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Trace Element Concentrations in Aquatic Vegetation and Periphyton: 2011

Tennessee Valley Authority
Ash Recovery Project
Kingston, Tennessee

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Acronyms

°C	degrees Celsius
ANOVA	Analysis of Variance
CRM	Clinch River Mile
Cy	Cubic Yards
ERM	Emory River Mile
ft	feet
KIF	Kingston Fossil Plant
MDL	Method Detection Limit
mg/kg	Milligram per kilogram
RL	Reporting Limit
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority

1. Introduction

The Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) is located at the confluence of the Emory and Clinch Rivers on Watts Bar Reservoir in Roane County, near Kingston, Tennessee. Ash, a by-product of a coal-fired power plant, is stored in unlined containment areas, including a former Dredge Cell. Failure of the Dredge Cell dike released about 5.4 million cubic yards (cy) of coal ash covering approximately 300 acres. Fly ash also entered the channel and overbank areas of the riverine section of the Emory River. While the released fly ash itself is primarily composed of fine silica particles very similar to sand, it also contains trace amounts of arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, zinc, and other metals which occur naturally in the ash after combustion.

The evaluations of the spatial extent of ash deposition indicated that ash may have traveled upstream as far as Emory River Mile (ERM) 6.0, and as far downstream as Tennessee River Mile (TRM) 566. In the upstream direction, the thickness of ash appeared to diminish quickly beyond about ERM 3.5. In the downstream direction, ash deposition generally diminished to trace amounts by about ERM 1.0, with pockets of greater thickness [about 2 inches to about 1 foot (ft) in some places] occurring in depositional areas in the Clinch River. Downstream of Clinch River Mile (CRM) 2.0, ash deposits varied from trace amounts to 2 inches. Ash deposition of 0.5 to 1 inch was observed in the Tennessee River at TRM 566 (south of the Clinch River). Only trace amounts of ash have been observed further downstream (Jacobs 2011).

Dredging efforts in the Emory River began on March 20, 2009 and continued until May 29, 2010. Hydraulic dredging in the river began during an initial dredging pilot program on March 20, 2009. This pilot study continued until July 20, 2009 (during the time-critical removal action) and included three 10-inch dredges. In August 2009, Phase I production dredging began and focused on removing the greatest volume of ash in the quickest time frame to reduce the potential for upstream flooding by clearing the river channel and to minimize downriver migration risk. At the end of the pilot and Phase I dredging, approximately 1.96 million cy of ash had been removed from the river. Phase II dredging began in February 2010 in order to further minimize the potential future ash migration down river. This period of dredging was considered “precision” dredging and was focused on returning the river channel to its original (pre-spill) depths while minimizing disturbance of legacy sediment. An estimated 780,000 cy of ash had been removed during the Phase II dredging.

During dredging operations, turbidity was expected to increase in the immediate area of the dredging. Control practices such as engineering controls (silt curtains) and operational controls (i.e., reduce cutter head speed, reduce rate of advance, and reverse cutter head rotation) were implemented to minimize suspended solids from the dredging operations. During dredging, several high flow events occurred, possibly washing ash further down into the Clinch and Tennessee Rivers. It was estimated that 532,000 cy of ash still remained in the river (Jacobs 2011). Areas in the Emory River were not dredged if the ash or sediment was too dense to dredge. Areas in the Emory, Clinch, and Tennessee Rivers may contain pockets of ash possibly intermixed with native river sediment.

The downstream transport and fate of ash includes intermixing with both seasonally-exposed and submerged sediments. Submerged sediment is below water year-round, however during the winter months from December to April, the water level is decreased in the reservoir and seasonally-exposed sediment was sampled at this time (Tennessee Valley Authority 2010). Both submerged and seasonally-exposed sediment may serve as a sink for some ash-related constituents. Adsorption, precipitation, and complexation with organic matter are just some of the possible mechanisms explaining metal retention in the sediments (Wieder 1998; Perry and Kleinmann 1991; Brodie et al. 1993 as cited in: Ye et al. 2001). Aquatic vegetation may accumulate metals from both sediment and water through phytoextraction into their shoots or phytostabilization from the sediments by root uptake (Dwivedi et al. 2008). Periphyton, a complex attached micro community of algae, bacteria, zooplankton, and protozoans (Weitzel 1979) is capable of bioaccumulating metals. Periphyton accumulates metals by adsorption on the extracellular matrix, cell surface adsorption, and intracellular uptake (Holding et al. 2003). Aquatic vegetation and periphyton may serve as an additional sink for the metals that remain in the sediments and water from the ash spill.

