They commonly prey on a variety of insects, and when nest boxes are placed along aquatic areas, they feed primarily on emergent aquatic insects (U.S. Geological Survey 2003; Blancher and McNicol 1991; Quinney and Ankney 1985). As a result, tree swallow tissue residues often reflect the local sediment contamination for those chemicals that transfer into the aquatic emergent insects (McCarty and Winkler 1999; Froese et al. 1998). Tree swallows serve as a useful receptor in order to understand exposure and potential effects of these constituents on the aerial-feeding insectivorous bird and mammal communities.

In 2013 and 2014, tree swallow colonies were erected at two locations along the Emory River (ERM 3.0 and ERM 1.4), and at one reference location (TRM 572.0). Boxes were monitored daily at ERM 1.4 and TRM 572.0 from April through July. Boxes at ERM 3.0 were not monitored due to the construction activity occurring in this area during the breeding season. A detailed description of the collection methods can be found in *Trace Element Concentrations and Productivity in Tree Swallows: 2009-2010* (ARCADIS 2012c).

The main study objectives were to 1) determine the extent of maternal transfer of metals and metalloids to the eggs between locations and across 5 years; 2) evaluate tree swallow reproductive success among locations and years; and 3) assess impacts to tree swallows by comparing concentrations measured at the study sites with literature-derived effects values, when available.

4.1 Tree Swallow Reproduction

The total number of eggs (clutch size), the number of eggs that hatched (hatching success), the number of young that survived to day 15 (fledgling success), and the number of females fledglings produced per nesting female (fecundity) were recorded in 2013 and 2014 at ERM 1.4 and TRM 572.0 colonies. In addition, egg mass and volume were recorded, as well as morphological measures (egg length and width).

In 2013, clutch size, hatching success, fledgling success, and fecundity were all slightly lower at ERM 1.4 compared to TRM 572.0 (Figure 4-1); however, these differences were not statistically significantly ($p>0.05$) different and were likely due to higher standard error at ERM 1.4. No differences were observed for the egg volume or egg mass between colonies. A preliminary evaluation of the 2014 reproductive data indicated no statistically significant differences in clutch size, hatching success, or fecundity between locations; however, fledgling success was statistically significantly higher at ERM 1.4 compared to the reference location (TRM 572.5, $p<0.05$). No differences were observed for egg volume or egg mass between colonies.

4.2 Tree Swallow Bioaccumulation

In 2013 and 2014, tree swallow eggs were collected to evaluate exposure of tree swallows to ash-related constituents of potential ecological concern (COPECs). Eggs were of particular interest as some ash-related COPECs can be maternally transferred from the adult female to her young. A single egg was randomly selected from each available nest within 2 days of clutch completion. Eggs were frozen and prepared for trace element analysis. Concentrations of arsenic and selenium in egg tissue collected in 2013 and 2014 are presented in Tables 4-1 and 4-2, respectively.

Arsenic was not detected in any reference or impacted colony eggs in 2013. In 2014, arsenic was detected in all but two samples; however, concentrations were not significantly different between locations and are not discussed further.

A one-tailed Student's t-test was used to compare selenium concentrations in eggs from ERM 1.4 to selenium concentrations in eggs from TRM 572.0 in 2013 and in 2014. The results showed a statistically significant difference between the colonies ($p<0.0001$) during both years, with slightly higher average concentration at ERM 1.4 (3.65 mg/kg dw in 2013; 2.21 mg/kg dw in 2014) compared to TRM 572.0 (2.89 mg/kg dw; 1.80 mg/kg dw in 2014). When compared to previous years of data, selenium concentrations of 2013 eggs from ERM 1.4 were slightly higher than those collected in 2012 at the lower Emory River colonies (ERM 0.0 and ERM 1.4, mean=2.55 mg/kg dw); however, the same difference was noted in the reference location, with higher concentrations in 2013 compared to 2012 (2.89 mg/kg vs. 2.03 mg/kg, Figure 4-2). However, 2014 concentrations at ERM 1.4 were lower compared to 2013. Literature studies of selenium in eggs of other species have recently been reviewed and suggest threshold effects (EC_{10}) concentrations ranging from 7.7 to 60 mg/kg dw in various species of avian eggs (Janz et al. 2010). Similar to previous years, selenium concentrations in eggs collected from ERM 1.4 in 2013 and 2014 were well below the most conservative of these literature values, indicating that it is unlikely that selenium is causing adverse effects on the tree swallow population.

5. Data Quality Assurance/Quality Control Results

This section focuses on the evaluation of data quality and usability.

5.1 Analytical Data Review

TVA's contracted laboratories were required to submit three types of deliverables: a limited (Level 1) data package containing sample results and batch quality control (QC) sample results; a fully-documented (Level 4) data package including raw data for all analyses; and electronic data deliverables (EDDs) for storage in TVA's EarthSoft EQuIS® database.

EDDs were subjected to completeness and correctness testing during loading to TVA's EQuIS database; once loaded to the EQuIS database, the data were subjected to verification. As defined in the TVA-KIF-QAPP (TVA 2010), data verification involved comparison of the data loaded in the EQuIS database to the results reported in the Level 1 data package. In addition, data verification included review of the batch QC summary forms for compliance with the applicable methods and for data usability with respect to the project data quality objectives (DQOs) and the TVA-KIF-QAPP.

Following receipt of the Level 4 data package, data were subjected to validation. As defined in the TVA-KIF-QAPP, data validation included review of raw data and associated QC summary forms for compliance with the applicable methods and for data usability with respect to the appropriate guidance documents. As stated in the QAPP: "Initially, 100% of the chemical analysis data will be reported in full documentation data packages for independent data validation. Depending on the nature and frequency of issues identified during data validation, the percentage of data undergoing full data validation may be reduced to a lesser percentage (such as 20%) or data verification may be substituted. The reduction in full data validation may be matrix specific, laboratory specific, or analyte specific. If after the percentage of full data validation has decreased, a trend in frequency of reporting issues, method non-compliances, or data usability issues is identified, data validation will be conducted for specific data points or the percentage of full data validation percentage may be increased until the issues have been minimized to their initial frequency." Data validation expands upon the completeness, correctness, and usability assessment performed during verification to include evaluation of instrumental QC analyses, review of sample preparation information, and recalculation of reported results from raw data. A summary of the data review efforts are presented in Table 5-1.

5.2 Data Quality Summary

Data validation was performed based on the sample results, summary QC data, and raw data provided by the laboratory. Data validation includes a review of the following QC measures (where applicable):

- Sample condition upon laboratory receipt;
- Initial calibration linearity;
- Blank analysis results greater than the method detection limits (MDL);
- Sample preparation and holding times;
- Initial calibration verification/continuing calibration verification standard recoveries;
- MDLs and linear ranges;
- Internal standard recoveries;
- Percent moisture;
- Matrix spike/matrix spike duplicate;
- Laboratory and field duplicate precision;
- Quantitation of positive results;
- Laboratory control sample/laboratory control sample duplicate recoveries and precision;
- Analytical sequence;
- Reporting limit standard recoveries (metals only);
- Serial dilutions (metals only);
- Post-digestion spike/post-digestion spike recoveries and precision (metals only);
- Internal standard recoveries;
- Inductively coupled plasma interference check standard results (metals only);
- Quantitation of positive results;
- MDL verification standards (metals only); and
- Standard reference material recoveries (metals only).

The data met the DQOs defined for this task and were acceptable for use for each of the receptors. Table 5-2 summarizes the data quality for each receptor based on the review performed and as compared to the data quality measures identified in the TVA-KIF-QAPP.

6. References

Adams, S.M., C.C. Brandt, and A.M. Fortner. 2012. Fish Bioaccumulation Studies Associated with the Kingston Fly Ash Spill, Spring 2009 – Fall 2010. May. (BERA Appendix K)

Adams, S.M. and A.M. Fortner. 2012. Fish Health Studies Associated with the Kingston Fly Ash Spill, Spring 2009 – Fall 2010. May. (BERA Appendix I)

ARCADIS. 2014. Emory and Clinch River Sediment Chemistry and Toxicity Testing Data Analysis Report. July.

ARCADIS. 2013. Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2012. October.

ARCADIS. 2012a. Baseline Ecological Risk Assessment (EPA-AO-050). Revision 1. 21 May 2012.

ARCADIS. 2012b. Trace Element Concentrations in Fish: 2010. May. (BERA Appendix L)

ARCADIS. 2012c. Trace Element Concentrations and Productivity in Tree Swallows: 2009-2010. May. (BERA Appendix Z).

Baker, T.F. 2011a. Evaluation of the Fish Community in the Vicinity of Kingston Fossil Plant, 2001-2010. October. (BERA Appendix F)

Baker, T.F. 2011b. Evaluation of Benthic Macroinvertebrate Communities in the Vicinity of TVA's Kingston Fossil Plant, 2009 – 2010. (BERA Appendix M). November.

Blancher, P.J., and D.K. McNicol. 1991. Tree swallow diet in relation to wetland acidity. Can. J. Zool. 66:842-849.

Froese, K., D. Verbrugge, G. Ankley, G. Niemi, C. Larsen, and J. Giesy. 1998. Bioaccumulation of Polychlorinated Biphenyls from Sediments to Aquatic Insects and Tree Swallow Eggs and Nestlings in Saginaw Bay, Michigan, USA. Environmental Toxicology and Chemistry, 17(3): 484-492.

Great Lakes Environmental Center (GLEC). 2014. Final Report: *Hyalella azteca* 10-day Whole Sediment Toxicity Test Results for Tennessee Valley Authority-Kingston Monitoring and Analysis Project: Clinch River and Emory River Sediment Samples. March.

Greeley, M.S., S.M. Adams, and M.K. McCracken. 2012. Evaluating the Effects of the Kingston Fly Ash Release on Fish Reproduction: Spring 2009-2010 Studies. May. (BERA Appendix H)

Janz, D.M., D.K. DeForest, J.L. Brooks, P.M. Chapman, G. Gilron, D. Hoff, W.A. Hopkins, D.O. McIntyre, C.A. Mebane, V.P. Palace, J.P. Skorupa, and M. Wayland. 2010. Chapter 6: Selenium toxicity in aquatic organisms. Pages 141-232 in: Chapman, P.M., W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser, and D.P. Shaw (eds.), Ecological Assessment of Selenium in the Aquatic Environment. Pensacola, Florida, USA: CRC Press and Society of Environmental Toxicology and Chemistry.

McCarty, J.P. and D.W. Winkler. 1999. Foraging ecology and diet of tree swallows feeing selectivity of nestlings. The Cooper Ornithological Society. The Condor, 101: 246-254.

Nicholson, C. 1997. Atlas of the Breeding Birds of Tennessee. Knoxville, Tennessee: The University of Tennessee Press.

Quinney, T.E. and C.D. Ankney. 1985. Prey size selection by Tree Swallows. Auk 102: 245-250.

Robinson, J. 1990. An Annotated Checklist of the Birds of Tennessee. Knoxville, Tennessee: The University of Tennessee Press.

Smith, J.G. 2012. Evaluation of Invertebrate Bioaccumulation of Fly Ash Contaminants in the Emory, Clinch, and Tennessee Rivers, 2009 – 2010. May. (BERA Appendix Q).

TVA. 2012. Kingston Ash Recovery Project Non-Time-Critical Removal Action River System Engineering Evaluation/Cost Analysis (EE/CA). EPA-AO-051. August.

TVA. 2010. Quality Assurance Project Plan for the Tennessee Valley Authority Kingston Ash Recovery Project. Revision 1. August. TVA-KIF-QAPP. EPA-AO-014. Prepared by Environmental Standards, Inc. December 18, 2009 (USEPA approval).

U.S. Geological Survey. 2003. Tree Swallows: A Nationwide Sentinel Species for Assessing and Monitoring Aquatic Contamination. Fact Sheet FS 2004-3042.

Table 2-1.
Largemouth Bass Fillet Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean[1]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9	7	7	0.89	±	0.35	0.62	-	1.45
	ERM 3.0	7	7	0.53	±	0.16	0.28	-	0.77
	ERM 8.0	7	7	0.63	±	0.29	0.28	-	1.00
	Clinch River								
	CRM 1.5	7	7	1.02	±	0.20	0.82	-	1.30
	CRM 8.0	3	7	0.92	±	0.24	0.64	-	1.30
	Little Emory River								
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Mercury	Emory River							-	
	ERM 0.9	7	7	1.46	±	0.85	0.40	-	2.71
	ERM 3.0	7	7	1.08	±	0.38	0.58	-	1.62
	ERM 8.0	7	7	2.11	±	0.71	0.83	-	2.95
	Clinch River							-	
	CRM 1.5	7	7	0.87	±	0.12	0.74	-	1.09
	CRM 8.0	7	7	0.83	±	0.19	0.62	-	1.16
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Selenium	Emory River							-	
	ERM 0.9	7	7	2.52	±	0.82	1.30	-	3.90
	ERM 3.0	7	7	2.47	±	0.58	1.73	-	3.60
	ERM 8.0	7	7	1.78	±	0.71	1.61	-	2.00
	Clinch River							-	
	CRM 1.5	7	7	2.72	±	0.59	2.00	-	3.59
	CRM 8.0	7	7	1.61	±	0.41	1.04	-	2.33
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
LERM = Little Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NC = not collected
SD = standard deviation

Table 2-2.
Largemouth Bass Ovary Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9	7	7	1.09	±	0.68	0.63	-	2.60
	ERM 3.0	7	7	0.77	±	0.12	0.59	-	0.92
	ERM 8.0	7	7	0.73	±	0.23	0.44	-	1.00
	Clinch River								
	CRM 1.5	7	7	1.11	±	0.23	0.78	-	1.34
	CRM 8.0	7	7	1.02	±	0.16	0.77	-	1.22
	Little Emory River								
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Mercury	Emory River							-	
	ERM 0.9	5	7	0.11	±	0.09	0.02	-	0.27
	ERM 3.0	2	7	0.05	±	0.01	0.03	-	0.05
	ERM 8.0	7	7	0.12	±	0.04	0.07	-	0.17
	Clinch River							-	
	CRM 1.5	1	7	0.04	±	0.01	0.03	-	0.06
	CRM 8.0	0	7	0.05	±	0.01	0.03	-	0.07
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Selenium	Emory River							-	
	ERM 0.9	7	7	3.77	±	1.57	2.83	-	7.20
	ERM 3.0	7	7	4.40	±	3.06	2.89	-	11.30
	ERM 8.0	7	7	2.87	±	0.11	2.76	-	3.06
	Clinch River							-	
	CRM 1.5	7	7	3.32	±	0.11	3.14	-	3.43
	CRM 8.0	7	7	2.99	±	0.35	2.38	-	3.33
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
LERM = Little Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NC = not collected
SD = standard deviation

Table 2-3.
Largemouth Bass Liver Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9	7	7	1.74	±	0.56	1.25	-	2.88
	ERM 3.0	7	7	1.11	±	0.34	0.41	-	1.46
	ERM 8.0	7	7	1.41	±	0.36	0.83	-	2.00
	Clinch River								
	CRM 1.5	7	7	1.71	±	0.70	0.25	-	2.23
	CRM 8.0	7	7	2.05	±	0.41	1.67	-	2.88
	Little Emory River								
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Mercury	Emory River							-	
	ERM 0.9	6	7	0.77	±	0.71	0.04	-	1.83
	ERM 3.0	6	7	0.49	±	0.35	0.04	-	0.88
	ERM 8.0	7	7	1.23	±	0.60	0.46	-	2.04
	Clinch River							-	
	CRM 1.5	7	7	0.37	±	0.09	5.56	-	0.48
	CRM 8.0	7	7	0.50	±	0.20	0.20	-	0.84
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC
Selenium	Emory River							-	
	ERM 0.9	7	7	6.65	±	2.50	3.24	-	9.17
	ERM 3.0	7	7	6.42	±	1.12	4.41	-	7.92
	ERM 8.0	7	7	6.26	±	0.73	5.22	-	7.31
	Clinch River							-	
	CRM 1.5	7	7	6.52	±	0.77	5.56	-	7.78
	CRM 8.0	7	7	5.94	±	0.98	4.23	-	6.92
	Little Emory River							-	
	LERM 2.0	NC	NC	NC	±	NC	NC	-	NC

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
LERM = Little Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NC = not collected
SD = standard deviation

Table 2-4.
Bluegill Sunfish Fillet Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	7	7	0.24	±	0.07	0.17	-	0.34
	ERM 3.0	7	7	0.19	±	0.08	0.12	-	0.31
	ERM 6.0/8.0	7	7	0.29	±	0.26	0.07	-	0.74
	Clinch River								
	CRM 1.5	0	7	0.18	±	0.08	0.12	-	0.33
	CRM 8.0	0	7	0.36	±	0.15	0.23	-	0.60
Mercury	Emory River							-	
	ERM 0.9/1.0	7	7	0.27	±	0.08	0.18	-	0.41
	ERM 3.0	7	7	0.62	±	0.23	0.25	-	0.95
	ERM 6.0/8.0	7	7	0.52	±	0.11	0.29	-	0.65
	Clinch River							-	
	CRM 1.5	7	7	0.35	±	0.12	0.26	-	0.56
	CRM 8.0	7	7	0.63	±	0.17	0.40	-	0.86
Selenium	Emory River							-	
	ERM 0.9/1.0	7	7	2.42	±	0.57	1.85	-	3.48
	ERM 3.0	7	7	3.71	±	0.51	2.80	-	4.20
	ERM 6.0/8.0	7	7	2.67	±	1.19	1.63	-	4.05
	Clinch River							-	
	CRM 1.5	7	7	2.20	±	0.46	1.72	-	3.13
	CRM 8.0	7	7	1.98	±	0.25	1.54	-	2.30

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation

Table 2-5.
Bluegill Sunfish Ovary Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	6	6	0.16	±	0.07	0.06	-	0.24
	ERM 3.0	7	7	0.12	±	0.08	0.06	-	0.25
	ERM 6.0/8.0	5	7	0.11	±	0.04	0.04	-	0.15
	Clinch River								
	CRM 1.5	6	6	0.27	±	0.12	0.15	-	0.43
	CRM 8.0	6	6	0.23	±	0.16	0.08	-	0.49
Mercury	Emory River							-	
	ERM 0.9/1.0	0	6	0.02	±	0.01	0.01	-	0.03
	ERM 3.0	1	7	0.03	±	0.02	0.02	-	0.08
	ERM 6.0/8.0	7	7	0.02	±	0.00	0.02	-	0.03
	Clinch River							-	
	CRM 1.5	6	6	0.03	±	0.01	0.02	-	0.05
	CRM 8.0	0	6	0.03	±	0.01	0.02	-	0.04
Selenium	Emory River							-	
	ERM 0.9/1.0	6	6	4.53	±	0.38	4.29	-	5.28
	ERM 3.0	7	7	4.63	±	1.58	3.33	-	8.00
	ERM 6.0/8.0	7	7	3.10	±	0.50	2.53	-	3.89
	Clinch River							-	
	CRM 1.5	6	6	3.92	±	0.50	3.24	-	4.36
	CRM 8.0	6	6	3.45	±	0.72	2.64	-	4.57

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation

Table 2-6.
Bluegill Sunfish Liver Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	1	1	NA	±	NA	0.63	-	0.63
	ERM 3.0	1	1	NA	±	NA	0.67	-	0.67
	ERM 6.0/8.0	1	1	NA	±	NA	0.71	-	0.71
	Clinch River								
	CRM 1.5	1	1	NA	±	NA	1.64	-	1.64
	CRM 8.0	1	1	NA	±	NA	0.96	-	0.96
Mercury	Emory River							-	
	ERM 0.9/1.0	1	1	NA	±	NA	0.19	-	0.19
	ERM 3.0	1	1	NA	±	NA	0.24	-	0.24
	ERM 6.0/8.0	1	1	NA	±	NA	0.20	-	0.20
	Clinch River							-	
	CRM 1.5	1	1	NA	±	NA	0.31	-	0.31
	CRM 8.0	1	1	NA	±	NA	0.24	-	0.24
Selenium	Emory River							-	
	ERM 0.9/1.0	1	1	NA	±	NA	8.15	-	8.15
	ERM 3.0	1	1	NA	±	NA	10.40	-	10.40
	ERM 6.0/8.0	1	1	NA	±	NA	6.25	-	6.25
	Clinch River							-	
	CRM 1.5	1	1	NA	±	NA	7.60	-	7.60
	CRM 8.0	1	1	NA	±	NA	6.67	-	6.67

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NA = not applicable
SD = standard deviation

Table 2-7.
Redear Sunfish Fillet Summary Statistics for 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	7	7	0.95	±	0.20	0.64	-	1.17
	ERM 3.0	7	7	0.68	±	0.27	0.15	-	1.00
	ERM 6.0/8.0	7	7	0.34	±	0.11	0.14	-	0.45
	Clinch River								
	CRM 1.5	7	7	1.02	±	0.25	0.71	-	1.48
	CRM 8.0	7	7	0.86	±	0.20	0.68	-	1.09
Mercury	Emory River							-	
	ERM 0.9/1.0	6	7	0.42	±	0.21	0.21	-	0.74
	ERM 3.0	7	7	0.41	±	0.18	0.20	-	0.75
	ERM 6.0/8.0	7	7	0.54	±	0.15	0.37	-	0.79
	Clinch River							-	
	CRM 1.5	7	7	0.38	±	0.10	0.22	-	0.48
	CRM 8.0	7	7	0.83	±	0.17	0.59	-	1.05
Selenium	Emory River							-	
	ERM 0.9/1.0	7	7	4.44	±	1.14	2.79	-	6.36
	ERM 3.0	7	7	4.36	±	0.66	3.30	-	5.24
	ERM 6.0/8.0	7	7	2.77	±	1.24	1.79	-	4.58
	Clinch River							-	
	CRM 1.5	7	7	3.73	±	0.24	3.43	-	4.19
	CRM 8.0	7	7	2.72	±	0.35	2.14	-	3.18