As part of the Kinston Ash Recovery Project *Non-Time-Critical Removal Action for the River System Sampling and Analysis Plan* (Tennessee Valley Authority 2010), the initial assessment of ash-related metal and metalloid bioaccumulation in aquatic emergent and shoreline vegetation and periphyton was conducted post-dredging. In 2011, 1 year after Phase II dredging, ARCADIS and Restoration Services, Inc. collected aquatic vegetation and periphyton with the objectives to: 1) quantify metal concentrations in both emergent and shoreline vegetation, as well as in periphyton and evaluate differences between reference and impacted sites; 2) assess risk to aquatic vegetation and periphyton by relating concentrations measured at the study sites to reference sites and literature derived effects values, when available; and 3) provide concentrations of metals in aquatic vegetation and periphyton for estimating exposures in herbivores and omnivores. The purpose of this report is to summarize concentrations of trace elements measured in aquatic vegetation and periphyton tissue, and to evaluate potential spatial trends in vegetation collected within the study site.

2. Methods

2.1 Collection Locations

Sections of the Emory, Clinch, and Tennessee Rivers were all impacted to some degree by the ash spill. Each river is comprised of impacted reaches and areas unimpacted by ash that are referred to as reference reaches, which have been identified upstream from CRM 4.5, ERM 6.0, and TRM 568. Downstream of these reference areas, the following reaches have been established:

- Emory River
  - Reach A: ERM 0.0 – 1.5
  - Reach B: ERM 1.5 – 3.5
  - Reach C: ERM 3.5 – 6.0

- Clinch River
  - Reach A: CRM 0.0 – 3.0
  - Reach B: CRM 3.0 – 4.5

- Tennessee River
  - Reach A: TRM 550.0 – 566.0
  - Reach B: TRM 566.0 – 568.0

2.2 Sampling and Analysis

Aquatic vegetation was collected from June 21 through June 24, 2011. Aquatic vegetation samples were collected at three locations within each river reach, as well as from each reference area (Figure 1). At each location within a river reach, a sample was taken for emergent vegetation from the summer pool and a second sample from the vegetation growing along the shoreline. Both types of vegetation were sampled using Kyocera ceramic scissors that were decontaminated between each use (Figure 2). Emergent vegetation samples were collected only from the area of the plant emerging from the water. Roots and other submerged parts of the plant were not included as part of the sample. Shoreline vegetation was cut above the ground and roots were also not included with the sample. Samples from the two types of vegetation were bagged separately in 2-gallon plastic sample bags, labeled, double bagged, and custody sealed. Two sets of quality assurance/quality control samples served as duplicates and laboratory matrix spike/matrix spike duplicate samples for both types of vegetation. Sufficient mass was met when plants filled half of the 2-gallon bag. Samples were stored on dry ice on the boat and transported back to the field house where they were stored at < -10 degrees Celsius (°C) prior to shipment.

Periphyton samples were collected from May 31 through June 24, 2011. Periphytometers were constructed using glazed ceramic tiles (four) attached using silicone glue to a nylon rope and suspended with a foam float. Ceramic tiles and rope were decontaminated prior to deployment. Three periphytometers were each attached to a cinder block anchor and deployed within an area to serve as a set to be composited as one

sample upon retrieval. One set of periphytometers was placed in each river reach. Periphytometers were monitored, and 3 weeks was determined to allow sufficient growth and mass for collection. Upon retrieval, all three samplers were removed from the river and each ceramic tile was scraped using a sterile plastic cell lifter (Figure 3). Periphyton was collected in a plastic sample cup and stored on dry ice for transport back to the Kingston field station. Samples were stored in a <-10°C freezer prior to shipment.

Aquatic vegetation and periphyton samples were shipped frozen on dry ice to Pace Analytical Services, Inc., (Pace), located in Green Bay, Wisconsin, for analysis of metals and percent moisture. Metals were analyzed using the Method SW-846 6010B/6020/7471A and measurement of percent moisture was done according to Pace Standard Operating Procedure. Pace reported all metals results in milligrams per kilogram (mg/kg) wet weight and also provided percent moisture results for each sample. Pace analyzed the plant and periphyton tissues for a suite of 26 metals and metalloids and for those that were below detection limits, the method detection limit (MDL) was provided. The MDL was based on 40 CFR Part 136 procedure (Tennessee Valley Authority 2009). Project-specific MDLs, also referred to as limit of detection, were reported as the greater of historical blank concentrations and on the 40 CFR Part 136 MDL procedure (Tennessee Valley Authority 2009).

2.3 Statistical Analysis

Statistical analyses were conducted to compare trace element concentrations in emergent and shoreline vegetation collected from the Emory, Clinch, and Tennessee Rivers. Periphyton was not evaluated using statistical comparison methods due to sample size limitations (i.e., fewer than two samples for most reaches) (Table 1). All 26 metals and metalloids were evaluated for their frequency of detection; when an analyte was not detected, the result was reported at a project-specific MDL and considered the reporting limit (RL) specific to that sample.

For all constituents detected at a frequency greater than 50 percent (i.e., when the concentration of a metal or metalloid exceeded the detection limit at greater than half the 27 samples from the nine reference and impacted sites), one-way analysis of variance (ANOVA) tests were conducted using Statistical Analysis Software (v. 9.3) and log-transformed metal concentrations. The RL was substituted for non-detected concentrations for constituents with a frequency of detection greater than 50 percent.

Two general approaches were used to evaluate spatial trends of metal and metalloid concentrations in aquatic vegetation. In the first approach, ANOVA tests were conducted for each metal at the nine sampling locations (Table 1). Each ANOVA test was followed by post-hoc pairwise comparisons using the Tukey-Kramer test. In the second approach, samples from each reference location were grouped (N=9 samples from the three reference locations) and compared to non-reference locations grouped by river using the ANOVA test. A one-tailed Dunnett's test was then performed on locations to compare potential differences between impacted sites and reference sites. For all statistical tests, the null hypothesis of no difference was rejected with a p-value < 0.05.

3. Results

The frequency of detection, range of detected concentrations, and range of sample-specific detection limits for all analytes in emergent and shoreline vegetation are presented in Table 2 and Appendices A and B, respectively. Metals that were all non-detects or mostly non-detects (e.g., < 50 percent detection) in emergent and shoreline vegetation were excluded from the statistical analyses. In addition, constituents that are considered plant macronutrients (e.g., calcium, magnesium and potassium) were not statistically evaluated or otherwise evaluated for temporal trends. All raw analytical results from emergent vegetation, shoreline vegetation, and periphyton can be found in Appendices C, D, and E, respectively.

Detection frequencies of elements were similar between the 27 samples of emergent vegetation and 27 samples of shoreline vegetation (Figure 4). In emergent and shoreline vegetation, antimony, beryllium, and mercury were below detection limits in all samples. In addition, sodium, thallium, and selenium were also below detection limits in all shoreline vegetation samples. Excluding plant macronutrients, 13 constituents were detected in greater than 50 percent of the emergent vegetation samples and 12 constituents were detected in greater than 50 percent of the shoreline vegetation samples. As discussed below, many of these constituents are considered essential or beneficial elements to plant growth and are typically found in plant tissue.

Compared to shoreline and emergent vegetation, fewer total periphyton samples were submitted for trace element analyses (ten total samples excluding field duplicates). Samples of periphyton were collected from a reference location in the Emory and Clinch Rivers, in addition to two impacted locations in the Clinch River and three impacted locations in the Emory River. Periphyton samples were not collected in the Tennessee River. Most metals and metalloids were found above detection limits in periphyton samples (Figure 5). Thallium was the only constituent not detected above detection limits in periphyton samples; potassium, silver, and sodium were detected above detection limits in less than half the samples. All remaining constituents were found above detections limits in greater than 80 percent of the periphyton samples.