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation

Table 2-8.
Redear Sunfish Ovary Summary Statistics for 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	7	7	1.90	±	0.70	0.97	-	2.89
	ERM 3.0	7	7	0.88	±	0.42	0.22	-	1.50
	ERM 6.0/8.0	7	7	0.34	±	0.13	0.16	-	0.50
	Clinch River								
	CRM 1.5	7	7	2.45	±	0.53	1.75	-	3.41
	CRM 8.0	7	7	2.41	±	0.55	1.69	-	3.43
Mercury	Emory River							-	
	ERM 0.9/1.0	0	7	0.01	±	0.00	0.01	-	0.02
	ERM 3.0	0	7	0.02	±	0.00	0.01	-	0.02
	ERM 6.0/8.0	7	7	0.02	±	0.00	0.02	-	0.02
	Clinch River							-	
	CRM 1.5	4	7	0.02	±	0.00	0.01	-	0.02
	CRM 8.0	0	7	0.04	±	0.01	0.02	-	0.05
Selenium	Emory River							-	
	ERM 0.9/1.0	7	7	4.21	±	1.02	3.16	-	5.68
	ERM 3.0	7	7	4.42	±	0.47	3.72	-	5.00
	ERM 6.0/8.0	7	7	3.46	±	0.59	2.82	-	4.36
	Clinch River							-	
	CRM 1.5	7	7	3.31	±	0.43	2.37	-	3.66
	CRM 8.0	7	7	3.48	±	0.41	3.13	-	4.29

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation

Table 2-9.
Redear Sunfish Liver Summary Statistics for 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 0.9/1.0	1	1	NA	±	NA	4.78	-	4.78
	ERM 3.0	1	1	NA	±	NA	2.15	-	2.15
	ERM 6.0/8.0	1	1	NA	±	NA	1.48	-	1.48
	Clinch River								
	CRM 1.5	1	1	NA	±	NA	7.92	-	7.92
	CRM 8.0	1	1	NA	±	NA	4.58	-	4.58
Mercury	Emory River							-	
	ERM 0.9/1.0	1	1	NA	±	NA	0.14	-	0.14
	ERM 3.0	1	1	NA	±	NA	0.19	-	0.19
	ERM 6.0/8.0	1	1	NA	±	NA	0.35	-	0.35
	Clinch River							-	
	CRM 1.5	1	1	NA	±	NA	0.23	-	0.23
	CRM 8.0	1	1	NA	±	NA	0.37	-	0.37
Selenium	Emory River							-	
	ERM 0.9/1.0	1	1	NA	±	NA	11.30	-	11.30
	ERM 3.0	1	1	NA	±	NA	11.90	-	11.90
	ERM 6.0/8.0	1	1	NA	±	NA	8.40	-	8.40
	Clinch River							-	
	CRM 1.5	1	1	NA	±	NA	10.00	-	10.00
	CRM 8.0	1	1	NA	±	NA	8.75	-	8.75

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NA = not applicable
SD = standard deviation

Table 3-1.
Benthic Invertebrate Community Results for the Emory River: 2009 – 2013

Tennessee Valley Authority
Kingston, Tennessee

	River	Emory River																																							
	Transect	ERM 6.0						ERM 5.0					ERM 4.1					ERM 3.5		ERM 3.0				ERM 2.6				ERM 2.2					ERM 1.0						ERM 0.7		
	Sample Period	1	2	3	4	5	6	1	2	3	4	5	2	3	4	5	6	4	5	3	4	5	6	3	4	5	6	2	3	4	5	6	1	2	3	4	5	6	4	5	6
	Sample Period	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Dec-11	Dec-12	Dec-10	Dec-11	Dec-12	Dec-13	Dec-10	Dec-11	Dec-12	Dec-13	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Dec-11	Dec-12	Dec-13
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	20	10	10	10	20	10	10	10	10	20	10	10	10	10	10	20	10	10	10	10	10	10
Average Abundance (# / m^2)	Population	752	737	452	707	1612	1135	587	733	355	1231	930	988	2142	1300	1547	1748	1050	617	2433	2258	1558	3390	2093	2157	2175	3690	1315	2073	1823	3203	4483	967	1108	1577	2832	1462	1155	2648	2182	2333
	Oligochaetes	273	110	48	402	335	317	344	43	58	892	173	255	507	592	517	722	333	163	1108	1407	332	1668	628	743	735	1995	260	543	1190	1335	2520	373	465	689	1025	277	210	847	590	1083
	Chironomids	375	415	227	247	987	557	84	383	220	235	500	552	1107	422	645	747	587	223	1056	697	518	1053	1219	948	662	993	378	1026	508	893	1417	320	318	718	1230	632	507	1347	1153	853
	Hexagenia	9	12	5	3	5	12	7	35	8	8	25	10	35	37	28	52	50	32	20	13	33	40	55	55	58	65	168	126	23	63	73	35	115	39	168	77	143	193	128	177
	Sphaeriidae	0	0	0	0	0	0	30	0	0	3	2	5	0	22	80	15	2	2	94	40	415	337	53	255	402	423	360	104	42	657	32	163	128	64	242	372	205	145	70	130
Average Compostion	% Oligochaetes	34.8	14.8	18.8	54.7	19.3	23.6	46.1	6.7	13.1	50.3	15.0	23.1	26.4	41.1	30.2	34.4	33.9	21.4	41.5	60.6	19.0	39.0	22.7	32.5	30.7	41.3	12.1	14.1	45.9	30.0	48.7	33.0	46.7	35.8	36.1	20.4	20.7	34.9	23.0	40.9
	% Chironomids	50.2	57.5	47.7	34.9	59.5	47.9	16.9	57.2	56.6	25.4	52.5	56.5	47.7	36.2	39.8	44.4	47.0	39.0	46.7	31.3	34.3	35.1	56.1	42.5	32.8	32.1	27.5	50.1	42.6	33.7	35.2	37.1	27.9	48.9	40.9	45.1	44.8	47.5	47.8	35.6
Taxa Richness	Total Richness	26	23	23	28	27	43	23	22	28	52	38	45	41	57	26	38	51	34	47	43	32	44	39.5	41	30	37	47	40.5	48	32	45	23	24	39.5	55	40	30	43	41	34
	Average Richness	8.6	7.7	5.9	8.0	7.6	12.8	6.4	7.7	5.5	11.2	11.5	11.5	11.3	12.3	11.4	13.4	11.4	9.3	13.5	12.8	11.7	16.7	13.9	13.9	12.2	13.1	11.0	12.5	13.4	12.7	16.1	9.0	9.2	11.2	17.6	12.6	12.7	15.1	16.0	13.8
	Total EPT Richness	2	2	3	1	2	5	3	2	3	6	3	6	5	5	2	3	5	5	3	2	2	4	3	1	2	2	4	2.5	3	2	3	1	3	3.5	3	2	2	2	3	2
	Average EPT Richness	0.5	0.5	0.4	0.2	0.3	1.1	0.6	0.6	0.5	0.7	1.1	1.0	1.1	0.8	0.8	1.1	0.8	1.3	0.7	0.3	1.0	1.5	1.0	0.7	0.8	0.9	1.5	1.0	0.6	1.0	1.1	0.6	0.9	0.9	1.1	1.1	0.9	0.6	1.5	1.0

General Notes:

1. Sample periods are defined as follows: 1- January 2009; 2- December 2009; 3- December 2010-January 2011; 4- December 2011- January 2012; 5- November-December 2012.

Acronyms and Abbreviations:

% = percent
# / m^2 = number per square meter
EPT = Ephemeroptera, Plecoptera, and Trichoptera
ERM = Emory River Mile

Table 3-2.
Benthic Invertebrate Community Results for the Clinch and Tennessee Rivers: 2009 – 2013

Tennessee Valley Authority
Kingston, Tennessee

	River	Clinch River																																				
	Transect	CRM 8.7					CRM 6.0						CRM 4.0						CRM 3.0						CRM 1.5						CRM 0.5				
	Sample Period	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5
	Sample Period	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12	Dec-13	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12
	Number of Samples	10	10	10	10	10	10	10	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7	9	10	10	10	10	10	10	10
Average Abundance (# / m^2)	Population	3448	582	1853	2542	2422	3013	972	2478	1602	3203	2185	1652	1300	1643	2638	2047	2385	1587	947	1207	1320	2338	2568	1380	1230	981	1826	1757	2797	1153	1328	1297	2118	2228
	Oligochaetes	2738	92	1025	613	392	1838	345	1005	242	462	188	550	57	527	417	237	255	190	70	160	303	372	365	150	333	217	526	217	382	302	362	228	373	648
	Chironomids	307	85	602	267	637	790	238	1040	487	1105	773	393	325	702	695	557	817	575	318	573	370	433	638	420	380	488	469	412	587	388	425	517	542	612
	Hexagenia	147	0	20	10	85	145	88	91	445	335	388	150	278	188	470	458	560	345	140	245	402	392	538	292	252	176	404	387	363	147	225	280	732	272
	Sphaeriidae	30	2	7	8	23	90	30	22	3	225	53	477	352	143	195	453	458	388	392	150	103	855	782	402	188	10	215	493	1203	187	247	183	357	427
Average Compostion	% Oligochaetes	74.2	15.7	54.3	30.7	20.3	62.4	30.3	37.7	21.6	16.7	9.8	46.7	7.0	28.7	18.3	10.9	10.3	9.2	11.7	11.9	26.0	15.1	13.6	15.5	25.5	14.8	27.8	12.2	14.2	26.0	26.6	17.3	19.2	26.8
	% Chironomids	9.1	19.0	33.3	20.8	17.1	24.7	17.8	42.3	28.8	29.2	33.2	22.7	29.9	46.3	26.4	27.7	34.7	35.1	32.6	45.8	28.1	17.3	23.8	30.9	32.6	43.0	25.8	23.3	19.3	31.9	30.2	36.0	26.1	30.0
Taxa Richness	Total Richness	34	25	42	46	53	36	34	48	46	53	46	35	21	53	56	47	52	25	19	27	41	39	34	17	20	26	41	32	51	34	24	31	36	33
	Average Richness	12.9	6.6	13.2	11.2	17.1	15.1	8.8	16.9	14.7	20.2	20.8	10.2	8.7	16.4	16.9	16.3	18.7	9.9	8.6	11.2	14.2	14.6	16.1	10.0	10.1	9.6	14.8	13.5	19.0	11.5	10.1	12.5	15.1	15.1
	Total EPT Richness	3	4	4	8	8	2	4	4.5	2	5	5	2	2	4	7	3	3	2	1	2	4	3	3	2	1	2	3	2	3	5	1	3	1	2
	Average EPT Richness	1.1	0.7	0.7	1.1	1.9	1.1	0.9	1.2	1.0	1.7	1.9	0.7	1.0	1.2	1.8	1.3	1.5	1.1	1.0	1.2	1.4	1.1	1.5	1.1	1.0	0.7	1.0	1.1	1.3	1.7	1.0	1.2	1.0	1.1

** In December 2010, replicate transects were sampled at selected locations (i.e., 20 samples). For these transects, Total Richness and Total EPT Richness were calculated for each replicate and then averaged.*

	River	Tennessee River												
	Transect	TRM 573.9				TRM 566.3				TRM 560.8				
	Sample Period	1	2	3	4	1	2	3	4	1	2	3	4	5
	Sample Period	Jan-09	Dec-09	Dec-10	Dec-11	Jan-09	Dec-09	Dec-10	Dec-11	Jan-09	Dec-09	Dec-10	Dec-11	Dec-12
	Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10
Average Abundance (# / m^2)	Population	1975	1285	1835	1772	1998	1553	1315	2060	828	897	930	1140	1218
	Oligochaetes	1120	173	95	195	1052	718	207	405	55	50	58	68	63
	Chironomids	460	263	467	352	550	498	602	672	650	400	435	677	602
	Hexagenia	68	262	375	383	105	142	223	443	30	98	58	112	58
	Sphaeriidae	163	427	827	632	82	137	152	408	60	323	322	248	423
Average Compostion	% Oligochaetes	55.6	15.7	8.7	12.2	50.8	37.6	15.7	23.1	6.5	5.9	6.6	6.8	6.0
	% Chironomids	24.1	22.8	32.5	19.9	29.2	36.4	48.8	31.2	79.0	53.3	47.7	57.8	48.4
Taxa Richness	Total Richness	31	31	24	25	35	20	26	34	15	14	18	21	16
	Average Richness	13.2	10.0	10.6	10.0	12.1	9.1	11.0	13.2	6.8	6.3	8.2	10.0	7.9
	Total EPT Richness	2	3	3	2	4	1	2	1	3	3	3	1	2
	Average EPT Richness	1.0	1.1	1.4	1.1	1.1	0.8	1.1	1.0	0.9	0.7	1.2	0.9	0.8

Acronyms and Abbreviations:
% = percent
# / m^2 = number per square meter
EPT = Ephemeroptera, Plecoptera, and Trichoptera
CRM = Clinch River Mile
TRM = Tennessee River Mile

Table 3-3.
Snail (Non-Depurated) Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 1.0	6	6	9.93	±	1.79	7.10	-	12.20
	ERM 2.5	8	8	8.68	±	0.83	7.70	-	9.90
	ERM 4.0	3	3	11.60	±	1.74	10.40	-	13.60
	ERM 6.0	6	6	8.98	±	1.21	7.30	-	10.60
	Clinch River								
	CRM 1.5	6	6	13.92	±	1.90	11.70	-	16.50
	CRM 3.5	6	6	11.32	±	2.48	9.40	-	16.20
	CRM 6.0	7	7	9.83	±	1.56	8.30	-	12.60
	Little Emory River								
	LERM 1.0	4	4	8.70	±	0.84	7.60	-	9.60
	Tennessee River								
	TRM 566.3	3	3	9.40	±	1.15	8.30	-	10.60
	TRM 572.5	4	4	7.78	±	0.70	7.20	-	8.80
Selenium	Emory River				±			-	
	ERM 1.0	6	6	4.22	±	0.51	3.50	-	4.80
	ERM 2.5	8	8	4.09	±	0.22	3.70	-	4.40
	ERM 4.0	3	3	4.10	±	0.26	3.80	-	4.30
	ERM 6.0	6	6	3.17	±	0.18	2.90	-	3.40
	Clinch River								
	CRM 1.5	6	6	4.98	±	0.64	4.10	-	5.70
	CRM 3.5	6	6	4.07	±	0.42	3.60	-	4.80
	CRM 6.0	7	7	3.36	±	0.35	2.90	-	3.90
	Little Emory River								
	LERM 1.0	4	4	4.35	±	0.58	3.90	-	5.20
	Tennessee River								
	TRM 566.3	3	3	2.93	±	0.06	2.90	-	3.00
	TRM 572.5	4	4	2.40	±	0.12	2.30	-	2.50

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation

Table 3-4.
Mayfly Nymph (Non-Depurated) Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 1.0	4	4	10.53	±	0.59	9.90	-	11.30
	ERM 2.5	3	3	6.77	±	0.74	6.20	-	7.60
	ERM 3.0	4	4	9.48	±	1.51	7.60	-	11.30
	ERM 4.0	4	4	3.45	±	0.13	3.30	-	3.60
	ERM 6.0	3	3	2.77	±	0.21	2.60	-	3.00
	Clinch River								
	CRM 1.5	3	3	5.63	±	0.67	4.90	-	6.20
	CRM 3.5	3	3	6.10	±	0.26	5.90	-	6.40
	CRM 6.0	3	3	5.33	±	0.12	5.20	-	5.40
	Tennessee River								
	TRM 560.8	2	2	3.70	±	0.28	3.50	-	3.90
	TRM 566.3	3	3	3.40	±	0.78	2.90	-	4.30
	TRM 571.9	3	3	2.30	±	0.62	1.60	-	2.80
	Little Emory River								
	LERM 1.0	3	3	3.97	±	0.06	3.90	-	4.00
Selenium	Emory River				±			-	
	ERM 1.0	4	4	6.43	±	0.49	5.80	-	6.90
	ERM 2.5	3	3	5.63	±	0.25	5.40	-	5.90
	ERM 3.0	4	4	4.20	±	0.63	3.70	-	5.00
	ERM 4.0	4	4	3.75	±	0.06	3.70	-	3.80
	ERM 6.0	3	3	3.20	±	0.36	2.90	-	3.60
	Clinch River				±			-	
	CRM 1.5	3	3	4.77	±	0.06	4.70	-	4.80
	CRM 3.5	3	3	5.20	±	0.26	5.00	-	5.50
	CRM 6.0	3	3	4.47	±	0.12	4.40	-	4.60
	Tennessee River				±			-	
	TRM 560.8	2	2	2.75	±	0.07	2.70	-	2.80
	TRM 566.3	3	3	2.90	±	0.78	2.40	-	3.80
	TRM 571.9	3	3	2.03	±	0.55	1.40	-	2.40
	Little Emory River				±			-	
	LERM 1.0	3	3	3.77	±	0.23	3.50	-	3.90

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
LERM = Little Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation
TRM = Tennessee River Mile

Table 3-5.
Mayfly Nymph (Depurated) Summary Statistics in 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 1.0	4	4	3.40	±	0.94	2.40	-	4.20
	ERM 2.5	3	3	2.13	±	0.78	1.50	-	3.00
	ERM 4.0	3	3	1.60	±	0.40	1.20	-	2.00
	ERM 6.0	3	3	1.20	±	0.10	1.10	-	1.30
	Clinch River								
	CRM 1.5	3	3	2.37	±	1.00	1.40	-	3.40
	CRM 3.5	4	4	2.13	±	0.34	1.80	-	2.60
	CRM 6.0	3	3	2.17	±	0.50	1.70	-	2.70
	Tennessee River								
	TRM 566.3	3	3	1.40	±	0.17	1.30	-	1.60
	TRM 571.9	4	4	1.38	±	0.25	1.10	-	1.70
Selenium	Emory River				±			-	
	ERM 1.0	4	4	6.05	±	0.58	5.60	-	6.90
	ERM 2.5	3	3	5.63	±	0.50	5.10	-	6.10
	ERM 4.0	3	3	3.50	±	0.10	3.40	-	3.60
	ERM 6.0	3	3	3.30	±	0.10	3.20	-	3.40
	Clinch River								
	CRM 1.5	3	3	4.47	±	0.15	4.30	-	4.60
	CRM 3.5	4	4	4.45	±	0.35	4.10	-	4.80
	CRM 6.0	3	3	4.10	±	0.36	3.70	-	4.40
	Tennessee River				±			-	
	TRM 566.3	3	3	3.40	±	0.10	3.30	-	3.50
	TRM 571.9	4	4	2.78	±	0.19	2.50	-	2.90

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation
TRM = Tennessee River Mile

Table 3-6.
Mayfly Adult Summary Statistics for 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River								
	ERM 1.0	11	11	0.26	±	0.09	0.17	-	0.43
	ERM 2.5	11	11	0.23	±	0.06	0.15	-	0.35
	ERM 3.0	9	9	0.18	±	0.04	0.13	-	0.24
	ERM 4.0	10	10	0.18	±	0.06	0.10	-	0.28
	ERM 6.0	6	6	0.22	±	0.03	0.17	-	0.25
	Clinch River								
	CRM 1.5	13	13	0.26	±	0.08	0.13	-	0.42
	CRM 3.5	10	10	0.24	±	0.06	0.15	-	0.33
	CRM 6.0	9	9	0.23	±	0.05	0.15	-	0.31
	Tennessee River								
	TRM 560.8	1	1	4.20	±			-	
	TRM 563.0	10	10	0.21	±	0.07	0.15	-	0.32
	TRM 566.3	10	10	0.26	±	0.05	0.19	-	0.35
	TRM 567.6	10	10	0.136	±	0.04	0.1	-	0.22
	TRM 572.0	10	10	0.18	±	0.05	0.11	-	0.27
	Little Emory River								
	LERM 1.0	10	10	0.21	±	0.06	0.16	-	0.32
Selenium	Emory River				±			-	
	ERM 1.0	11	11	6.65	±	0.22	6.30	-	7.00
	ERM 2.5	11	11	5.04	±	0.20	4.60	-	5.30
	ERM 3.0	9	9	4.38	±	0.32	4.00	-	5.00
	ERM 4.0	10	10	3.88	±	0.27	3.20	-	4.10
	ERM 6.0	6	6	3.30	±	0.09	3.20	-	3.40
	Clinch River				±			-	
	CRM 1.5	13	13	4.72	±	0.35	4.10	-	5.50
	CRM 3.5	10	10	5.25	±	0.56	4.20	-	6.00
	CRM 6.0	9	9	3.04	±	0.17	2.90	-	3.40
	Tennessee River				±			-	
	TRM 560.8	1	1	2.90	±			-	
	TRM 563.0	10	10	2.98	±	0.24	2.70	-	3.30
	TRM 566.3	10	10	2.94	±	0.25	2.4	-	3.3
	TRM 567.6	10	10	3.41	±	0.38	2.8	-	3.9
	TRM 572.0	10	10	2.23	±	0.12	2.10	-	2.40
	Little Emory River				±			-	
	LERM 1.0	10	10	4.13	±	0.28	3.80	-	4.50

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
CRM = Clinch River Mile
ERM = Emory River Mile
LERM = Little Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
SD = standard deviation
TRM = Tennessee River Mile

Table 4-1.
Tree Swallow Egg Summary Statistics for 2013

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River				±			-	
	ERM 1.4	0	30	0.09	±	0.03	0.07	-	0.15
	Tennessee River				±			-	
	TRM 572.0	0	31	0.12	±	0.07	0.07	-	0.40
Mercury	Emory River				±			-	
	ERM 1.4	26	30	0.29	±	0.08	0.20	-	0.54
	Tennessee River				±			-	
	TRM 572.0	11	31	0.15	±	0.04	0.09	-	0.26
Selenium	Emory River				±			-	
	ERM 1.4	30	30	3.65	±	0.71	2.39	-	5.43
	Tennessee River				±			-	
	TRM 572.0	31	31	2.89	±	0.72	1.68	-	4.89

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NC = Not calculated because all samples were non-detects; range represents reporting limits only
SD = standard deviation
TRM = Tennessee River Mile

Table 4-2.
Tree Swallow Egg Summary Statistics for 2014

Tennessee Valley Authority
Kingston, Tennessee

Analyte	Location	Number of Detects	Number of Samples	Mean [a]	±	SD	Range		
Arsenic	Emory River ERM 1.4	30	30	0.91	±	0.39	0.44	-	2.23
	Tennessee River TRM 572.0	28	30	0.88	±	0.20	0.33	-	1.25
Mercury	Emory River ERM 1.4	20	30	0.16	±	0.07	0.07	-	0.31
	Tennessee River TRM 572.0	21	30	0.10	±	0.05	0.03	-	0.21
Selenium	Emory River ERM 1.4	24	30	2.21	±	0.53	1.25	-	3.26
	Tennessee River TRM 572.0	13	30	1.80	±	0.05	1.36	-	3.91

Footnotes:
a. Mean calculations include reporting limits substituted for non-detects; concentrations presented in mg/kg dw.