Summary results and statistics are presented in Table 2 for emergent and shoreline vegetation; raw data for vegetation and periphyton are included in Appendices C and D. Mean concentrations of trace elements detected in emergent vegetation and shoreline vegetation are presented in Figures 6 through 22 and Figures 23 through 38, respectively.

3.1 Aquatic Emergent Vegetation

Significant differences in emergent vegetation evaluated by individual sample reaches were only found for aluminum, iron, lead, nickel, and vanadium (Table 3; Figures 6, 14, 15, 18, and 21). These differences are discussed below, with particular focus on potential spatial trends.

Aluminum concentrations in emergent vegetation collected from the Emory River reference location were significantly greater than impacted reaches ERM 1.5 and ERM 3.0. Within the Clinch River, the reference

location had significantly greater concentrations of aluminum compared to the impacted reach CRM 2.5. Overall, aluminum concentrations in emergent vegetation were greatest in samples collected from the Emory River reference reach and lowest in samples collected from the Tennessee River reference reach. Reference locations from the Emory, Clinch, and Tennessee Rivers were subsequently combined into a single reference group and compared to mean concentrations of impacted reaches of each river (Figure 6). Although the grouped reference locations had the greatest mean concentrations of aluminum, differences were not significant when compared to impacted reaches (Figure 6).

Iron concentrations were significantly different between sample reaches, with the highest mean concentrations in the Emory River reference reach (Figure 14). Emergent vegetation collected from two impacted reaches within the Emory River (ERM 1.5 and ERM 3.0) had significantly lower concentrations of iron compared to the Emory River reference location. Samples collected from the Emory River reference location were also significantly greater than all impacted reaches within the Clinch River and the Tennessee River reference reach. Within the Clinch River, the reference reach was significantly greater than each impacted reach. The reference location on the Tennessee River had significantly less iron compared to the reference reaches on the Clinch and Emory Rivers, but not the impacted Tennessee reach. When evaluated by grouped locations, no significant differences were evident between locations.

Lead concentrations in emergent aquatic vegetation collected from the Emory River reference location were significantly greater compared to impacted reaches ERM 1.5 and ERM 3.0. These were the only significant differences between a reference location and corresponding impacted reaches (Figure 15). Reference reaches of the Emory and Clinch Rivers were each significantly greater than the Tennessee River reference reach. No other differences were detected between sample reaches. When evaluated by grouped locations, no significant differences were evident between locations.

Nickel concentrations in samples from the Clinch River reference were significantly greater than samples collected in the Tennessee reference location (Figure 18). When evaluated by grouped locations, no significant differences were evident between locations.

Vanadium concentrations were only detected above detection limits in 52 percent of emergent aquatic vegetation samples (Figure 4). Most samples collected from impacted reaches were below vanadium detection limits. In contrast, samples from Clinch and Emory Rivers reference reaches were detected at 100 percent frequency. Mean concentrations from the Emory River reference reach were significantly greater than ERM 3.0 (1/3 detections) as well as the Tennessee River references location and CRM 2.5 (0/3 detections) (Figure 21). When evaluated by grouped locations, no significant differences were evident between locations.

3.2 Aquatic Shoreline Vegetation

Significant differences in shoreline vegetation evaluated by individual sample reaches were detected for aluminum, boron, copper, manganese, nickel, strontium, and zinc (Table 4; Figures 23, 26, 30, 33, 35, 36, and 38). A summary of these spatial differences are described below for each constituent.

Aluminum concentrations in shoreline vegetation samples collected from the Tennessee River reference location were significantly greater than samples collected in impacted reaches of the Emory River (ERM 3.0) and Tennessee River (TRM 567) (Figure 23). When evaluated by grouped locations, no significant differences were evident between locations.

Boron concentrations in samples collected from the Emory River reference reach were significantly greater than samples collected in the reference and impacted reaches of the Tennessee River (TRM 567). In addition, boron concentrations in TRM 567 samples were significantly less than samples collected in the Clinch River reference reach (Figure 26). When evaluated by grouped locations, no significant differences were evident between locations.

Copper concentrations in samples collected from the Tennessee River reference reach were significantly greater than samples from impacted reaches of the Emory River (ERM 3.0 and ERM 4.5) and Clinch River (CRM 2.5) (Figure 30). When evaluated by grouped locations, no significant differences were evident between locations.

Manganese concentrations varied between a few sample locations (Figure 33). The only within-river differences were between impacted reaches: samples from CRM 4.0 were greater in manganese concentrations compared to CRM 2.5 samples and ERM 3.0 and 4.5 samples were greater than ERM 1.5 samples. Manganese concentrations in samples collected from the Tennessee River reference location, ERM 3.0 and ERM 4.5 were significantly greater than concentrations in the Clinch River reference, CRM 2.5, and ERM 1.5. When evaluated by grouped locations, no significant differences were evident between locations.

Nickel concentrations were greatest in samples collected from the Emory River reference location; these samples were significantly greater than samples collected from CRM 2.5 (Figure 35). When evaluated by grouped locations, no significant differences were evident between locations.

Strontium concentrations were greatest in samples collected from the Emory River reference location; these samples were significantly greater than samples collected from TRM 567 (Figure 36). When evaluated by grouped locations, no significant differences were evident between locations.

Zinc concentrations in TRM 567 samples were significantly greater than concentrations in samples collected from ERM 1.5 and all Clinch River samples, including the Clinch River reference location (Figure 38). When evaluated by grouped locations, no significant differences were evident between locations.

3.3 Periphyton

Trace-element concentrations in periphyton were not statistically compared among sites due to small sample sizes (N ≤ 2 per reach). Concentration plots of raw periphyton data are provided in Figures 39 through 49 for the detected, non-macronutrient constituents. In addition, a quantitative evaluation of potential spatial trends was not conducted for periphyton samples due to sample size limitations.

Based on the available data, trace element concentrations were detected at greater frequencies in periphyton compared to emergent and shoreline vegetation (Figure 5; Appendix E). In addition, concentrations of trace elements were generally much greater in periphyton tissue compared to emergent and shoreline vegetation. Concentration ranges of several constituents were approximately an order of magnitude greater than concentrations in emergent and shoreline vegetation, including aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, selenium, and vanadium.

When evaluated qualitatively, spatial trends were generally not discernable among sample locations (Figures 39 through 49). Mercury appeared to be trending towards greater concentrations in the Clinch River compared to the Emory River, although it is currently unknown if this is an artifact of the small sample size.

4. Discussion of Findings

Several spatial differences were observed in emergent and shoreline vegetation samples collected within the study area. When impacted river reaches were compared to corresponding references reaches (i.e., impacted reaches within a river compared to the reference reach for that river), the concentrations of trace elements were always elevated in reference reaches whenever a difference was statistically significant.

Overall, potential spatial trends observed for each vegetation type appear to be limited to elevated concentrations of select trace metals in the reference reaches relative to impacted reaches. Based on the assumption that upstream reference sites on the Emory, Clinch, and Tennessee Rivers were not impacted by ash, as described in the *Sampling and Analysis Plan* (Tennessee Valley Authority 2010), available data do not indicate ash-related impacts to aquatic vegetation growing within impacted reaches. However, background contamination from other sources might confound that interpretation, along with other uncertainties as discussed below.

Uncertainty is inherent in many aspects of field surveys, particularly in systems with complex analyte mixtures. Additionally, the study site consists of confluences of three river systems with potential differences in the geology and soil types of the drainage areas, potential legacy metals contamination in upstream reaches, and potential upstream migration and deposition of constituents. Each of these factors can confound interpretation of spatial trends. Aspects of the present study design also limit interpretation of results, including small sample sizes (N=3 for emergent and shoreline vegetation per location; N≤2 for periphyton per location) that decrease statistical power and thus decrease the ability to detect significant differences when differences may truly exist. In addition, use of ceramic tiles for periphyton colonization represents an artificial substrate that might support a different algal community relative to periphyton colonizing natural substrata.