Acronyms and Abbreviations:
ERM = Emory River Mile
mg/kg dw = milligrams per kilogram dry weight
NC = Not calculated because all samples were non-detects; range represents reporting limits only
SD = standard deviation
TRM = Tennessee River Mile

Table 5-1.
Analytical Data Review 2013

Tennessee Valley Authority
Kingston, Tennessee

Matrix	Number of COCs	Number of Samples by Matrix	Number of Equipment Blanks by Lab	Number of Analytical Results	Percentage Final-Verified	Percentage Validated
Fish (fillets, livers, and ovaries)	18	251	0	3,746	78%	22%
Mayfly Adults (whole body)		139		1,807	72%	28%
Mayfly Nymphs (depurated, non-depurated)	19	68	15	884	71%	29%
Snails (whole body)		53		689	66%	34%
Tree Swallow (egg content)	4	61	0	793	67%	33%
Sediment	46	278	6	1,285	60%	40%

General Notes:
All biota samples were analyzed at Pace Analytical Services, Inc. Sediment samples were analyzed by RJ Lee Group and TestAmerica, Inc. (Nashville, TN;

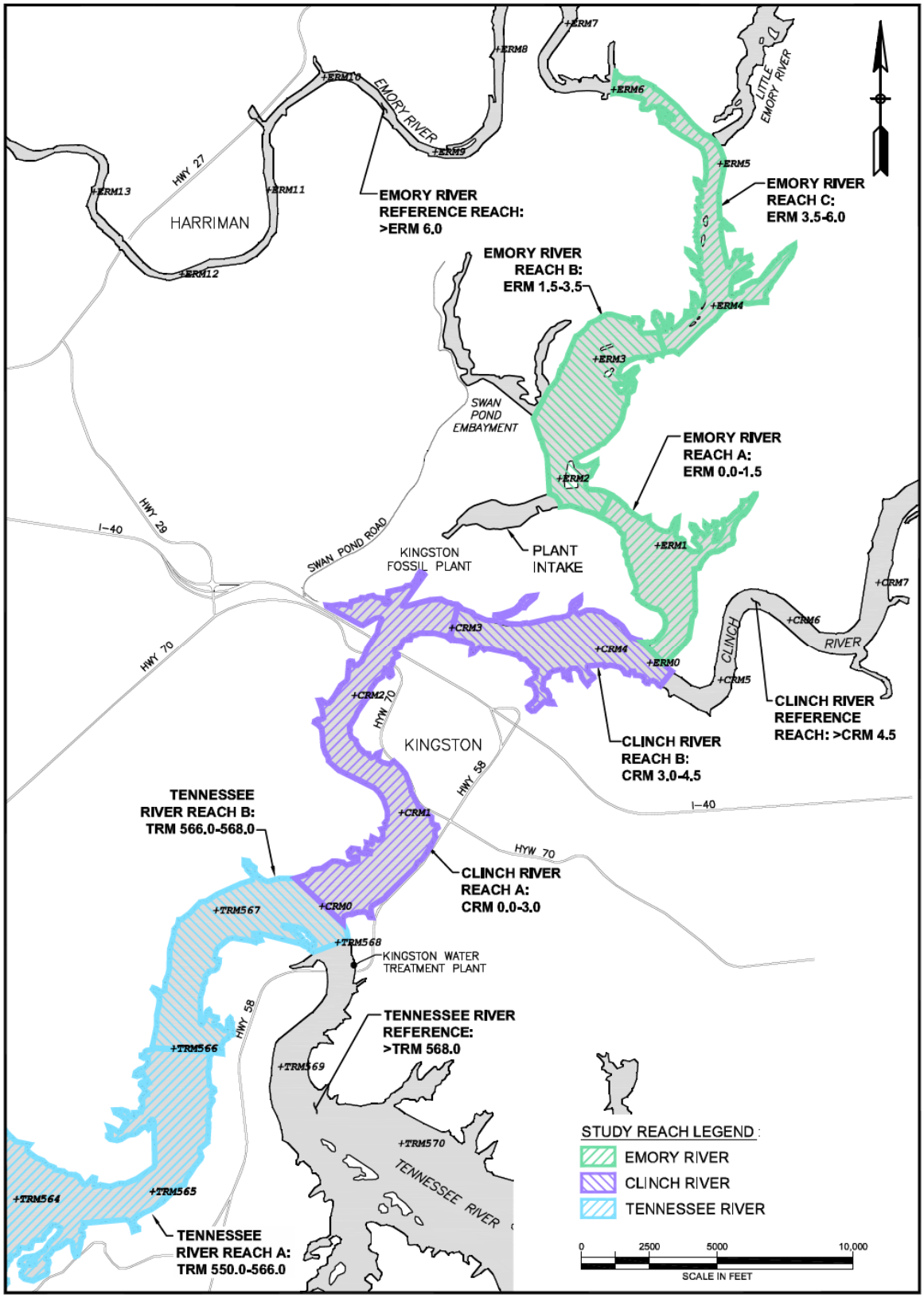
Acronyms and Abbreviations:
COCs = constituents of concern
– = not applicable

Table 5-2.
Data Quality Review 2013

Tennessee Valley Authority
Kingston, Tennessee

Matrix	Analytical Results (Total Count)	Acceptable (No Qualification)[a]		Acceptable (Estimated)[b]		Blank Qualified[c]		Rejected[d]	
Fish (fillets, livers, and ovaries)	3,746	2,786	*74%*	680	*18%*	280	*7%*	0	*0%*
Mayfly Adults (whole body)	1,807	1,403	*78%*	371	*21%*	33	*2%*	0	*0%*
Mayfly Nymphs (depurated, non-depurated)	884	111	*13%*	755	*85%*	18	*2%*	0	*0%*
Snails (whole body)	689	604	*88%*	78	*11%*	7	*1%*	0	*0%*
Tree Swallow (egg content)	793	615	*78%*	134	*17%*	44	*6%*	0	*0%*
Sediment	1,285	887	*69%*	378	*29%*	2	*0%*	18	*1%*

Notes:
[a]Acceptable, No Qualification – Qualification of data was not warranted based on a review of the applicable quality control measures.
[b]Acceptable, Estimated – Quantitation or detection limit is approximate due to limitations or bias identified during a review of the applicable quality control measures.
[c]Blank Qualified – Result is considered “not-detected” because it was detected in an associated blank at a similar level.
[d]Rejected – Unreliable result or detection limit; analyte may or may not be present in sample.



River Reaches

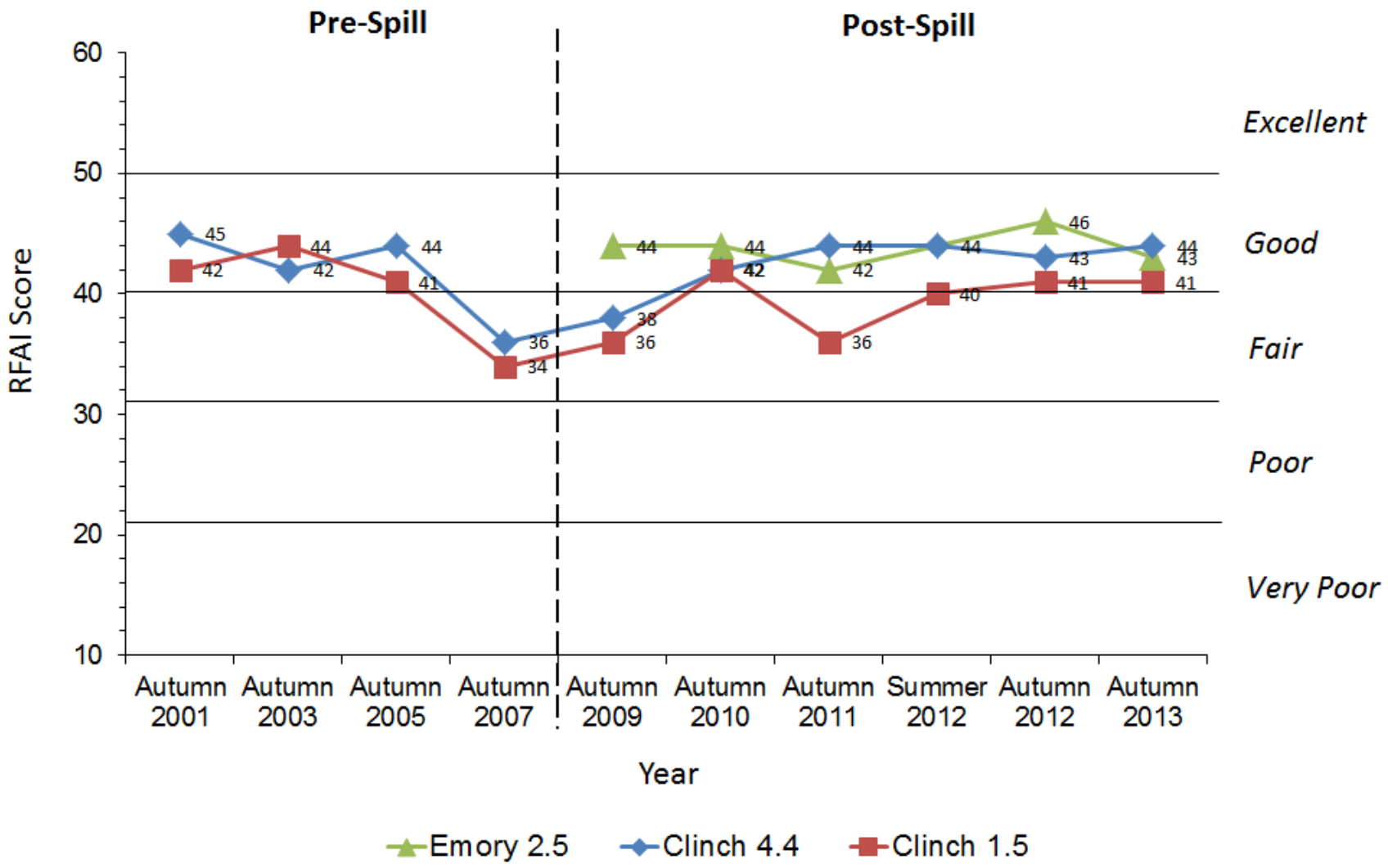
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

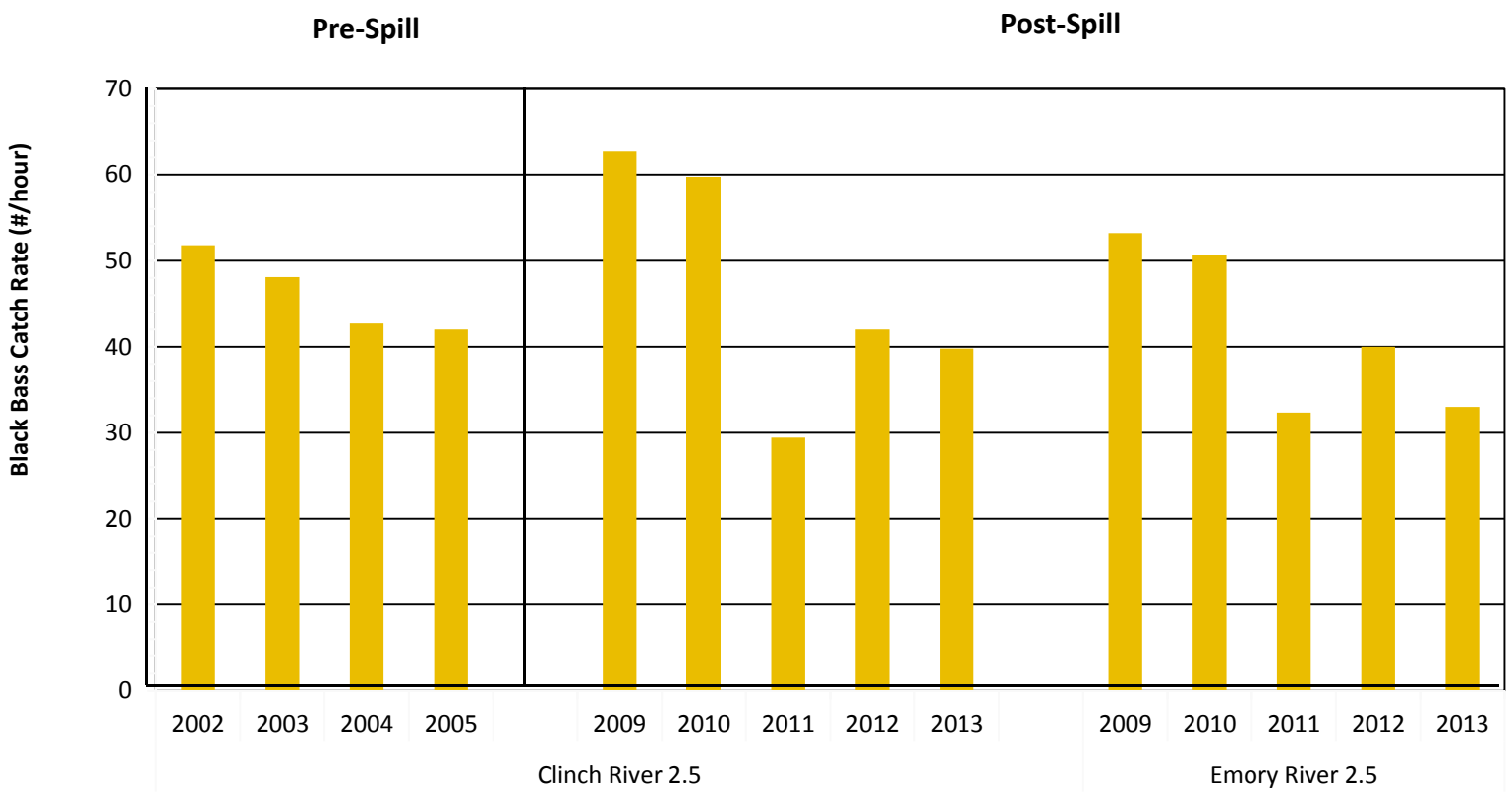
1-1



ARCADIS

Fish Community Survey: Reservoir Fish Assemblage Index Scores: 2001-2013
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

FIGURE
2-1



ARCADIS

Black Bass Catch Rates: 2002-2013

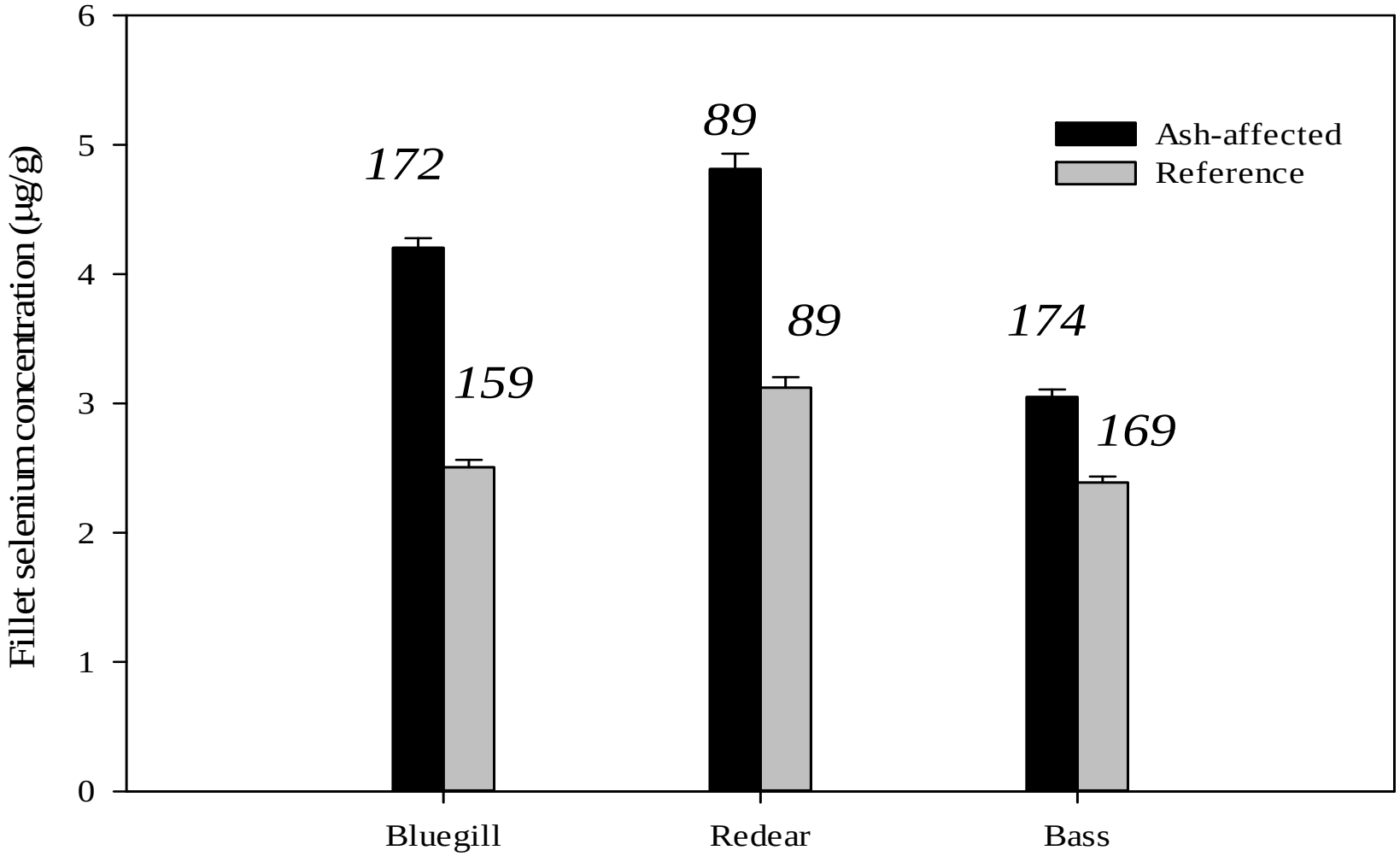
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