Another factor contributing to uncertainty is the collection of different species of vegetation and periphyton across sampling locations. Compositional differences in periphyton communities might be expected across sampling sites that contain habitat differences, which can influence metal bioaccumulation rates and therefore introduce uncertainty in the interpretation of spatial trends of metal concentrations in periphyton tissue. Aquatic vegetation sampling sites were selected based on the availability of emergent vegetation (Tennessee Valley Authority 2010), resulting in the collection of a variety of emergent and shoreline species. Thus, inter-species differences in bioaccumulation of metals typically observed for aquatic plant species (Lopez and Carballeira 1993) may bias the spatial trends observed in these results. In addition, only plant biomass emerging from the ground or water surfaces were analyzed for metals. Since plant roots can be a significant source of accumulated metals relative to aboveground biomass (Outridge and Noller 1991), it is possible that these tissue results underestimate concentrations in aquatic vegetation.

Some trace elements are essential for normal plant growth (e.g., potassium, calcium, magnesium, iron, boron, manganese, zinc, copper, molybdenum, nickel, and selenium) (Epstein 1965), although both essential and non-essential metals (e.g., mercury, cadmium, and lead) can result in growth inhibition and

toxicity (Vardanyan et al. 2008). To evaluate potential adverse effects of these metals to primary producers, vegetation and periphyton tissue concentrations reported herein will be compared to available tissue-based effects levels in the Baseline Ecological Risk Assessment. In addition, these tissue-based concentrations will be used as direct inputs for dietary exposure models to estimate potential trophic transfer and doses to herbivorous and omnivorous wildlife.

4.1 Summary and Conclusions

A total of 26 metals and metalloids were measured in emergent vegetation, shoreline vegetation, and periphyton. Spatial differences in metal concentrations potentially caused by the ash spill were not apparent from the available data. In fact, higher concentrations in the reference sites of the Clinch and Emory Rivers accounted for the majority of the statistically-significant differences observed. Such differences may indicate legacy concentrations in upstream locations that are unrelated to the ash spill. However, care should be exercised when interpreting and drawing conclusions from these data given underlying uncertainties, as discussed above.

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Table 1. Summary of Aquatic Vegetation and Periphyton Collections for 2011
Tennessee Valley Authority Kingston, Tennessee

Site Name	Type	Vegetation Type		
		Emergent[1]	Shoreline[1]	Periphyton[1]
Upstream Emory River (>6.0)	Reference Sites	3	4	2
Upstream Clinch River (>4.5)		4	3	2
Upstream Tennessee River (>568)		3	3	0
Emory River 1.5	Potentially Affected Sites	3	4	1
Emory River 3.0		3	3	3
Emory River 4.5		3	3	1
Clinch River 2.5		4	3	2
Clinch River 4.0		3	3	1
Tennessee River 567		3	3	0

[1] Number of samples include field duplicates; does not include laboratory blanks of laboratory duplicates.

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Table 2. Emergent and Shoreline Vegetation Summary Statistics for 2011

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Site	2011 Emergent Vegetation Results (mg/kg dw)				2011 Shoreline Vegetation Results (mg/kg dw)			
		Number of Detects	Number of Samples	Mean ± SD	Range	Number of Detects	Number of Samples	Mean ± SD	Range
Aluminum	CRM REF	3	3	355.5 ± 152.0	202.8 - 506.8	3	3	29.7 ± 3.1	26.35 - 32.55
	CRM 2.5	3	3	64.5 ± 36.2	26.21 - 98.25	3	3	178.5 ± 235.9	38.04 - 450.8
	CRM 4.0	3	3	115.2 ± 34.5	88.44 - 154.1	3	3	53.6 ± 35.8	25.91 - 94.03
	ERM REF	3	3	710.3 ± 363.0	293.2 - 955	3	3	137.4 ± 88.7	37.25 - 206
	ERM 4.5	3	3	247.6 ± 167.0	141.9 - 440.1	3	3	85.0 ± 53.1	31.82 - 138.1
	ERM 1.5	3	3	69.9 ± 24.3	49.66 - 96.79	3	3	94.5 ± 92.3	35.34 - 200.8
	ERM 3.0	3	3	106.0 ± 53.3	70.51 - 167.3	3	3	23.4 ± 4.4	18.99 - 27.76
	TRM REF	3	3	46.9 ± 47.7	18.58 - 102	3	3	195.9 ± 24.7	175.8 - 223.4
	TRM 567	3	3	214.9 ± 136.5	92.77 - 362.2	3	3	24.4 ± 11.0	14.49 - 36.26
Antimony	CRM REF	0	3	NC ± NC	0.1 - 0.12	0	3	NC ± NC	0.05 - 0.07
	CRM 2.5	0	3	NC ± NC	0.06 - 0.07	0	3	NC ± NC	0.04 - 0.05
	CRM 4.0	0	3	NC ± NC	0.04 - 0.1	0	3	NC ± NC	0.04 - 0.06
	ERM REF	0	3	NC ± NC	0.04 - 0.12	0	3	NC ± NC	0.05 - 0.08
	ERM 4.5	0	3	NC ± NC	0.04 - 0.08	0	3	NC ± NC	0.03 - 0.05
	ERM 1.5	0	3	NC ± NC	0.09 - 0.1	0	3	NC ± NC	0.04 - 0.06
	ERM 3.0	0	3	NC ± NC	0.05 - 0.06	0	3	NC ± NC	0.05 - 0.054
	TRM REF	0	3	NC ± NC	0.05 - 0.07	0	3	NC ± NC	0.05 - 0.06
	TRM 567	0	3	NC ± NC	0.06 - 0.11	0	3	NC ± NC	0.04 - 0.05
Arsenic	CRM REF	2	3	NC ± NC	0.2 - 0.53	0	3	NC ± NC	0.09 - 0.13
	CRM 2.5	3	3	0.4 ± 0.3	0.2 - 0.77	1	3	NC ± NC	0.08 - 0.31
	CRM 4.0	1	3	NC ± NC	0.09 - 0.25	0	3	NC ± NC	0.08 - 0.11
	ERM REF	3	3	0.3 ± 0.2	0.14 - 0.5	0	3	NC ± NC	0.11 - 0.15
	ERM 4.5	1	3	NC ± NC	0.16 - 0.24	1	3	NC ± NC	0.07 - 0.27
	ERM 1.5	0	3	NC ± NC	0.17 - 0.35	0	3	NC ± NC	0.07 - 0.11
	ERM 3.0	3	3	0.5 ± 0.5	0.1 - 1.08	3	3	0.2 ± 0.1	0.13 - 0.34
	TRM REF	1	3	NC ± NC	0.13 - 0.26	0	3	NC ± NC	0.09 - 0.11
	TRM 567	2	3	NC ± NC	0.25 - 0.33	2	3	NC ± NC	0.11 - 0.16
Barium	CRM REF	3	3	34.2 ± 1.3	33.06 - 35.59	3	3	27.7 ± 17.0	10.54 - 44.59
	CRM 2.5	3	3	36.2 ± 9.4	26.21 - 44.92	3	3	22.2 ± 12.6	7.669 - 30.04
	CRM 4.0	3	3	28.5 ± 13.1	16.97 - 42.61	3	3	25.0 ± 18.4	11.96 - 45.97