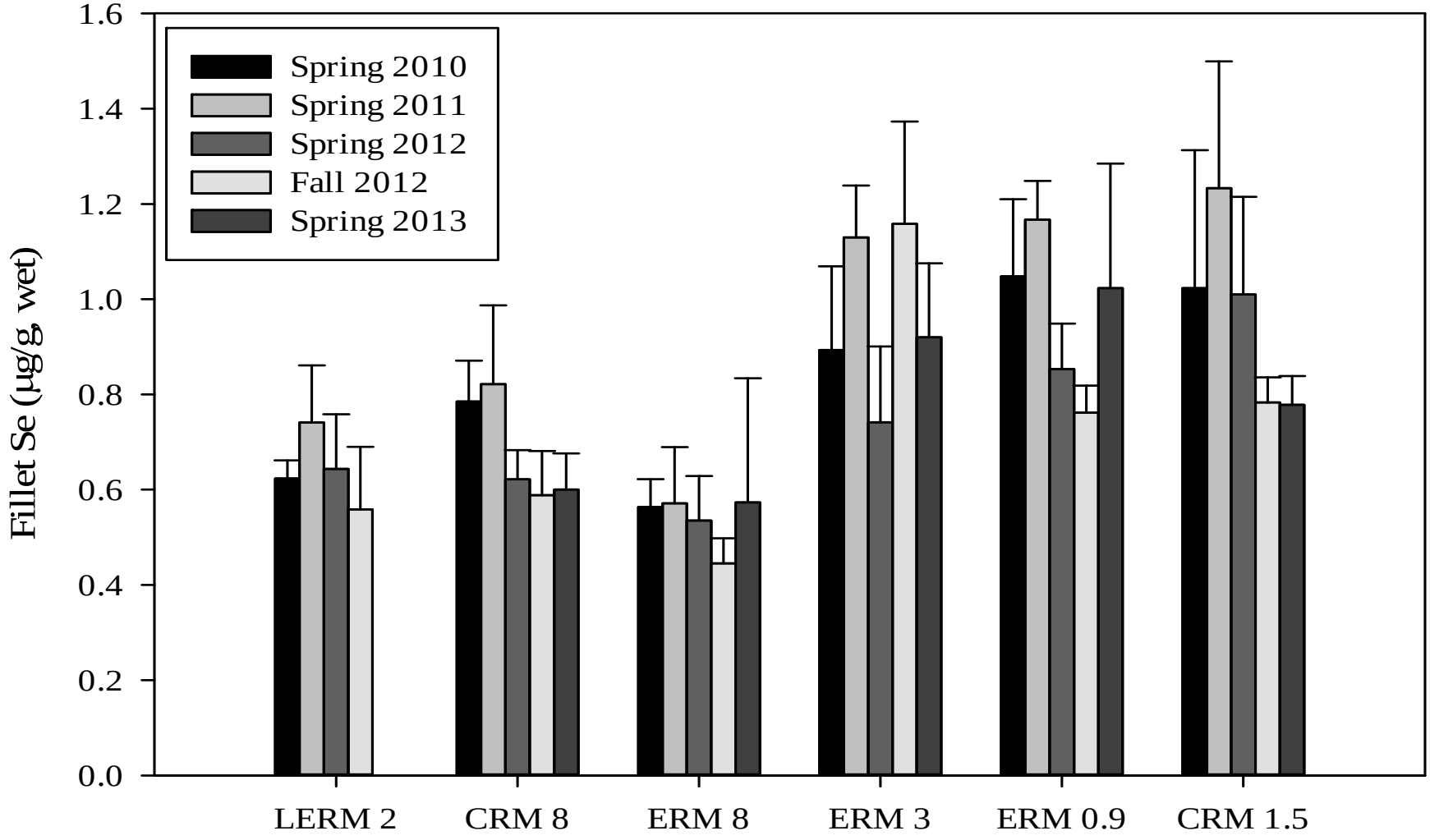
FIGURE

2-2



Selenium Concentrations in Bluegill Sunfish, Redear Sunfish, and Largemouth Bass Fillets
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

FIGURE
2-3



ARCADIS

Selenium Concentrations in Redear Sunfish Fillets: 2010-2013
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

FIGURE
2-4

ARCADIS

Fish Health Condition Indices

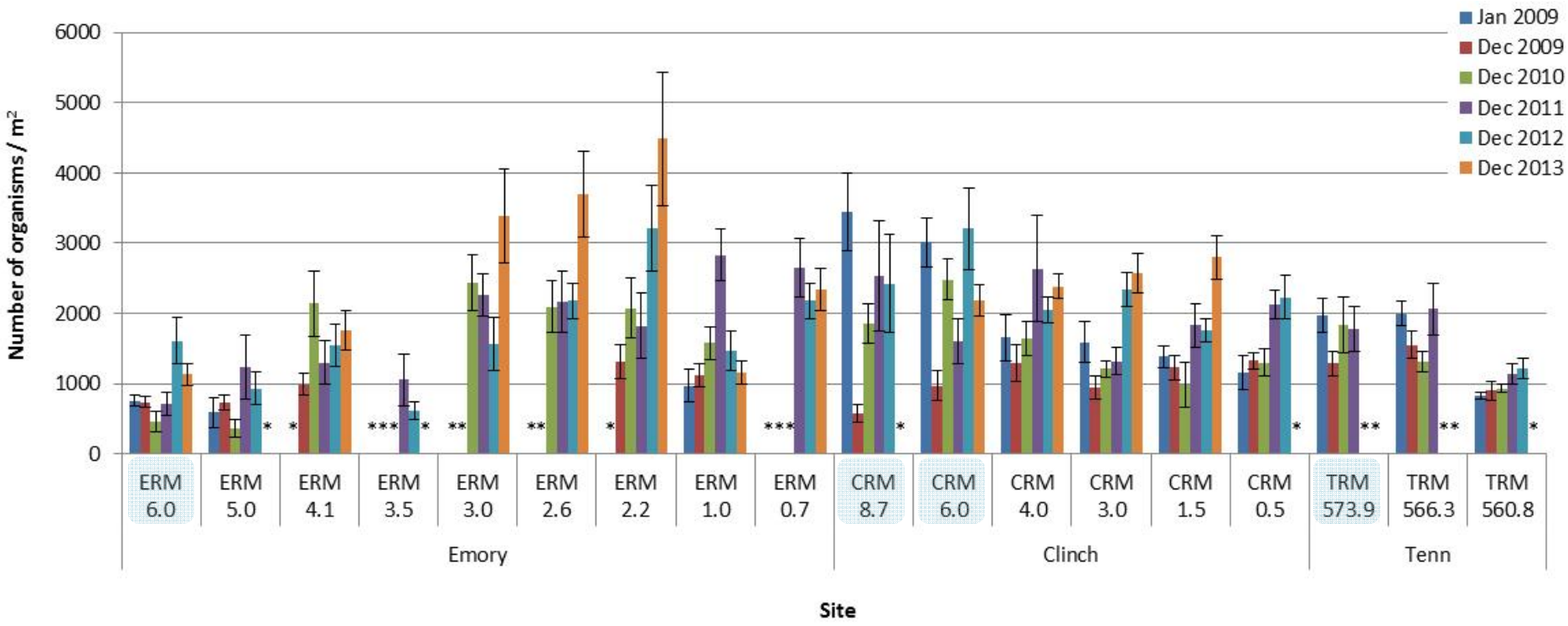
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

2-5



Reference Sites

Error Bars = Standard Error

* Indicates a sampling event(s) in which a site was not sampled

ARCADIS

Benthic Invertebrate Community Population Density: 2009-2013

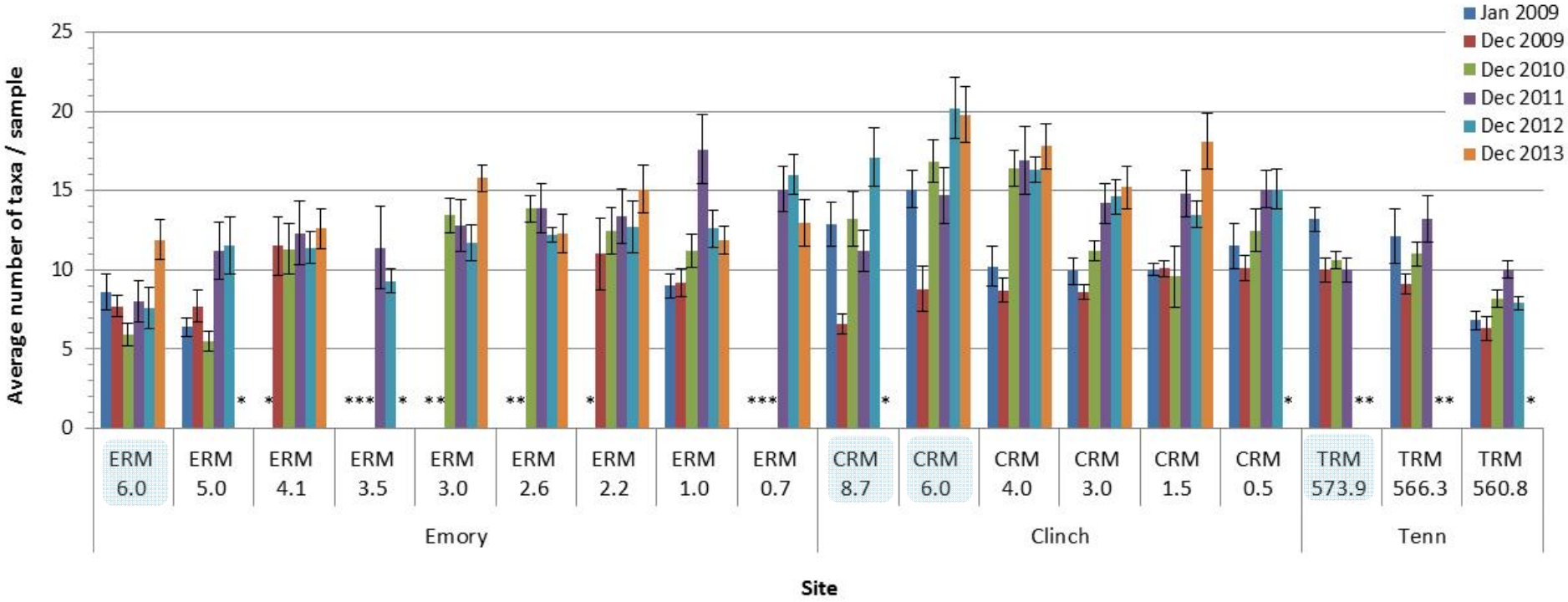
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

3-1



Reference Sites

Error Bars = Standard Error

* Indicates a sampling event(s) in which a site was not sampled

ARCADIS

Benthic Invertebrate Community Average Taxa Richness: 2009-2013

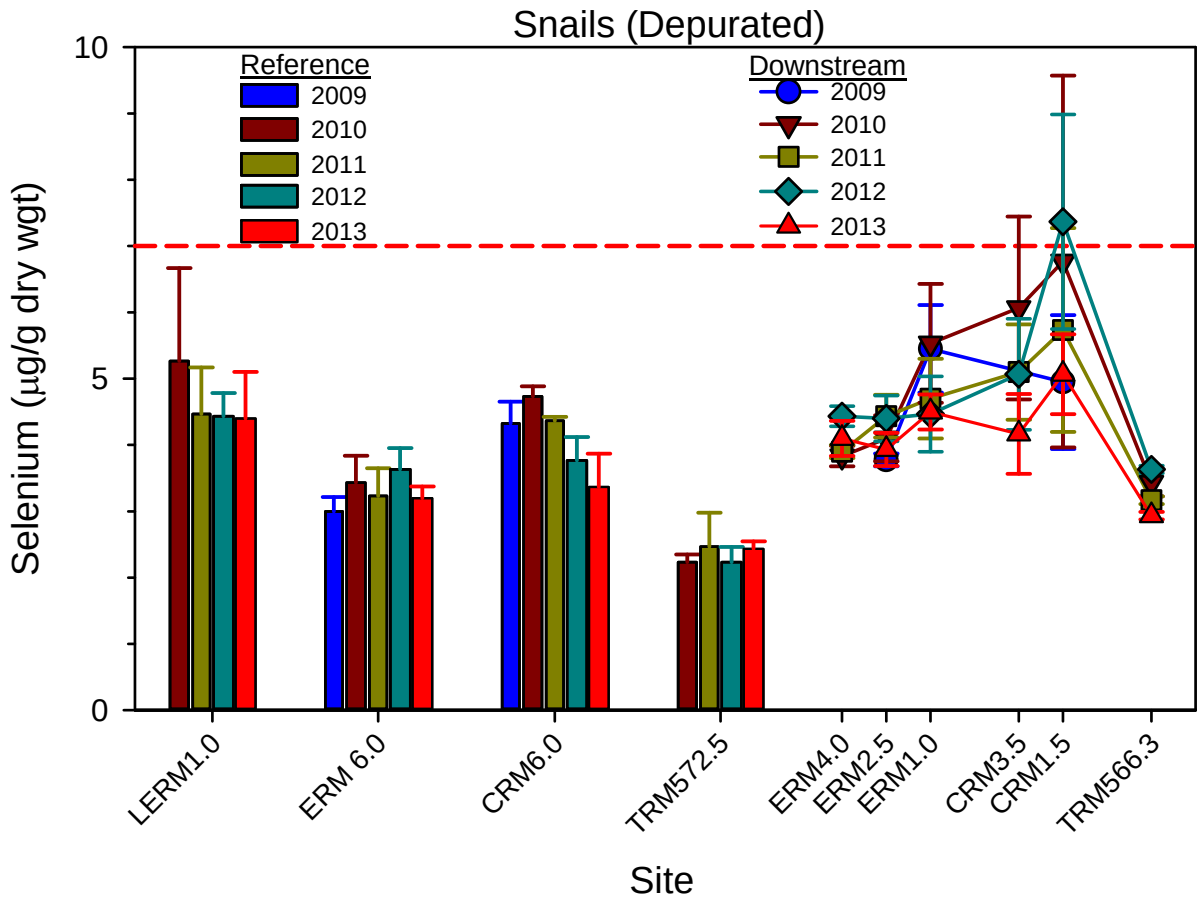
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

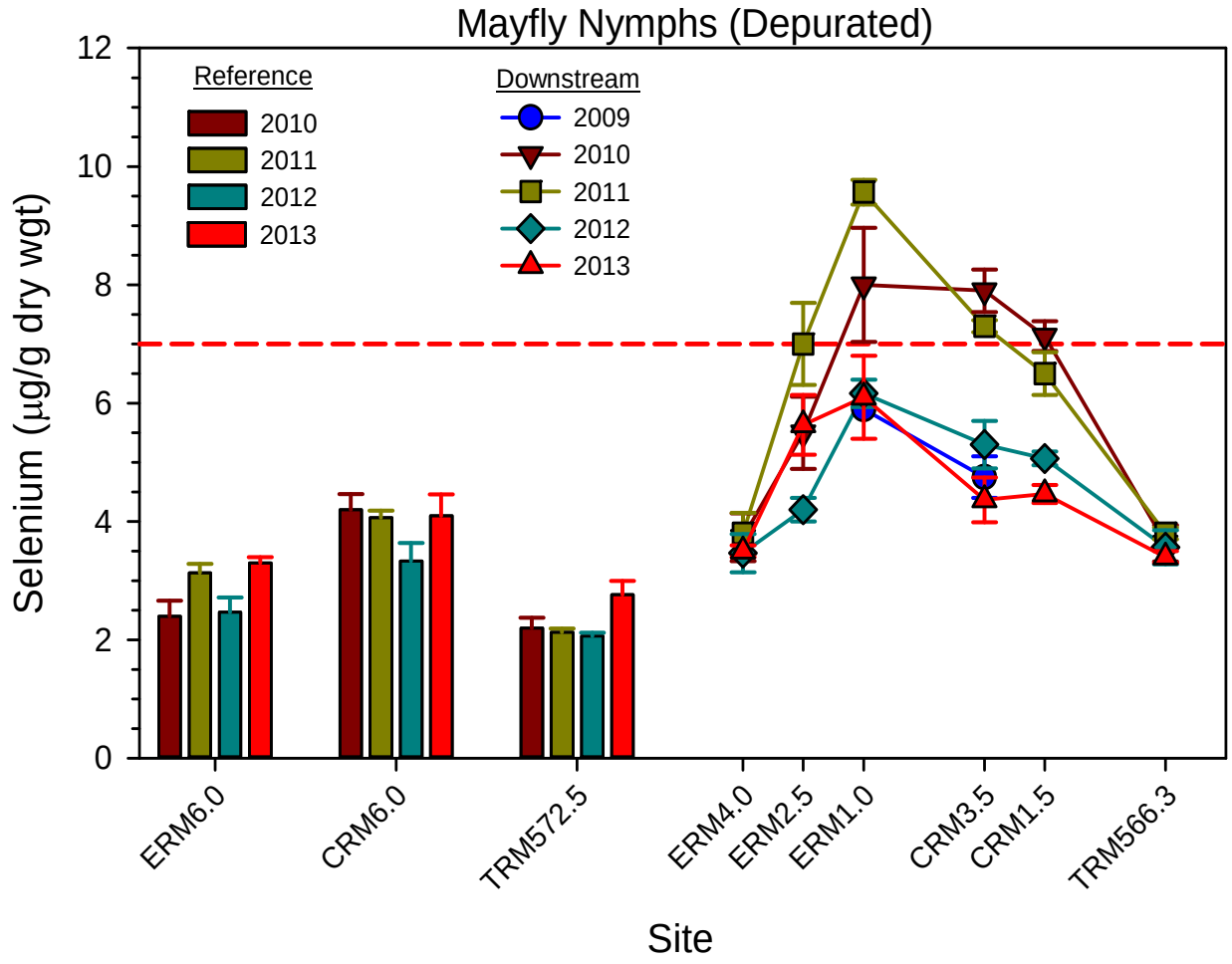
3-2



ARCADIS

Selenium Concentrations in Depurated Snail Tissue: 2009-2013
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

FIGURE
3-3



ARCADIS

Selenium Concentrations in Depurated Mayfly Nymph Tissue: 2009-2013

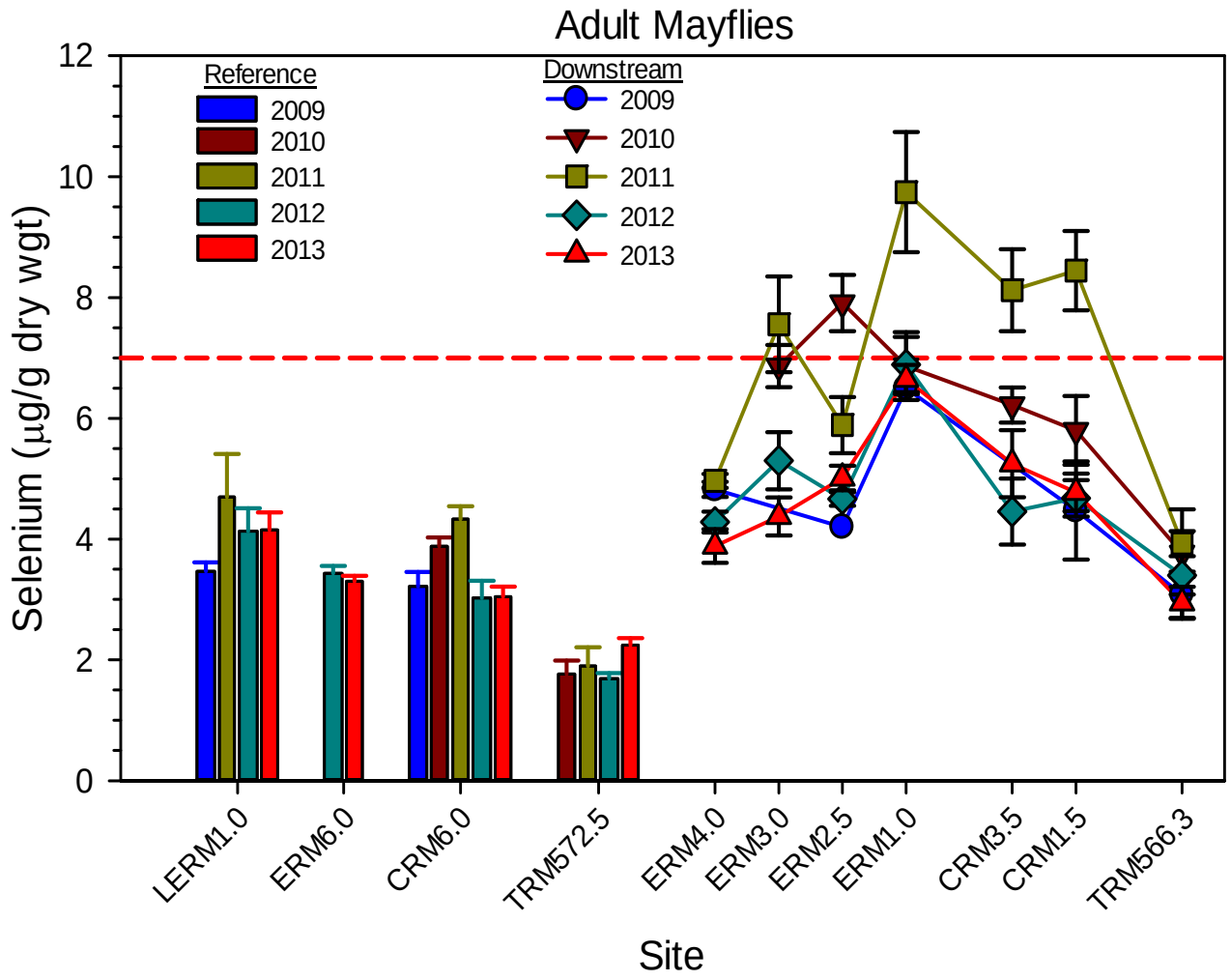
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

3-4



ARCADIS

Selenium Concentrations in Mayfly Adult Tissue: 2009-2013

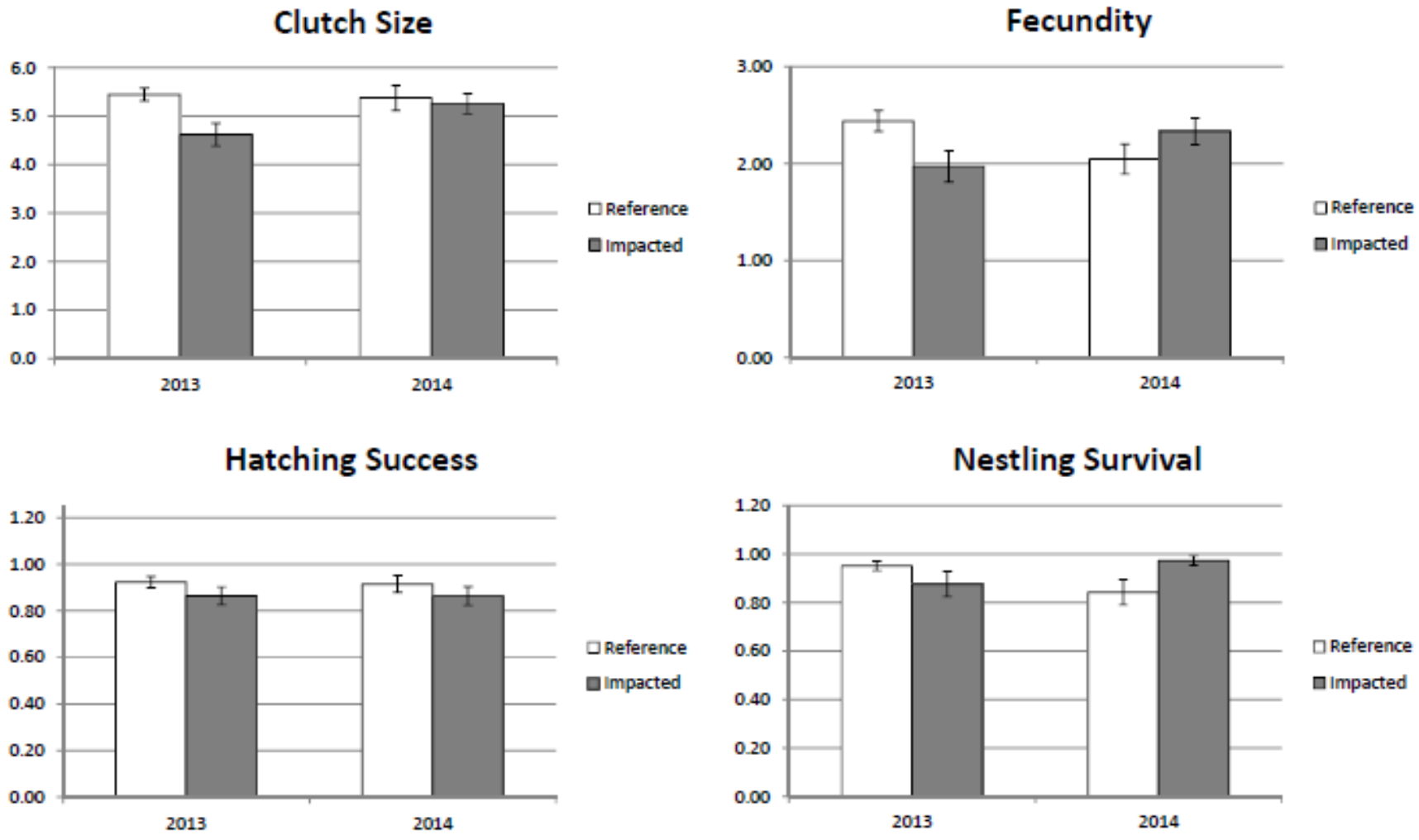
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

3-5



ARCADIS

Reproductive Metrics in Tree Swallows: 2013-2014

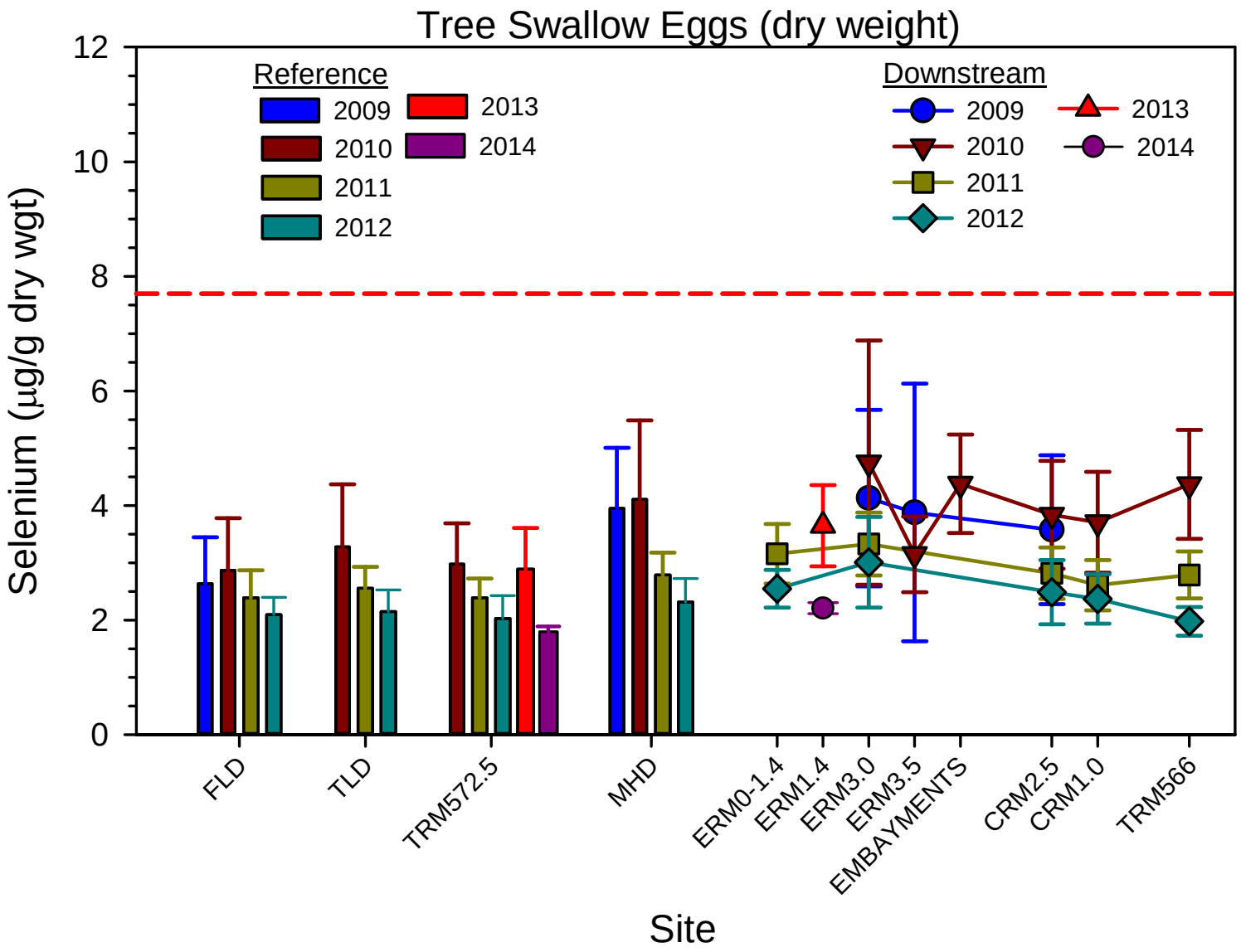
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013

TENNESSEE VALLEY AUTHORITY

KINGSTON, TENNESSEE

FIGURE

4-1



ARCADIS

Selenium Concentrations in Tree Swallow Eggs: 2009-2014
Updated Data Analysis and Temporal Trend Evaluations in Biota: 2009-2013
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

FIGURE
4-2

Appendix A

2013 Fish Community Survey Results

Tables

2013 Fish Community Survey Results
Kingston Fossil Plant Ash Recovery Project

Updated
July 28, 2014

Table 1. Reservoir Fish Assemblage Index (RFAI) scores for ERM 2.5, CRM 4.4, and CRM 1.5: 2001-2013.

Site	Pre-spill								Post-spill						Average Scores		
	2001 A	**2002 ---**	**2003 A**	**2004 ---**	**2005 A**	**2006 ---**	**2007 A**	**2008 ---**	**2009 A**	**2010 A**	**2011 A**	**2012 Su**	**2012 A**	**2013 A**	**Pre-Spill**	**Post-Spill**	**Long-Term**
ERM 2.5	---	---	---	---	---	---	---	---	44	44	42	---	46	43	---	43.8	43.8
CRM 4.4	45	---	42	---	44	---	36	---	38	42	44	44	43	44	41.8	42.5	42.2
CRM 1.5	42	---	44	---	41	---	34	---	36	42	36[1]	40	41	41	40.3	39.3	39.7

A-Autumn; Su-Summer

1-RFAI score for CRM 1.5 in 2011 was originally reported as 37. A correction in the classification of redbreast sunfish from indigenous to non-indigenous resulted in a one-point reduction in the score for "Percent non-indigenous species" thereby reducing the final RFAI score by one point.

RFAI scoring range for five rating categories:
12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent")

Table 2. Individual metric scores, contributing species, and overall RFAI scores for CRM 1.5, 2001-2013.

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
1. Number of indigenous species	Combined	(see Table 7)	**32**	**5**	**32**	**5**	**30**	**5**	**24**	**3**	**27**	**3**	**34**	**5**	**26**	**3**	**31**	**5**	**33**	**5**	**31**	**5**
2. Number of centrarchid species (less Micropterus)	Combined		**7**	**5**	**6**	**5**	**5**	**5**	**5**	**5**	**6**	**5**	**6**	**5**	**7**	**5**	**6**	**5**	**6**	**5**	**5**	**5**
		Black crappie	12		1		--		2		2		4		2		3		--		--	
		Bluegill	540		365		330		364		970		704		319		388		545		772	
		Green sunfish	11		4		36		16		43		35		30		16		22		20	
		Longear sunfish	12		16		52		106		197		71		38		37		24		28	
		Redear sunfish	59		51		40		47		52		107		44		57		32		52	
		Warmouth	2		--		--		--		3		--		6		2		4		1	
		White crappie	8		2		2		--		--		4		1		--		6		--	
3. Number of benthic invertivore species	Combined		**3**	**1**	**4**	**3**	**4**	**3**	**2**	**1**	**3**	**1**	**4**	**3**	**3**	**1**	**5**	**3**	**5**	**3**	**5**	**3**
		Black redhorse	--		--		--		--		--		--		3		2		1		2	
		Freshwater drum	10		30		9		8		11		13		11		16		13		8	
		Golden redhorse	--		1		--		1		1		2		--		1		--		--	
		Logperch	5		6		2		--		--		3		--		1		2		4	
		Northern hog sucker	--		--		4		--		--		--		--		--		2		1	
		Spotted sucker	14		11		18		--		15		11		52		12		30		23	
4. Number of intolerant species	Combined		**5**	**5**	**6**	**5**	**7**	**5**	**3**	**3**	**5**	**5**	**6**	**5**	**5**	**5**	**6**	**5**	**8**	**5**	**7**	**5**
		Black redhorse	--		--		--		--		--		--		3		2		1		2	
		Brook silverside	17		34		5		11		20		21		--		1		7		6	
		Longear sunfish	12		16		52		106		197		71		38		37		24		28	
		Mooneye	--		1		4		--		--		--		--		--		--		--	
		Northern hog sucker	--		--		4		--		--		--		--		--		2		1	
		Rock bass	--		--		--		--		3		3		1		--		2		1	
		Skipjack herring	21		21		22		--		--		10		--		12		1		--	
		Smallmouth bass	6		2		21		1		23		8		7		14		16		15	
		Spotted sucker	14		11		18		--		15		11		52		12		30		23	
5. Percent tolerant individuals	Electrofishing		**83.4%**	**0.5**	**75.7%**	**0.5**	**74.8%**	**0.5**	**76.6%**	**0.5**	**74.1%**	**0.5**	**66.4%**	**0.5**	**75.8%**	**0.5**	**79.3%**	**0.5**	**83.5%**	**0.5**	**79.7%**	**0.5**
		Bluegill	45.0		43.8		34.0		46.1		45.5		40.5		35.8		40.1		47.2		51.9	
		Bluntnose minnow	0.2		0.6		0.3		0.1		1.3		3.9		0.1		2.3		2.3		2.5	
		Common carp	1.6		1.9		1.8		0.6		0.6		0.4		2.0		1.0		0.9		1.6	
		Gizzard shad	21.6		21.2		29.4		22.4		6.9		14.5		25.8		27.3		11.9		6.1	
		Golden shiner	0.8		0.6		--		--		0.1		--		--		--		--		--	
		Green sunfish	0.9		0.5		3.7		2.0		2.0		2.0		3.4		1.7		1.9		1.3	
		Largemouth bass	8.0		4.1		2.6		2.6		4.6		3.2		6.6		2.7		10.8		4.7	
		Redbreast sunfish	0.4		0.1		0.6		0.1		0.7		0.3		0.7		0.8		0.6		0.6	
		River carpsucker	0.1		--		--		--		--		--		--		--		--		--	
		Spotfin shiner	4.6		2.7		2.4		2.7		12.4		1.2		1.4		3.4		7.5		11.0	
		Striped shiner	--		--		--		--		--		0.2		--		--		--		--	
		White crappie	0.2		0.2		--		--		--		0.2		--		--		0.4		--	

Table 2. (CRM 1.5, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
5. Percent tolerant individuals (continued)	Gill Netting		**27.7%**	**1.5**	**24.5%**	**1.5**	**25.8%**	**1.5**	**37.7%**	**0.5**	**17.7%**	**1.5**	**23.7%**	**1.5**	**10.0%**	**2.5**	**21.6%**	**1.5**	**21.7%**	**1.5**	**6.0%**	**2.5**
		Bluegill	6.1		2.8		--		5.2		--		0.6		2.0		--		--		--	
		Common carp	0.4		3.5		3.0		2.6		2.5		4.0		2.0		3.1		6.5		2.0	
		Gizzard shad	16.9		14.7		19.2		14.3		12.7		17.3		4.0		18.5		13.0		4.0	
		Largemouth bass	1.7		2.1		1.8		1.3		2.5		0.6		--		--		--		--	
		Longnose gar	--		1.4		0.6		14.3		--		0.6		--		--		--		--	
		White crappie	2.6		--		1.2		--		--		0.6		2.0		--		2.2		--	
6. Percent dominance by one species	Electrofishing	Bluegill	**45.0%**	**0.5**	**43.8%**	**0.5**	**34.0%**	**1.5**	**46.1%**	**0.5**	**45.5%**	**0.5**	**40.5%**	**0.5**	**35.8%**	**1.5**	**40.1%**	**0.5**	**47.2%**	**0.5**	**51.9%**	**0.5**
	Gill Netting	Blue catfish	--	--	--	--	--	--	--	--	**21.5%**	**1.5**	--	--	--	--	--	--	**26.1%**	**1.5**	**34.0%**	**0.5**
		Gizzard shad	**16.9%**	**1.5**	**14.7%**	**1.5**	**19.2%**	**1.5**	**14.3%**	**1.5**	--	--	--	--	--	--	--	--	--	--	--	--
		Sauger	--	--	--	--	--	--	--	--	--	--	--	--	**30.0%**	**0.5**	--	--	--	--	--	--
		Striped bass	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Yellow bass	--	--	--	--	--	--	--	--	--	--	**18.5%**	**1.5**	--	--	**22.3%**	**1.5**	--	--	--	--
7. Percent non-indigenous species	Electrofishing		**2.3%**	**2.5**	**2.4%**	**2.5**	**12.7%**	**0.5**	**1.0%**	**2.5**	**11.7%**	**0.5**	**19.1%**	**0.5**	**6.6%**	**0.5**	**4.1%**	**1.5**	**5.0%**	**1.5**	**10.4%**	**0.5**
		Common carp	1.6		1.9		1.8		0.6		0.6		0.4		2.0		1.0		0.9		1.6	
		Mississippi silverside	--		--		10.3		0.3		10.3		18.3		3.6		2.3		3.4		8.1	
		Redbreast sunfish	0.4		0.1		0.6		0.1		0.7		0.3		0.7		0.8		0.6		0.6	
		Striped bass	--		--		--		--		--		0.1		0.3		--		--		0.1	
		Yellow perch	0.3		0.4		--		--		0.1		--		--		--		0.1		--	
	Gill Netting		**7.4%**	**1.5**	**9.8%**	**0.5**	**13.8%**	**0.5**	**13.0%**	**0.5**	**6.3%**	**1.5**	**9.8%**	**0.5**	**6.0%**	**1.5**	**12.3%**	**0.5**	**13.0%**	**0.5**	**4.0%**	**2.5**
		Common carp	0.4		3.5		3.0		2.6		2.5		4.0		2.0		3.1		6.5		2.0	
		Striped x white bass	0.9		--		--		--		--		--		--		--		--		--	
		Striped bass	6.1		6.3		10.8		10.4		3.8		5.8		4.0		9.2		6.5		2.0	
8. Number of top carnivore species	Combined		**11**	**5**	**12**	**5**	**11**	**5**	**10**	**5**	**10**	**5**	**12**	**5**	**10**	**5**	**10**	**5**	**11**	**5**	**9**	**5**
		Black crappie	12		1		--		2		2		4		2		3		--		--	
		Flathead catfish	6		15		7		8		1		11		1		11		3		1	
		Largemouth bass	98		37		32		21		125		69		68		31		141		83	
		Longnose gar	--		2		1		11		--		1		--		--		--		--	
		Rock bass	--		--		--		--		3		3		1		--		2		1	
		Sauger	4		4		8		--		14		5		15		--		2		3	
		Skipjack herring	21		21		22		--		--		10		--		12		1		--	
		Smallmouth bass	6		2		21		1		23		8		7		14		16		15	
		Spotted bass	25		8		14		1		8		--		2		4		2		3	
		Spotted gar	2		1		4		1		1		1		--		1		--		1	
		Walleye	--		--		--		1		--		--		--		3		3		3	
		White bass	5		6		6		1		3		17		6		1		1		--	
		White crappie	8		2		2		--		--		4		1		--		6		--	
		Yellow bass	19		22		14		5		5		32		1		29		3		8	

Table 2. (CRM 1.5, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
9. Percent top carnivores	Electrofishing		**10.7%**	**1.5**	**6.4%**	**1.5**	**5.3%**	**0.5**	**3.0%**	**0.5**	**5.9%**	**1.5**	**5.0%**	**0.5**	**8.1%**	**1.5**	**4.4%**	**0.5**	**12.8%**	**2.5**	**5.6%**	**0.5**
		Black crappie	0.1		0.1		--		--		--		0.2		--		0.3		--		--	
		Flathead catfish	0.2		0.8		0.3		0.1		--		0.2		--		0.8		0.2		0.1	
		Largemouth bass	8.0		4.1		2.6		2.6		4.6		3.2		6.6		2.7		10.8		4.7	
		Rock bass	--		--		--		--		0.1		0.1		0.1		--		0.2		--	
		Skipjack herring	--		--		--		--		--		0.1		--		--		--		--	
		Smallmouth bass	0.5		0.2		0.9		0.1		0.8		0.3		0.8		0.4		0.8		0.5	
		Spotted bass	1.5		0.8		1.2		0.1		0.4		--		0.1		0.1		0.2		0.1	
		Spotted gar	0.2		--		0.3		0.1		--		0.1		--		0.1		--		0.1	
		Striped bass	--		--		--		--		--		0.1		0.3		--		--		0.1	
		White bass	--		0.1		--		--		0.0		0.5		0.2		--		0.1		--	
		White crappie	0.2		0.2		--		--		--		0.2		--		--		0.4		--	
		Yellow bass	--		0.1		--		--		--		--		--		--		0.1		--	
	Gill Netting		**42.0%**	**1.5**	**52.5%**	**2.5**	**48.6%**	**1.5**	**46.8%**	**1.5**	**37.9%**	**1.5**	**44.6%**	**1.5**	**52.0%**	**1.5**	**46.1%**	**1.5**	**28.2%**	**1.5**	**34.0%**	**1.5**
		Black crappie	4.8		--		--		2.6		2.5		0.6		4.0		--		--		--	
		Flathead catfish	1.7		5.6		2.4		9.1		1.3		4.6		2.0		2.3		2.2		--	
		Striped x white bass	0.9		--		--		--		--		--		--		--		--		--	
		Largemouth bass	1.7		2.1		1.8		1.3		2.5		0.6		--		--		--		--	
		Longnose gar	--		1.4		0.6		14.3		--		0.6		--		--		--		--	
		Rock bass	--		--		--		--		--		0.6		--		--		--		2.0	
		Sauger	1.7		2.8		4.8		--		17.7		2.9		30.0		--		4.3		6.0	
		Skipjack herring	9.1		14.7		13.2		--		--		4.6		--		9.2		2.2		--	
		Smallmouth bass	--		--		--		--		--		--		--		--		--		2.0	
		Spotted bass	3.0		0.7		1.2		--		--		--		--		--		--		--	
		Spotted gar	--		0.7		0.6		--		1.3		--		--		--		--		--	
		Striped bass	6.1		6.3		10.8		10.4		3.8		5.8		4.0		9.2		6.5		2.0	
		Walleye	--		--		--		1.3		--		--		--		2.3		6.5		6.0	
		White bass	2.2		3.5		3.6		1.3		2.5		5.2		8.0		0.8		--		--	
		White crappie	2.6		--		1.2		--		--		0.6		2.0		--		2.2		--	
		Yellow bass	8.2		14.7		8.4		6.5		6.3		18.5		2.0		22.3		4.3		16.0	
10. Percent omnivores	Electrofishing		**25.2%**	**1.5**	**27.2%**	**1.5**	**32.2%**	**1.5**	**24.2%**	**1.5**	**9.5%**	**2.5**	**20.1%**	**2.5**	**29.4%**	**1.5**	**33.2%**	**1.5**	**16.4%**	**2.5**	**11.0%**	**2.5**
		Black buffalo	--		--		0.2		--		--		0.1		--		0.3		0.2		--	
		Blue catfish	--		--		--		--		--		--		--		--		0.1		--	
		Bluntnose minnow	0.2		0.6		0.3		0.1		1.3		3.9		0.1		2.3		2.3		2.5	
		Channel catfish	0.2		1.6		0.5		0.5		0.5		0.8		1.0		0.5		0.7		0.5	
		Common carp	1.6		1.9		1.8		0.6		0.6		0.4		2.0		1.0		0.9		1.6	
		Gizzard shad	21.6		21.2		29.4		22.4		6.9		14.5		25.8		27.3		11.9		6.1	
		Golden shiner	0.8		0.6		--		--		0.1		--		--		--		--		--	
		Quillback	--		--		--		--		--		--		--		--		0.1		--	

Table 2. (CRM 1.5, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**
10. Percent omnivores (continued)	Electrofishing	River carpsucker	0.1		--		--		--		--		--		--		--		--		--	
		Smallmouth buffalo	0.7		1.3		--		0.6		0.1		0.2		0.5		1.8		0.2		0.3	
		Striped shiner	--		--		--		--		--		0.2		--		--		--		--	
	Gill Netting		**45.1%**	**1.5**	**37.1%**	**1.5**	**35.4%**	**1.5**	**39.0%**	**1.5**	**48.1%**	**0.5**	**37.5%**	**1.5**	**34.0%**	**1.5**	**47.0%**	**0.5**	**50.0%**	**0.5**	**48.0%**	**0.5**
		Black buffalo	1.3		--		--		--		--		0.6		--		--		--		--	
		Blue catfish	13.9		10.5		8.4		9.1		21.5		9.8		26.0		16.9		26.1		34.0	
		Channel catfish	7.4		4.9		3.0		5.2		8.9		4.6		--		3.1		2.2		2.0	
		Common carp	0.4		3.5		3.0		2.6		2.5		4.0		2.0		3.1		6.5		2.0	
		Gizzard shad	16.9		14.7		19.2		14.3		12.7		17.3		4.0		18.5		13.0		4.0	
		Smallmouth buffalo	5.2		3.5		1.8		7.8		2.5		1.2		2.0		5.4		2.2		6.0	
11. Average number per run	Electrofishing		**77.9**	**0.5**	**54.9**	**0.5**	**64.7**	**0.5**	**52.1**	**0.5**	**142.1**	**1.5**	**115.8**	**1.5**	**59.2**	**0.5**	**64.5**	**0.5**	**76.9**	**0.5**	**99.1**	**0.5**
	Gill Netting		**23.1**	**1.5**	**14.3**	**1.5**	**16.7**	**1.5**	**7.7**	**0.5**	**7.9**	**0.5**	**17.3**	**1.5**	**5**	**0.5**	**13**	**1.5**	**4.6**	**0.5**	**5**	**0.5**
12. Percent anomalies	Electrofishing		**0.9**	**2.5**	**0.1**	**2.5**	**0.3**	**2.5**	**0.1**	**2.5**	**4.1**	**1.5**	**1.2**	**2.5**	**3.4**	**1.5**	**0.3**	**2.5**	**0.8**	**2.5**	**0.9**	**2.5**
	Gill Netting		**0.4**	**2.5**	**0**	**2.5**	**1.8**	**2.5**	**0**	**2.5**	**2.5**	**1.5**	**0.6**	**2.5**	**2**	**1.5**	**0.8**	**2.5**	**4.3**	**1.5**	**0**	**2.5**
RFAI Score				**42**		**44**		**41**		**34**		**36**		**42**		**36**		**40**		**41**		**41**

Table 3. Individual metric scores, contributing species, and overall RFAI scores for CRM 4.4, 2001-2013.

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
1. Number of indigenous species (Tables 5 and 6)	Combined	(see Table 8)	**32**	**5**	**34**	**5**	**30**	**5**	**28**	**3**	**27**	**3**	**33**	**5**	**27**	**3**	**31**	**5**	**27**	**3**	**31**	**5**
2. Number of centrarchid species (less Micropterus)	Combined		**7**	**5**	**7**	**5**	**6**	**5**	**4**	**3**	**7**	**5**	**7**	**5**	**5**	**5**	**6**	**5**	**6**	**5**	**5**	**5**
		Black crappie	5		2		3		--		3		3		--		16		2		--	
		Bluegill	483		298		288		305		539		764		157		443		106		488	
		Green sunfish	4		3		14		1		25		49		42		7		36		8	
		Longear sunfish	10		25		13		40		112		31		7		13		13		16	
		Redear sunfish	74		50		67		35		73		89		51		40		34		38	
		Warmouth	1		3		--		--		3		3		2		--		1		1	
		White crappie	1		1		3		--		2		3		--		5		--		--	
3. Number of benthic invertivore species	Combined		**5**	**3**	**5**	**3**	**7**	**3**	**5**	**3**	**3**	**1**	**5**	**3**	**4**	**3**	**4**	**3**	**4**	**3**	**7**	**3**
		Black redhorse	1		1		2		1		2		3		4		--		1		2	
		Freshwater drum	6		17		12		10		8		18		3		22		2		8	
		Golden redhorse	1		2		5		2		--		1		--		1		2		7	
		Logperch	1		2		4		1		--		7		--		3		--		1	
		Northern hog sucker	--		--		--		--		--		--		1		--		--		2	
		River redhorse	--		--		1		--		--		--		--		--		--		--	
		Silver redhorse	--		--		1		--		--		--		--		--		--		1	
		Spotted sucker	17		64		80		15		15		16		25		32		19		23	
4. Number of intolerant species	Combined		**6**	**5**	**7**	**5**	**7**	**5**	**5**	**5**	**6**	**5**	**6**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**7**	**5**
		Black redhorse	1		1		2		1		2		3		4		--		1		2	
		Brook silverside	14		44		18		14		40		13		--		--		--		5	
		Longear sunfish	10		25		13		40		112		31		7		13		13		16	
		Mooneye	--		1		--		--		--		--		--		--		--		--	
		Northern hog sucker	--		--		--		--		--		--		1		--		--		2	
		River redhorse	--		--		1		--		--		--		--		--		--		--	
		Rock bass	--		--		--		--		3		--		--		3		--		--	
		Skipjack herring	20		18		12		--		--		4		--		12		3		5	
		Smallmouth bass	6		4		29		5		14		16		10		5		7		17	
		Spotted sucker	17		64		80		15		15		16		25		32		19		23	
5. Percent tolerant individuals	Electrofishing		**81.7%**	**0.5**	**72.2%**	**0.5**	**77.0%**	**0.5**	**77.7%**	**0.5**	**74.4%**	**0.5**	**67.2%**	**0.5**	**71.5%**	**0.5**	**71.7%**	**0.5**	**77.6%**	**0.5**	**81.6%**	**0.5**
		Bluegill	52.2		32.8		27.0		44.5		36.4		45.4		30.9		44.7		31.1		46.0	
		Bluntnose minnow	0.2		0.2		--		0.3		7.0		0.6		--		0.4		0.3		0.2	
		Common carp	3.8		1.6		1.9		1.2		1.0		1.0		1.8		1.9		3.3		2.5	
		Gizzard shad	9.5		24.8		36.1		24.6		6.4		9.6		18.2		17.3		16.2		0.1	
		Golden shiner	0.1		1.0		--		0.1		--		--		--		--		--		--	
		Green sunfish	0.4		0.3		1.3		0.1		1.7		2.9		8.4		0.7		10.8		0.8	
		Largemouth bass	9.2		6.9		7.4		4.0		6.4		4.7		10.8		3.6		14.4		5.1	
		Redbreast sunfish	0.3		--		--		--		0.1		0.4		0.4		--		0.3		0.1	
		Spotfin shiner	6.0		4.6		3.1		2.9		15.3		2.4		1.0		2.6		1.2		26.8	
		White crappie	--		--		0.2		--		0.1		0.2		--		0.5		--		--	

Table 3. (CRM 4.4, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
5. Percent tolerant individuals (continued)	Gill Netting		**22.6%**	**1.5**	**33.4%**	**0.5**	**22.9%**	**1.5**	**29.3%**	**1.5**	**10.4%**	**2.5**	**17.8%**	**1.5**	**8.4%**	**2.5**	**7.7%**	**2.5**	**16.8%**	**1.5**	**3.5%**	**2.5**
		Bluegill	1.4		1.4		--		1.1		1.9		--		6.3		0.7		2.6		--	
		Common carp	3.8		3.7		6.4		5.4		3.8		2.0		--		1.4		1.3		--	
		Gizzard shad	16.4		26.4		11.0		21.7		1.9		15.8		--		5.6		10.3		3.5	
		Largemouth bass	0.5		0.9		3.7		--		1.9		--		--		--		2.6		--	
		Longnose gar	--		0.5		--		1.1		--		--		2.1		--		--		--	
		River carpsucker	--		--		0.9		--		--		--		--		--		--		--	
		White crappie	0.5		0.5		0.9		--		0.9		--		--		--		--		--	
6. Percent dominance by one species	Electrofishing	Bluegill	**52.2%**	**0.5**	**32.8%**	**1.5**			**44.5%**	**0.5**	**36.4%**	**1.5**	**45.4%**	**0.5**	**30.9%**	**1.5**	**44.7%**	**0.5**	**31.1%**	**1.5**	**46.0%**	**0.5**
		Gizzard shad	--	--	--	--	**36.1%**	**1.5**	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Gill Netting	Blue catfish	--	--	--	--	--	--	--	--	--	--	--	--	**22.9%**	**1.5**	--	--	--	--	--	--
		Gizzard shad	--	--	**26.4%**	**1.5**	**11.0%**	**2.5**	**21.7%**	**1.5**	--	--	--	--	--	--	--	--	--	--	--	--
		Lake sturgeon	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**14.0%**	**1.5**
		Striped bass	--	--	--	--	--	--	--	--			**21.8%**	**1.5**	--	--	--	--	--	--	--	--
		Yellow bass	**16.9%**	**1.5**	--	--	--	--	--	--	**25.5%**	**1.5**	--	--	--	--	**31.0%**	**0.5**	**16.7%**	**1.5**	**14.0%**	**1.5**
7. Percent non-indigenous species	Electrofishing		**4.6%**	**1.5**	**1.8%**	**2.5**	**2.9%**	**2.5**	**4.8%**	**1.5**	**7.4%**	**0.5**	**22.7%**	**0.5**	**5.2%**	**1.5**	**9.5%**	**0.5**	**3.9%**	**1.5**	**8.9%**	**0.5**
		Common carp	3.8		1.6		1.9		1.2		1.0		1.0		1.8		1.9		3.3		2.5	
		Mississippi silverside	--		--		0.9		3.5		6.2		21.1		0.2		7.5		0.3		5.9	
		Muskellunge	--		--		--		--		--		--		0.2		--		--		--	
		Redbreast sunfish	0.3		--		--		--		0.1		0.4		0.4		--		0.3		0.1	
		Yellow perch	0.5		0.2		0.1		0.1		0.1		0.2		2.6		0.1		--		0.4	
	Gill Netting		**4.7%**	**2.5**	**12.0%**	**0.5**	**16.5%**	**0.5**	**15.2%**	**0.5**	**7.6%**	**1.5**	**23.8%**	**0.5**	**0.0%**	**2.5**	**4.9%**	**2.5**	**2.6%**	**2.5**	**7.0%**	**1.5**
		Common carp	3.8		3.7		6.4		5.4		3.8		2.0		--		1.4		1.3		--	
		Striped x white bass	--		--		0.9		--		--		--		--		--		--		--	
		Striped bass	0.9		8.3		9.2		9.8		3.8		21.8		--		3.5		1.3		7.0	
8. Number of top carnivore species	Combined		**10**	**5**	**12**	**5**	**10**	**5**	**9**	**5**	**10**	**5**	**12**	**5**	**9**	**5**	**13**	**5**	**10**	**5**	**8**	**5**
		Black crappie	5		2		3		--		3		3		--		16		2		--	
		Flathead catfish	4		2		2		3		2		3		1		3		2		--	
		Largemouth bass	86		64		97		27		106		90		60		54		65		70	
		Longnose gar	--		1		--		1		--		--		1		--		--		--	
		Rock bass	--		--		--		--		3		--		--		3		--		--	
		Sauger	9		4		6		5		12		5		6		5		4		4	
		Skipjack herring	20		18		12		--		--		4		--		12		3		5	
		Smallmouth bass	6		4		29		5		14		16		10		5		7		17	
		Spotted bass	19		18		12		4		7		2		3		8		2		2	
		Spotted gar	--		5		--		--		--		1		--		3		1		1	
		Walleye	--		--		--		2		--		3		2		8		5		5	
		White bass	17		6		2		3		2		12		5		2		--		--	
		White crappie	1		1		3		--		2		3		--		5		--		--	
		Yellow bass	38		32		9		8		28		5		20		44		13		8	

Table 3. (CRM 4.4, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
9. Percent top carnivores	Electrofishing		**12.2%**	**2.5**	**9.9%**	**1.5**	**11.1%**	**2.5**	**5.3%**	**0.5**	**8.1%**	**1.5**	**6.4%**	**1.5**	**14.6%**	**2.5**	**7.3%**	**1.5**	**16.2%**	**2.5**	**6.5%**	**1.5**
		Black crappie	0.2		0.2		0.3		--		0.1		0.2		--		1.6		--		--	
		Flathead catfish	0.1		0.1		0.1		0.1		--		--		--		0.2		--		--	
		Hybrid bass	--		--		--		--		--		0.1		--		--		--		--	
		Largemouth bass	9.2		6.9		7.4		4.0		6.4		4.7		10.8		3.6		14.4		5.1	
		Muskellunge	--		--		--		--		--		--		0.2		--		--		--	
		Rock bass	--		--		--		--		0.2		--		--		0.1		--		--	
		Skipjack herring	--		0.2		--		--		--		--		--		--		--		--	
		Smallmouth bass	0.7		0.4		2.0		0.7		0.9		0.5		1.2		0.4		0.9		1.3	
		Spotted bass	1.6		1.3		1.0		0.4		0.3		0.1		0.2		0.4		0.6		--	
		Spotted gar	--		0.6		--		--		--		0.1		--		0.3		0.3		0.1	
		White bass	0.2		--		--		--		--		0.5		0.2		0.2		--		--	
		White crappie	--		--		0.2		--		0.1		0.2		--		0.5		--		--	
		Yellow bass	0.2		0.2		0.1		0.1		0.1		--		2.0		--		--		--	
	Gill Netting		**44.1%**	**1.5**	**39.5%**	**1.5**	**42.1%**	**1.5**	**32.7%**	**1.5**	**49.1%**	**1.5**	**45.8%**	**1.5**	**54.2%**	**2.5**	**54.2%**	**2.5**	**42.4%**	**1.5**	**49.2%**	**1.5**
		Black crappie	1.4		--		--		--		1.9		--		--		--		2.6		--	
		Flathead catfish	1.4		0.5		0.9		2.2		1.9		3.0		2.1		0.7		2.6		--	
		Striped x white bass			--		0.9		--		--		--		--		--		--		--	
		Largemouth bass	0.5		0.9		3.7		--		1.9		--		--		--		2.6		--	
		Hybrid black bass	--		--		--		--		--		--		--		--		--		1.8	
		Longnose gar	--		0.5		--		1.1		--		--		2.1		--		--		--	
		Rock bass	--		--		--		--		--		--		--		1.4		--		--	
		Sauger	4.2		1.9		5.5		5.4		11.3		5.0		12.5		3.5		5.1		7.0	
		Skipjack herring	9.4		7.4		11.0		--		--		4.0		--		8.5		3.8		8.8	
		Smallmouth bass	--		--		--		--		--		--		4.2		--		1.3			
		Spotted bass	1.9		2.8		0.9		1.1		--		--		--		--		--		1.8	
		Striped bass	0.9		8.3		9.2		9.8		3.8		21.8		--		3.5		1.3		7.0	
		Walleye	--		--		--		2.2		--		3.0		4.2		5.6		6.4		8.8	
		White bass	7.0		2.8		1.8		3.3		1.9		4.0		8.3		--		---		--	
		White crappie	0.5		0.5		0.9		--		0.9		--		--		--		--		--	
		Yellow bass	16.9		13.9		7.3		7.6		25.5		5.0		20.8		31.0		16.7		14.0	
10. Percent omnivores	Electrofishing		**15.3%**	**2.5**	**30.5%**	**1.5**	**39.1%**	**1.5**	**28.0%**	**1.5**	**15.6%**	**2.5**	**11.6%**	**2.5**	**21.8%**	**2.5**	**21.9%**	**1.5**	**21.6%**	**2.5**	**4.1%**	**2.5**
		Black buffalo	0.1		0.3		0.3		--		--		0.1		0.4		0.1		--		0.1	
		Blue catfish	--		--		--		--		--		--		0.2		--		--		--	
		Bluntnose minnow	0.2		0.2		--		0.3		7.0		0.6		--		0.4		0.3		0.2	
		Channel catfish	0.8		0.6		0.5		1.5		1.0		0.2		0.8		0.9		1.8		0.8	
		Common carp	3.8		1.6		1.9		1.2		1.0		1.0		1.8		1.9		3.3		2.5	
		Gizzard shad	9.5		24.8		36.1		24.6		6.4		9.6		18.2		17.3		16.2		0.1	
		Golden shiner	0.1		1.0		--		0.1		--		--		--		--		--		--	
		Smallmouth buffalo	0.8		2.0		0.3		0.3		0.2		0.1		0.4		1.3		--		0.4	

Table 3. (CRM 4.4, continued)

Metric	Gear	Common Name	2001 Autumn		2003 Autumn		2005 Autumn		2007 Autumn		2009 Autumn		2010 Autumn		2011 Autumn		2012 Summer		2012 Autumn		2013 Autumn	
			Obs	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**	**Obs**	**Sc**
10. Percent omnivores (continued)	Gill Netting		**44.5%**	**1.5**	**51.9%**	**0.5**	**33.9%**	**1.5**	**45.6%**	**1.5**	**36.8%**	**1.5**	**35.7%**	**1.5**	**27.1%**	**1.5**	**30.2%**	**1.5**	**34.8%**	**1.5**	**15.8%**	**2.5**
		Black buffalo	0.9		--		--		--		--		--		--		--		--		--	
		Blue catfish	16.4		12.0		5.5		14.1		19.8		10.9		22.9		14.8		10.3		10.5	
		Channel catfish	7.0		4.2		4.6		3.3		10.4		3.0		4.2		6.3		10.3		1.8	
		Common carp	3.8		3.7		6.4		5.4		3.8		2.0		--		1.4		1.3		--	
		Gizzard shad	16.4		26.4		11.0		21.7		1.9		15.8		--		5.6		10.3		3.5	
		Quillback	--		0.5		--		--		--		--		--		--		--		--	
		River carpsucker	--		--		0.9		--		--		--		--		--		--		--	
		Smallmouth buffalo	--		5.1		5.5		1.1		0.9		4.0		--		2.1		2.6		--	
11. Average number per run	Electrofishing		**61.3**	**0.5**	**60**	**0.5**	**71**	**0.5**	**45.5**	**0.5**	**98.3**	**0.5**	**112.2**	**1.5**	**33.3**	**0.5**	**65.9**	**0.5**	**22.3**	**0.5**	**70.7**	**0.5**
	Gill Netting		**21.3**	**1.5**	**21.6**	**1.5**	**10.9**	**0.5**	**9.2**	**0.5**	**10.6**	**0.5**	**10.1**	**0.5**	**4.8**	**0.5**	**14.2**	**1.5**	**7.8**	**0.5**	**5.7**	**0.5**
12. Percent anomalies	Electrofishing		**1.3**	**2.5**	**0.2**	**2.5**	**1.2**	**2.5**	**0.4**	**2.5**	**2.8**	**1.5**	**1.1**	**2.5**	**8.6**	**0.5**	**0.2**	**2.5**	**3.6**	**1.5**	**0.6**	**2.5**
	Gill Netting		**2.3**	**1.5**	**0**	**2.5**	**2.8**	**1.5**	**0**	**2.5**	**2.8**	**1.5**	**0**	**2.5**	**0**	**2.5**	**0.7**	**2.5**	**0**	**2.5**	**1.8**	**2.5**
RFAI Score				**45**		**42**		**44**		**36**		**38**		**42**		**44**		**44**		**43**		**44**

Table 4. Individual metric scores, contributing species, and overall RFAI scores for ERM 2.5, 2009-2013.

Metric	Gear	Common Name	2009 Autumn		2010 Autumn		2011 Autumn		2012 Autumn		2013 Autumn	
			Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc	Obs	Sc
1. Number of indigenous species	Combined	(see Table 9)	**31**	**5**	**34**	**5**	**27**	**3**	**28**	**3**	**36**	**5**
2. Number of centrarchid species (less Micropterus)	Combined		**7**	**5**	**7**	**5**	**7**	**5**	**7**	**5**	**7**	**5**
		Black crappie	3		13		5		21		20	
		Bluegill	515		330		1012		1674		867	
		Green sunfish	9		43		24		42		7	
		Longear sunfish	38		6		6		25		8	
		Redear sunfish	132		56		64		96		89	
		Warmouth	7		7		8		20		16	
		White crappie	2		4		7		11		9	
3. Number of benthic invertivore species	Combined		**5**	**3**	**5**	**3**	**4**	**3**	**4**	**3**	**6**	**3**
		Black redhorse	1		1		--		3		4	
		Freshwater drum	6		6		1		8		7	
		Golden redhorse	2		2		4		--		2	
		Logperch	--		12		--		--		23	
		Northern hog sucker	1		--		1		3		3	
		Spotted sucker	19		28		17		29		47	
4. Number of intolerant species	Combined		**6**	**5**	**6**	**5**	**5**	**5**	**7**	**5**	**7**	**5**
		Black redhorse	1		1		--		3		4	
		Brook silverside	56		29		8		39		92	
		Longear sunfish	38		6		6		25		8	
		Northern hog sucker	1		--		1		3		3	
		Skipjack herring	--		25		--		11		11	
		Smallmouth bass	2		1		1		4		1	
		Spotted sucker	19		28		17		29		47	
5. Percent tolerant individuals	Electrofishing		**79.1%**	**0.5**	**78.5%**	**0.5**	**90.0%**	**0.5**	**89.6%**	**0.5**	**78.4%**	**0.5**
		Bluegill	39.5		21.4		69.2		74.3		53.3	
		Bluntnose minnow	3.2		1.2		1.8		1.0		0.1	
		Common carp	1.0		1.0		0.4		0.4		0.7	
		Gizzard shad	9.0		41.1		7.6		1.2		1.1	
		Golden shiner	--		--		--		--		0.1	
		Green sunfish	0.7		2.8		1.6		1.9		0.4	
		Largemouth bass	11.7		7.7		8.6		7.5		7.1	
		Redbreast sunfish	0.2		0.1		--		0.2		--	
		Spotfin shiner	13.8		3.1		0.3		2.7		15.0	
		White crappie	--		0.1		0.5		0.4		0.6	
	Gill Netting		**7.4%**	**2.5**	**15.4%**	**2.5**	**4.9%**	**2.5**	**11.4%**	**2.5**	**21.3%**	**1.5**
		Bluegill	0.9		0.7		--		2.4		--	
		Common carp	0.9		1.5		3.3		0.6		7.4	
		Gizzard shad	2.8		11.0		--		5.4		12.8	
		Largemouth bass	0.9		0.7		1.6		1.2		--	
		River carpsucker	--		--		--		--		1.1	
		White crappie	1.9		1.5		--		1.8		--	
6. Percent dominance by one species	Electrofishing	Bluegill	**39.5%**	**1.5**	--	--	**69.2%**	**0.5**	**74.3%**	**0.5**	**53.3%**	**0.5**
		Gizzard shad	--	--	**41.1%**	**0.5**	--	--	--	--	--	--
	Gill Netting	Blue catfish	--	--	--	--	**29.5%**	**0.5**	--	--	**20.2%**	**1.5**
		Channel catfish	**47.7%**	**0.5**	--	--	--	--	--	--	--	--
		Skipjack herring	--	--	**18.4%**	**1.5**	--	--	--	--	--	--
		Yellow bass	--	--	--	--	--	--	**23.8%**	**1.5**	--	--

Table 4. (ERM 2.5, continued)

Metric	Gear	Common Name	2009 Autumn Obs	2009 Autumn Sc	2010 Autumn Obs	2010 Autumn Sc	2011 Autumn Obs	2011 Autumn Sc	2012 Autumn Obs	2012 Autumn Sc	2013 Autumn Obs	2013 Autumn Sc
7. Percent non-indigenous species	Electrofishing		**1.6%**	**2.5**	**9.3%**	**0.5**	**1.1%**	**2.5**	**0.7%**	**2.5**	**1.5%**	**2.5**
		Common carp	1.0		1.0		0.4		0.4		0.7	
		Grass carp	--		0.1		--		--		--	
		Mississippi silverside	--		7.7		0.6		0.1		0.2	
		Redbreast sunfish	0.2		0.1		--		0.2		--	
		Striped bass	--		0.1		--		--		--	
		Yellow perch	0.4		0.3		0.1		0.0		0.6	
	Gill Netting		**1.8%**	**2.5**	**4.4%**	**2.5**	**3.3%**	**2.5**	**3.6%**	**2.5**	**13.8%**	**0.5**
		Common carp	0.9		1.5		3.3		0.6		7.4	
		Muskellunge	--		--		--		0.6		--	
		Striped bass	0.9		2.9		--		2.4		6.4	
8. Number of top carnivore species	Combined		**10**	**5**	**12**	**5**	**9**	**5**	**12**	**5**	**12**	**5**
		Black crappie	3		13		5		21		20	
		Flathead catfish	3		6		3		4		2	
		Largemouth bass	180		125		144		190		134	
		Sauger	1		4		10		2		3	
		Skipjack herring	--		25		--		11		11	
		Smallmouth bass	2		1		1		4		1	
		Spotted bass	8		11		--		1		17	
		Spotted gar	11		2		--		1		4	
		Walleye	--		1		4		7		2	
		White bass	1		8		1		13		2	
		White crappie	2		4		7		11		9	
		Yellow bass	1		22		1		41		8	
9. Percent top carnivores	Electrofishing		**12.4%**	**2.5**	**9.7%**	**1.5**	**9.6%**	**1.5**	**8.1%**	**1.5**	**9.6%**	**1.5**
		Black crappie	--		0.8		0.3		0.1		1.0	
		Flathead catfish	--		0.2		--		--		--	
		Largemouth bass	11.7		7.7		8.6		7.5		7.1	
		Skipjack herring	--		--						0.1	
		Smallmouth bass	0.2		0.1		0.1		0.1		0.1	
		Spotted bass	0.5		0.4		--		--		0.6	
		Spotted gar	--		0.1		--		--		0.1	
		Striped bass	--		0.1		--		--		--	
		White bass	--		0.1		--		--		--	
		White crappie	--		0.1		0.5		0.4		0.6	
		Yellow bass	--		0.1		0.1		0.0		--	
	Gill Netting		**22.3%**	**0.5**	**51.9%**	**2.5**	**32.7%**	**1.5**	**63.7%**	**2.5**	**40.3%**	**1.5**
		Black crappie	2.8		0.7		1.6		10.7		3.2	
		Flathead catfish	2.8		2.2		4.9		2.4		2.1	
		Largemouth bass	0.9		0.7		1.6		1.2		--	
		Muskellunge	--		--		--		0.6		--	
		Sauger	0.9		2.9		16.4		1.2		3.2	
		Skipjack herring	--		18.4		--		6.5		10.6	
		Spotted bass	--		0.7		--		0.6		--	
		Spotted gar	10.3		0.7		--		0.6		2.1	
		Striped bass	0.9		2.9		--		2.4		6.4	
		Walleye	--		0.7		6.6		4.2		2.1	
		White bass	0.9		5.1		1.6		7.7		2.1	
		White crappie	1.9		1.5		--		1.8		--	
		Yellow bass	0.9		15.4		--		23.8		8.5	

Table 4. (ERM 2.5, continued)

10. Percent omnivores	Electrofishing		**13.6%**	**2.5**	**44.4%**	**0.5**	**10.0%**	**2.5**	**3.1%**	**2.5**	**3.2%**	**2.5**
		Black buffalo	0.1		0.2		0.1		--		0. 4	
		Bluntnose minnow	3.2		1.2		1.8		1.0		0. 1	
		Channel catfish	0.2		0.7		0.1		0.4		0. 3	
		Common carp	1.0		1.0		0.4		0.4		0. 7	
		Gizzard shad	9.0		41.1		7.6		1.2		1.1	
		Golden Shiner	--		--		--		--		0.1	
		Smallmouth buffalo	0.1		0.2		--		0.1		0.5	
	Gill Netting		**65.3%**	**0.5**	**42.7%**	**1.5**	**45.9%**	**1.5**	**28.0%**	**1.5**	**50.1%**	**0.5**
		Black buffalo	0.9		--		--		--		--	
		Blue catfish	12.1		11.8		29.5		12.5		20.2	
		Channel catfish	47.7		13.2		13.1		7.1		4.3	
		Common carp	0.9		1.5		3.3		0.6		7.4	
		Gizzard shad	2.8		11.0		--		5.4		12.8	
		Quillback	0.9		1.5		--		--		--	
		River carpsucker	--		--		--		--		1.1	
		Smallmouth buffalo	--		3.7		--		2.4		4.3	
11. Average number per run	Electrofishing		**86.5**	**0.5**	**102.4**	**0.5**	**97.5**	**0.5**	**149.9**	**1.5**	**108.5**	**1.5**
	Gill Netting		**10.7**	**0.5**	**13.6**	**1.5**	**6.1**	**0.5**	**16.8**	**1.5**	**9.4**	**0.5**
12. Percent anomalies	Electrofishing		**4.3**	**1.5**	**1.6**	**2.5**	**4.5**	**1.5**	**2.1**	**1.5**	**0.7**	**2.5**
	Gill Netting		**0.9**	**2.5**	**0**	**2.5**	**0**	**2.5**	**0.6**	**2.5**	**0**	**2.5**
RFAI Score				**44**		**44**		**42**		**46**		**43**

Table 5. Scoring criteria for forebay, transition, and inflow sections of upper mainstream reservoirs in the Tennessee River Valley. Upper mainstream reservoirs include Chickamauga, Fort Loudoun, Melton Hill, Nickajack, Tellico, and Watts Bar.

		Scoring Criteria								
		Forebay			Transition			Inflow		
Metric	Gear	1	3	5	1	3	5	1	3	5
1. Number of indigenous species	Combined	<14	14-27	>27	<15	15-29	>29	<14	14-27	>27
2. Number of Centrarchid species	Combined	<2	2-4	>4	<2	2-4	>4	<3	3-4	>4
3. Number of benthic invertivores species	Combined	<4	4-7	>7	<4	4-7	>7	<3	3-6	>6
4. Number of intolerant species	Combined	<2	2-4	>4	<2	2-4	>4	<2	2-4	>4
5. Percent tolerant individuals	Electrofishing	>62%	31-62%	<31%	>62%	31-62%	<31%	>58%	29-58%	<29%
	Gill netting	>28%	14-28%	<14%	>32%	16-32%	<16%			
6. Percent dominance by one species	Electrofishing	>50%	25-50%	<25%	>40%	20-40%	<20%	>46%	23-46%	<23%
	Gill netting	>29%	15-29%	<15%	>28%	14-28%	<14%			
7. Percent non-indigenous species	Electrofishing	>4%	2-4%	<2%	>6%	3-6%	<3%	>17%	8-17%	<8%
	Gill netting	>16%	8-16%	<8%	>9%	5-9%	<5%			
8. Number of top carnivore species	Combined	<4	4-7	>7	<4	4-7	>7	<3	3-6	>6
9. Percent top carnivores	Electrofishing	<5%	5-10%	>10%	<6%	6-11%	>11%	<11%	11-22%	>22%
	Gill netting	<25%	25-50%	>50%	<26%	26-52%	>52%			
10. Percent omnivores	Electrofishing	>49%	24-49%	<24%	>44%	22-44%	<22%	>55%	27-55%	<27%
	Gill netting	>34%	17-34%	<17%	>46%	23-46%	<23%			
11. Average number per run	Electrofishing	<121	121-241	>241	<105	105-210	>210	<51	51-102	>102
	Gill netting	<12	12-24	>24	<12	12-24	>24			
12. Percent anomalies	Electrofishing	>5%	2-5%	<2%	>5%	2-5%	<2%	>5%	2-5%	<2%
	Gill netting	>5%	2-5%	<2%	>5%	2-5%	<2%			

Table 6. Total number of individuals collected of each species in RFAI electrofishing and gill netting samples combined: 2001-2013.

Common Name	IND	CRM 1.5											CRM 4.4											ERM 2.5				
		2001 A	2003 A	2005 A	2007 A	2009 A	2010 A	2011 A	2012 Su	2012 A	2013 A		2001 A	2003 A	2005 A	2007 A	2009 A	2010 A	2011 A	2012 Su	2012 A	2013 A		2009 A	2010 A	2011 A	2012 A	2013 A
Paddlefish	X	1	1	.	1*	.	1	.	.	.	.		.	.	.	.	.	1	.	.	.	.		.	.	.	.	.
Lake sturgeon	X	.	.	.	.	.	1	1	1	4	4		.	.	.	.	.	1	1	3	1	8		.	.	1	.	.
Longnose gar	X	.	2	1	11	.	1	.	.	.	.		.	1	.	1	.	.	1	.	.	.		.	.	.	.	.
Spotted gar	X	2	1	4	1	1	1	.	1	.	1		.	5	.	.	.	1	.	3	1	1		11	2	.	1	4
Skipjack herring	X	21	21	22	.	.	10	.	16	1	.		20	18	12	.	.	4	.	15	3	5		.	25	.	11	11
Gizzard shad	X	292	196	317	186	157	282	231	289	143	93		122	280	396	188	96	178	91	179	62	3		120	646	111	36	30
Threadfin shad	X	3	1	3	.	1	16	4	4	7	2		2	2	.	5	4	.	11	46	5	7		2	12	27	.	2
Mooneye	X	.	1	4	.	.	.	.	.	.	.		.	1	.	.	.	.	.	.	.	.		.	.	.	.	.
Common carp		20	21	22	7	15	14	19	16	13	25		43	22	27	13	19	19	9	21	12	27		14	18	8	11	19
Largescale stoneroller	X	.	.	.	.	.	5	.	.	.	1		.	.	.	.	.	.	.	.	.	.		.	3	.	.	.
Golden shiner	X	9	5	.	.	3	.	.	.	.	.		1	9	.	1	.	.	.	.	.	.		.	.	.	.	1
Emerald shiner	X	44	13	.	.	.	.	.	.	.	.		11	.	9	.	.	.	.	.	.	.		.	.	.	.	.
Spotfin shiner	X	54	22	23	21	264	20	12	33	87	164		55	41	33	20	225	40	5	26	4	284		179	48	4	61	244
Striped shiner	X	.	.	.	.	.	3	.	.	.	.		.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Steelcolor shiner	X	.	.	1	.	.	.	.	.	2	4		.	.	.	.	1	.	.	.	.	.		.	.	.	.	1
Bluntnose minnow	X	2	5	3	1	28	68	1	22	27	37		2	2	.	2	103	10	.	4	1	2		41	19	27	22	2
Bullhead minnow	X	.	.	.	.	.	.	.	13	.	28		.	.	.	1	.	.	1	11	.	.		1	5	.	.	4
Northern hog sucker	X	.	.	4	.	.	.	.	.	2	1		.	.	.	.	.	.	1	.	.	2		1	.	1	3	3
River carpsucker	X	1	.	.	.	.	.	.	.	.	.		.	.	1	.	.	.	.	.	.	.		.	.	.	.	1
Quillback	X	.	.	.	.	.	.	.	.	1	.		.	1	.	.	.	.	.	.	.	.		1	2	.	.	.
Smallmouth buffalo	X	20	16	3	11	4	6	5	27	3	7		7	29	9	3	4	6	2	18	2	4		1	8	.	6	12
Black buffalo	X	3	.	2	.	.	2	.	3	2	.		3	3	3	.	.	2	2	1	.	1		2	3	2	.	6
Spotted sucker	X	14	11	18	.	15	11	52	12	30	23		17	64	73	15	15	16	25	32	19	23		19	28	17	29	47
Silver redhorse	X	.	.	.	.	.	.	.	.	.	.		.	.	1	.	.	.	.	.	.	1		.	.	.	.	.
River redhorse	X	.	.	.	.	.	.	.	.	.	.		.	.	1	.	.	.	.	.	.	.		.	.	.	.	.
Black redhorse	X	.	.	.	.	.	.	3	2	1	2		1	1	2	1	2	3	4	.	1	2		1	1	.	3	4
Golden redhorse	X	.	1	.	1	1	2	.	1	.			1	2	5	2	.	1	.	1	2	7		2	2	4	.	2
Blue catfish	X	32	15	14	7	17	17	13	24	13	17		35	26	6	13	21	11	12	22	8	6		13	16	18	21	19
Channel catfish	X	19	20	10	8	18	22	9	11	9	9		22	14	10	13	26	6	6	21	14	10		53	28	10	20	9
Flathead catfish	X	6	15	7	8	1	11	1	13	3	1		4	2	2	3	2	3	1	3	2	.		3	6	3	4	2

Table 6. (continued)

Common Name	IND	CRM 1.5										CRM 4.4										ERM 2.5				
		2001	2003	2005	2007	2009	2010	2011	2012	2012	2013	2001	2003	2005	2007	2009	2010	2011	2012	2012	2013	2009	2010	2011	2012	2013
		A	A	A	A	A	A	A	Su	A	A	A	A	A	A	A	A	A	Su	A	A	A	A	A	A	A
White bass	X	5	6	6	1	3	17	6	2	1	.	17	6	2	3	2	12	5	2	.	.	1	8	1	13	2
Yellow bass	X	19	22	14	5	5	32	1	30	3	8	38	32	9	8	28	5	20	56	13	8	1	22	1	41	8
Striped bass		14	9	18	8	3	11	5	15	3	2	2	18	10	9	4	22	.	7	1	4	1	5	.	4	6
Striped bass x white bass[1]		2	.	.	.	.	.	.		.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Redbreast sunfish		5	1	6	1	14	5	6	8	7	9	3	.	.	.	2	6	2	.	1	1	3	2	.	4	.
Green sunfish	X	11	4	36	16	43	35	30	16	22	20	4	3	14	1	25	49	42	7	36	8	9	43	24	42	7
Warmouth	X	2	.	.	.	3	.	6	2	4	1	1	3	.	.	3	3	2	.	1	1	7	7	8	20	16
Bluegill	X	540	365	330	364	970	704	319	388	545	772	483	298	288	305	539	764	157	443	106	488	514	330	1012	1674	867
Longear sunfish	X	12	16	52	106	197	71	38	37	24	28	10	25	13	40	112	31	7	13	13	16	38	6	6	25	8
Redear sunfish	X	59	51	40	47	52	107	44	55	32	52	74	50	67	35	73	89	51	40	34	38	132	56	64	96	89
Hybrid sunfish[1]		.	.	.	.	.	.	3		.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	3	.
Rock bass	X	.	.	.	.	3	3	1		2	1	.	.	.	.	3	.	.	3	.	.	.	.	.	.	.
Smallmouth bass	X	6	2	9	1	16	6	7	4	9	9	6	4	21	5	14	8	8	4	4	14	2	1	1	3	1
Spotted bass	X	25	8	14	1	8	.	1	1	2	1	19	18	12	4	4	1	1	4	2	1	7	7	.	1	9
Largemouth bass	X	98	37	28	21	101	57	59	26	125	70	86	64	83	27	96	79	54	36	50	54	153	120	127	171	116
Hybrid bass[1]		.	.	.	.	.	.	.		.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.
White crappie	X	8	2	2	.	.	4	1		6	.	1	1	3	.	2	3	.	5	.	.	2	4	7	11	9
Black crappie	X	12	1	.	2	2	4	2	3	.	.	5	2	3	.	3	3	.	16	2	.	3	13	5	21	20
Redline Darter	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Snubnose darter	X	.	.	.	.	.	.	.		.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Yellow perch		3	3	.	.	2	.	.		1	.	5	2	1	1	1	4	13	1	.	4	5	4	2	1	9
Logperch	X	5	6	2	.	.	3	.	1	2	4	1	2	4	1	.	7	.	3	.	1	.	12	.	.	23
Sauger	X	4	4	8	.	14	5	15		2	3	9	4	6	5	12	5	6	6	4	4	1	4	10	2	3
Walleye	X	.	.	.	1	.	.	.	3	3	3	.	.	.	2	.	3	2	8	5	5	.	1	4	7	2
Muskellunge		.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.
Freshwater drum	X	10	30	9	8	11	13	11	17	13	8	6	17	12	10	8	18	3	24	2	8	6	6	1	8	7
Brook silverside	X	17	34	5	11	20	21	.	1	7	6	14	44	18	14	40	13	.	.	.	5	56	29	8	39	92
Mississippi silverside		.	.	100	2	219	318	32	22	39	121	.	.	10	24	92	355	1	74	1	63	.	119	9	2	4
Chestnut lamprey	X	.	.	.	.	.	1	.		.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Grass carp		.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Total Fish Collected	---	1400	967	1137	858	2211	1910	938	1119	1200	1537	1132	1116	1167	775	1581	1784	547	1158	412	1118	1405	1672	1523	2417	1721
Total Species Richness	57	36	36	34	28	32	38	30	35	38	35	36	37	34	32	32	38	32	35	31	37	35	40	30	34	40
Indigenous Species	50	32	32	30	24	27	34	26	31	33	31	32	34	30	28	27	33	27	31	27	31	31	34	27	28	36

*IND=Indigenous; A=Autumn; Su=Summer; *=Only young-of-year collected; 1=Hybrid fish do not contribute to total species richness or number of indigenous species*

Table 7. Species collected, ecological designations, and electrofishing (EF) and gill net (GN) catch per unit effort at CRM 1.5 – Autumn 2013.

Common Name	Scientific Name	Trophic Level	Sunfish[1] Species	Indigenous Species	Tolerance	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total fish Combined	Percent Composition
Lake sturgeon	Acipenser fulvescens	IN	.	X	.	.	.		0.4	4	4	0.3%
Spotted gar	Lepisosteus oculatus	TC	.	X	.	0.07	0.27	1	.	.	1	0.1%
Gizzard shad	Dorosoma cepedianum	OM	.	X	TO	6.07	24.86	91	0.2	2	93	6.1%
Threadfin shad	Dorosoma petenense	PK	.	X	.	0.13	0.55	2	.	.	2	0.1%
Common carp	Cyprinus carpio	OM	.	.	TO	1.6	6.56	24	0.1	1	25	1.6%
Largescale stoneroller	Campostoma oligolepis	HB	.	X	.	0.07	0.27	1	.	.	1	0.1%
Spotfin shiner	Cyprinella spiloptera	IN	.	X	TO	10.93	44.81	164	.	.	164	10.7%
Steelcolor shiner	Cyprinella whipplei	IN	.	X	.	0.27	1.09	4	.	.	4	0.3%
Bluntnose minnow	Pimephales notatus	OM	.	X	TO	2.47	10.11	37	.	.	37	2.4%
Bullhead minnow	Pimephales vigilax	IN	.	X	.	1.87	7.65	28	.	.	28	1.8%
Northern hog sucker	Hypentelium nigricans	BI	.	X	IN	0.07	0.27	1	.	.	1	0.1%
Smallmouth buffalo	Ictiobus bubalus	OM	.	X	.	0.27	1.09	4	0.3	3	7	0.5%
Spotted sucker	Minytrema melanops	BI	.	X	IN	1.47	6.01	22	0.1	1	23	1.5%
Black redhorse	Moxostoma duquesnei	BI	.	X	IN	0.13	0.55	2	.	.	2	0.1%
Blue catfish	Ictalurus furcatus	OM	.	X	.	.	.		1.7	17	17	1.1%
Channel catfish	Ictalurus punctatus	OM	.	X	.	0.53	2.19	8	0.1	1	9	0.6%
Flathead catfish	Pylodictis olivaris	TC	.	X	.	0.07	0.27	1	.	.	1	0.1%
Yellow bass	Morone mississippiensis	TC	.	X	.	.	.		0.8	8	8	0.5%
Striped bass	Morone saxatilis	TC	.	.	.	0.07	0.27	1	0.1	1	2	0.1%
Redbreast sunfish	Lepomis auritus	IN	X	.	TO	0.6	2.46	9	.	.	9	0.6%
Green sunfish	Lepomis cyanellus	IN	X	X	TO	1.33	5.46	20	.	.	20	1.3%
Warmouth	Lepomis gulosus	IN	X	X	.	0.07	0.27	1	.	.	1	0.1%
Bluegill	Lepomis macrochirus	IN	X	X	TO	51.47	210.93	772	.	.	772	50.2%
Longear sunfish	Lepomis megalotis	IN	X	X	IN	1.87	7.65	28	.	.	28	1.8%
Redear sunfish	Lepomis microlophus	IN	X	X	.	3.33	13.66	50	0.2	2	52	3.4%
Rock bass	Ambloplites rupestris	TC	.	X	IN	.	.		0.1	1	1	0.1%
Smallmouth bass	Micropterus dolomieu	TC	.	X	IN	0.53	2.19	8	0.1	1	9	0.6%
Spotted bass	Micropterus punctulatus	TC	.	X	.	0.07	0.27	1	.	.	1	0.1%
Largemouth bass	Micropterus salmoides	TC	.	X	TO	4.67	19.13	70	.	.	70	4.6%
Logperch	Percina caprodes	BI	.	X	.	0.27	1.09	4	.	.	4	0.3%
Sauger	Stizostedion canadense	TC	.	X	.	.	.		0.3	3	3	0.2%
Walleye	Stizostedion vitreum	TC	.	X	.	.	.		0.3	3	3	0.2%
Freshwater drum	Aplodinotus grunniens	BI	.	X	.	0.4	1.64	6	0.2	2	8	0.5%
Brook silverside	Labidesthes sicculus	IN	.	X	IN	0.4	1.64	6	.	.	6	0.4%
Mississippi silverside	Menidia audens	IN	.	.	.	8.07	33.06	121	.	.	121	7.9%
Total						99.17	406.27	1,487	5.0	50	1,537	100%
Number of Samples						15			10			
Species Collected			6	31		29			15			

1. Centrarchid species less Micropterus

Trophic: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), parasitic (PS), planktivore (PK), top carnivore (TC); Tolerance: tolerant (TOL), intolerant (INT).

Table 8. Species collected, ecological designations, and electrofishing (EF) and gill net (GN) catch per unit effort at CRM 4.4 – Autumn 2013.

Common Name	Scientific Name	Trophic Level	Sunfish[1] Species	Indigenous Species	Tolerance	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total fish Combined	Percent Composition
Lake sturgeon	Acipenser fulvescens	IN	.	X	.	.	.	.	0.8	8	8	0.7%
Spotted gar	Lepisosteus oculatus	TC	.	X	.	0.07	0.26	1	.	.	1	0.1%
Skipjack herring	Alosa chrysochloris	TC	.	X	IN	.	.	.	0.5	5	5	0.4%
Gizzard shad	Dorosoma cepedianum	OM	.	X	TO	0.07	0.26	1	0.2	2	3	0.3%
Threadfin shad	Dorosoma petenense	PK	.	X	.	0.47	1.82	7	.	.	7	0.6%
Common carp	Cyprinus carpio	OM	.	.	TO	1.8	7.03	27	.	.	27	2.4%
Spotfin shiner	Cyprinella spiloptera	IN	.	X	TO	18.93	73.96	284	.	.	284	25.4%
Bluntnose minnow	Pimephales notatus	OM	.	X	TO	0.13	0.52	2	.	.	2	0.2%
Northern hog sucker	Hypentelium nigricans	BI	.	X	IN	0.13	0.52	2	.	.	2	0.2%
Smallmouth buffalo	Ictiobus bubalus	OM	.	X	.	0.27	1.04	4	.	.	4	0.4%
Black buffalo	Ictiobus niger	OM	.	X	.	0.07	0.26	1	.	.	1	0.1%
Spotted sucker	Minytrema melanops	BI	.	X	IN	1.53	5.99	23	.	.	23	2.1%
Silver redhorse	Moxostoma anisurum	BI	.	X	.	.	.	.	0.1	1	1	0.1%
Black redhorse	Moxostoma duquesnei	BI	.	X	IN	0.07	0.26	1	0.1	1	2	0.2%
Golden redhorse	Moxostoma erythrurum	BI	.	X	.	0.4	1.56	6	0.1	1	7	0.6%
Blue catfish	Ictalurus furcatus	OM	.	X	.	.	.	.	0.6	6	6	0.5%
Channel catfish	Ictalurus punctatus	OM	.	X	.	0.6	2.34	9	0.1	1	10	0.9%
Yellow bass	Morone mississippiensis	TC	.	X	.	.	.	.	0.8	8	8	0.7%
Striped bass	Morone saxatilis	TC	.	.	.	.	.	.	0.4	4	4	0.4%
Redbreast sunfish	Lepomis auritus	IN	X	.	TO	0.07	0.26	1	.	.	1	0.1%
Green sunfish	Lepomis cyanellus	IN	X	X	TO	0.53	2.08	8	.	.	8	0.7%
Warmouth	Lepomis gulosus	IN	X	X	.	0.07	0.26	1	.	.	1	0.1%
Bluegill	Lepomis macrochirus	IN	X	X	TO	32.53	127.08	488	.	.	488	43.6%
Longear sunfish	Lepomis megalotis	IN	X	X	IN	1.07	4.17	16	.	.	16	1.4%
Redear sunfish	Lepomis microlophus	IN	X	X	.	2.27	8.85	34	0.4	4	38	3.4%
Smallmouth bass	Micropterus dolomieu	TC	.	X	IN	0.93	3.65	14	.	.	14	1.3%
Spotted bass	Micropterus punctulatus	TC	.	X	.	.	.	.	0.1	1	1	0.1%
Largemouth bass	Micropterus salmoides	TC	.	X	TO	3.6	14.06	54	.	.	54	4.8%
Hybrid bass	Hybrid micropterus sp.	TC	.	X	.	.	.	.	0.1	1	1	0.1%
Redline darter	Etheostoma rufilineatum	SP	.	X	.	0.07	0.26	1	.	.	1	0.1%
Yellow perch	Perca flavescens	IN	.	.	.	0.27	1.04	4	.	.	4	0.4%
Logperch	Percina caprodes	BI	.	X	.	0.07	0.26	1	.	.	1	0.1%
Sauger	Stizostedion canadense	TC	.	X	.	.	.	.	0.4	4	4	0.4%
Walleye	Stizostedion vitreum	TC	.	X	.	.	.	.	0.5	5	5	0.4%
Freshwater drum	Aplodinotus grunniens	BI	.	X	.	0.2	0.78	3	0.5	5	8	0.7%
Brook silverside	Labidesthes sicculus	IN	.	X	IN	0.33	1.3	5	.	.	5	0.4%
Mississippi silverside	Menidia audens	IN	.	.	.	4.2	16.41	63	.	.	63	5.6%
Total						70.75	276.28	1,061	5.70	57	1,118	100%
Number of Samples						15			10			
Species Collected			6	31		27			16			

1. Centrarchid species less Micropterus
Trophic: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), parasitic (PS), planktivore (PK), top carnivore (TC);
Tolerance: tolerant (TOL), intolerant (INT).

Table 9. Species collected, ecological designations, and electrofishing (EF) and gill net (GN) catch per unit effort at ERM 2.5 – Autumn 2013.

Common Name	Scientific Name	Trophic Level	Sunfish[1] Species	Indigenous Species	Tolerance	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total fish Combined	Percent Composition
Spotted gar	Lepisosteus oculatus	TC	.	X	.	0.13	0.57	2	0.2	2	4	0.2%
Skipjack herring	Alosa chrysochloris	TC	.	X	IN	0.07	0.28	1	1	10	11	0.6%
Gizzard shad	Dorosoma cepedianum	OM	.	X	TO	1.2	5.13	18	1.2	12	30	1.7%
Threadfin shad	Dorosoma petenense	PK	.	X	.	0.13	0.57	2	.	.	2	0.1%
Common carp	Cyprinus carpio	OM	.	.	TO	0.8	3.42	12	0.7	7	19	1.1%
Golden shiner	Notemigonus crysoleucas	OM	.	X	TO	0.07	0.28	1	.	.	1	0.1%
Spotfin shiner	Cyprinella spiloptera	IN	.	X	TO	16.27	69.52	244	.	.	244	14.2%
Steelcolor shiner	Cyprinella whipplei	IN	.	X	.	0.07	0.28	1	.	.	1	0.1%
Bluntnose minnow	Pimephales notatus	OM	.	X	TO	0.13	0.57	2	.	.	2	0.1%
Bullhead minnow	Pimephales vigilax	IN	.	X	.	0.27	1.14	4	.	.	4	0.2%
Northern hog sucker	Hypentelium nigricans	BI	.	X	IN	0.2	0.85	3	.	.	3	0.2%
River carpsucker	Carpiodes carpio	OM	.	X	TO	.	.	.	0.1	1	1	0.1%
Smallmouth buffalo	Ictiobus bubalus	OM	.	X	.	0.53	2.28	8	0.4	4	12	0.7%
Black buffalo	Ictiobus niger	OM	.	X	.	0.4	1.71	6	.	.	6	0.3%
Spotted sucker	Minytrema melanops	BI	.	X	IN	2.93	12.54	44	0.3	3	47	2.7%
Black redhorse	Moxostoma duquesnei	BI	.	X	IN	0.27	1.14	4	.	.	4	0.2%
Golden redhorse	Moxostoma erythrurum	BI	.	X	.	0.13	0.57	2	.	.	2	0.1%
Blue catfish	Ictalurus furcatus	OM	.	X	.	.	.	.	1.9	19	19	1.1%
Channel catfish	Ictalurus punctatus	OM	.	X	.	0.33	1.42	5	0.4	4	9	0.5%
Flathead catfish	Pylodictis olivaris	TC	.	X	.	.	.	.	0.2	2	2	0.1%
White bass	Morone chrysops	TC	.	X	.	.	.	.	0.2	2	2	0.1%
Yellow bass	Morone mississippiensis	TC	.	X	.	.	.	.	0.8	8	8	0.5%
Striped bass	Morone saxatilis	TC	.	.	.	.	.	.	0.6	6	6	0.3%
Green sunfish	Lepomis cyanellus	IN	X	X	TO	0.47	1.99	7	.	.	7	0.4%
Warmouth	Lepomis gulosus	IN	X	X	.	1.07	4.56	16	.	.	16	0.9%
Bluegill	Lepomis macrochirus	IN	X	X	TO	57.8	247.01	867	.	.	867	50.4%
Longear sunfish	Lepomis megalotis	IN	X	X	IN	0.53	2.28	8	.	.	8	0.5%
Redear sunfish	Lepomis microlophus	IN	X	X	.	5.93	25.36	89	.	.	89	5.2%
Smallmouth bass	Micropterus dolomieu	TC	.	X	IN	0.07	0.28	1	.	.	1	0.1%
Spotted bass	Micropterus punctulatus	TC	.	X	.	0.6	2.56	9	.	.	9	0.5%
Largemouth bass	Micropterus salmoides	TC	.	X	TO	7.73	33.05	116	.	.	116	6.7%
White crappie	Pomoxis annularis	TC	X	X	TO	0.6	2.56	9	.	.	9	0.5%
Black crappie	Pomoxis nigromaculatus	TC	X	X	.	1.13	4.84	17	0.3	3	20	1.2%
Yellow perch	Perca flavescens	IN	.	.	.	0.6	2.56	9	.	.	9	0.5%
Logperch	Percina caprodes	BI	.	X	.	1.53	6.55	23	.	.	23	1.3%
Sauger	Stizostedion canadense	TC	.	X	.	.	.	.	0.3	3	3	0.2%
Walleye	Stizostedion vitreum	TC	.	X	.	.	.	.	0.2	2	2	0.1%

Table 9. (ERM 2.5, continued)

Common Name	Scientific Name	Trophic Level	Sunfish Species	Indigenous Species	Tolerance	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total fish Combined	Percent Composition
Freshwater drum	Aplodinotus grunniens	BI	.	X	.	0.07	0.28	1	0.6	6	7	0.4%
Brook silverside	Labidesthes sicculus	IN	.	X	IN	6.13	26.21	92	.	.	92	5.3%
Mississippi silverside	Menidia audens	IN	.	.	.	0.27	1.14	4	.	.	4	0.2%
Total						108.46	463.50	1,627	9.40	94	1,721	100%
Number of Samples						15			10			
Species Collected			7	36		32			17			

1. Centrarchid species less Micropterus

Trophic: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), parasitic (PS), planktivore (PK), top carnivore (TC);
Tolerance: tolerant (TOL), intolerant (INT).

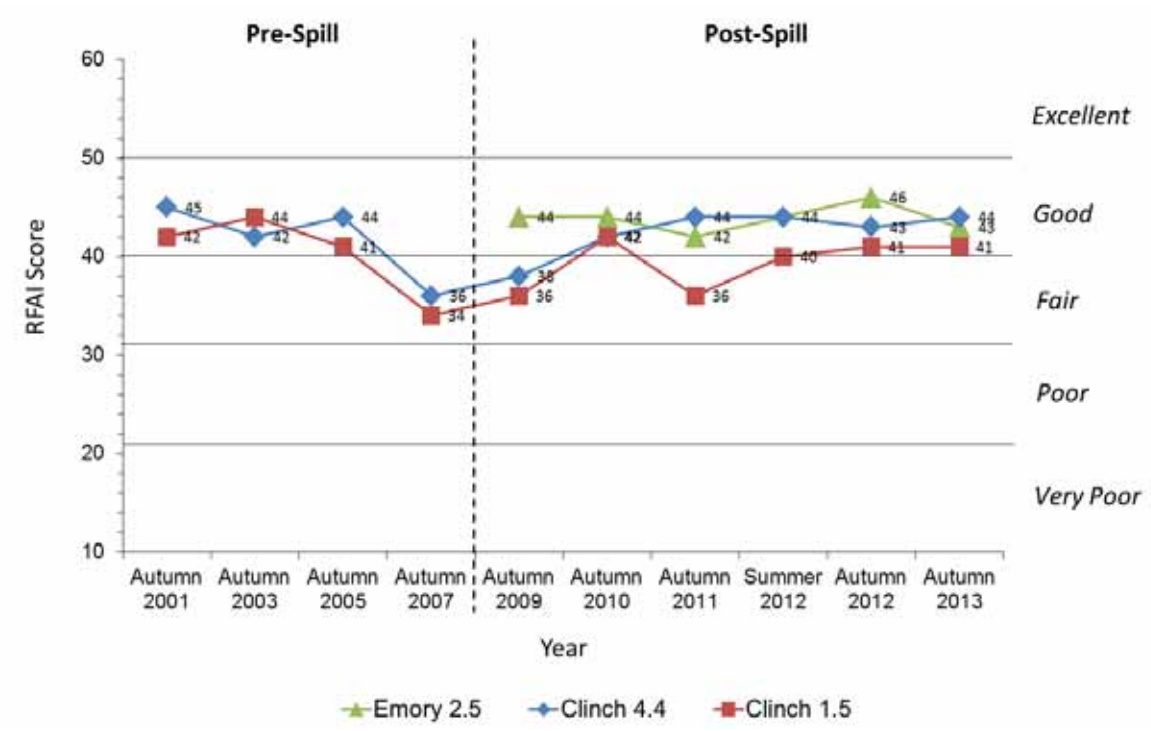


Figure 1. Reservoir Fish Assemblage Index (RFAI) ratings for fish community sampling results: 2001-2013.

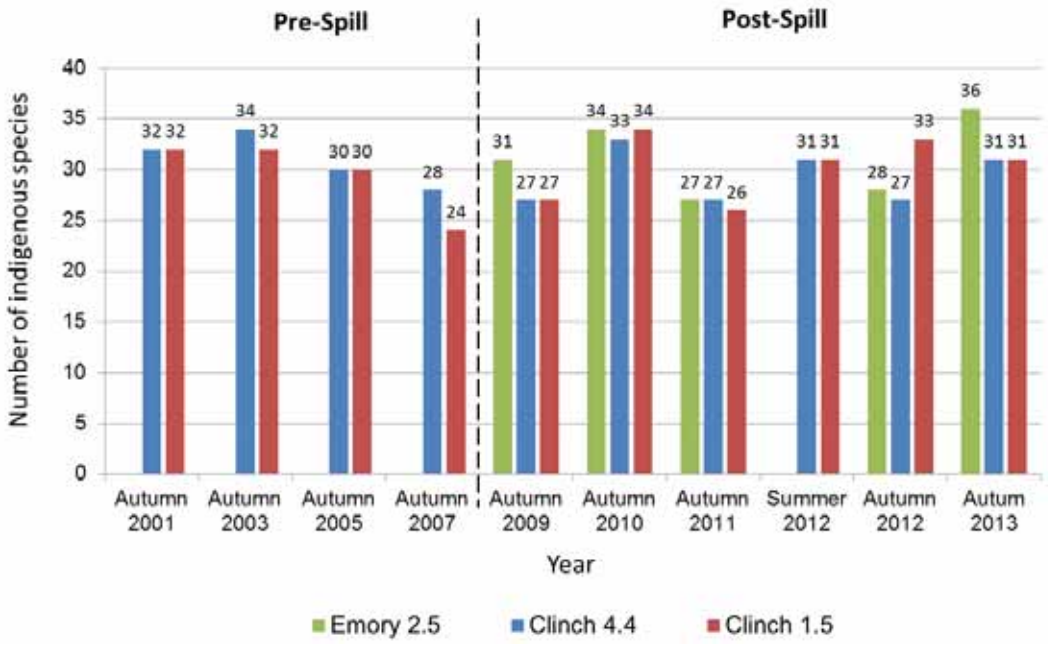


Figure 2. Number of indigenous species collect at ERM 2.5, CRM 4.4, and CRM 1.5 during fish community sampling: 2001- 2013.