	ERM REF	3	3	36.0 ± 22.0	17.29 - 60.16	3	3	77.5 ± 38.6	47.06 - 120.9
	ERM 4.5	3	3	49.2 ± 28.6	19.19 - 76.17	3	3	42.8 ± 21.6	24.69 - 66.67
	ERM 1.5	3	3	34.0 ± 7.4	25.6 - 39.74	3	3	28.9 ± 2.9	26.69 - 32.24
	ERM 3.0	3	3	34.4 ± 10.5	22.86 - 43.32	3	3	43.0 ± 11.5	31.13 - 54.09
	TRM REF	3	3	24.9 ± 20.1	3.557 - 43.41	3	3	24.7 ± 22.1	6.169 - 49.19
	TRM 567	3	3	90.3 ± 104.4	25.53 - 210.8	3	3	30.5 ± 3.9	27.48 - 34.88
Beryllium	CRM REF	0	3	NC ± NC	0.2 - 0.25	0	3	NC ± NC	0.09 - 0.14
	CRM 2.5	0	3	NC ± NC	0.11 - 0.16	0	3	NC ± NC	0.08 - 0.11
	CRM 4.0	0	3	NC ± NC	0.09 - 0.2	0	3	NC ± NC	0.09 - 0.12
	ERM REF	0	3	NC ± NC	0.07 - 0.23	0	3	NC ± NC	0.11 - 0.16
	ERM 4.5	0	3	NC ± NC	0.09 - 0.15	0	3	NC ± NC	0.07 - 0.1
	ERM 1.5	0	3	NC ± NC	0.18 - 0.21	0	3	NC ± NC	0.08 - 0.11
	ERM 3.0	0	3	NC ± NC	0.1 - 0.13	0	3	NC ± NC	0.1 - 0.11
	TRM REF	0	3	NC ± NC	0.11 - 0.14	0	3	NC ± NC	0.1 - 0.12
	TRM 567	0	3	NC ± NC	0.13 - 0.22	0	3	NC ± NC	0.08 - 0.11
Boron	CRM REF	3	3	50.9 ± 4.7	46.48 - 55.93	3	3	16.9 ± 3.8	12.59 - 19.81
	CRM 2.5	3	3	48.2 ± 19.6	27.82 - 67.01	3	3	15.3 ± 7.0	8.834 - 22.7
	CRM 4.0	3	3	32.8 ± 18.2	14.07 - 50.34	3	3	14.9 ± 3.4	11.34 - 18.21
	ERM REF	3	3	25.1 ± 28.4	6.516 - 57.81	3	3	21.6 ± 9.3	12.16 - 30.77
	ERM 4.5	3	3	26.6 ± 20.8	13.08 - 50.58	3	3	10.9 ± 1.5	10.02 - 12.59
	ERM 1.5	3	3	48.7 ± 11.3	37.5 - 60	3	3	16.4 ± 5.9	9.694 - 20.72
	ERM 3.0	3	3	19.1 ± 8.2	13.8 - 28.57	3	3	9.3 ± 0.3	8.915 - 9.609
	TRM REF	3	3	12.3 ± 6.6	4.743 - 16.94	3	3	7.4 ± 4.5	4.221 - 12.5
	TRM 567	3	3	31.9 ± 20.0	11.91 - 51.97	3	3	6.1 ± 1.0	4.982 - 6.957
Cadmium	CRM REF	1	3	NC ± NC	0.05 - 0.14	1	3	NC ± NC	0.027 - 0.035
	CRM 2.5	0	3	NC ± NC	0.03 - 0.04	2	3	NC ± NC	0.03 - 0.05
	CRM 4.0	2	3	NC ± NC	0.02 - 0.07	3	3	0.0 ± 0.0	0.03 - 0.05
	ERM REF	2	3	NC ± NC	0.06 - 0.16	3	3	0.3 ± 0.1	0.16 - 0.39
	ERM 4.5	2	3	NC ± NC	0.04 - 0.37	1	3	NC ± NC	0.05 - 0.15
	ERM 1.5	0	3	NC ± NC	0.047 - 0.053	0	3	NC ± NC	0.02 - 0.12
	ERM 3.0	3	3	0.1 ± 0.1	0.05 - 0.29	0	3	NC ± NC	0.05 - 0.1
	TRM REF	2	3	NC ± NC	0.03 - 0.13	0	3	NC ± NC	0.02 - 0.13
	TRM 567	0	3	NC ± NC	0.03 - 0.06	0	3	NC ± NC	0.02 - 0.03
Chromium	CRM REF	0	3	NC ± NC	0.85 - 1.07	0	3	NC ± NC	0.41 - 0.57
	CRM 2.5	0	3	NC ± NC	0.48 - 0.67	1	3	NC ± NC	0.37 - 0.73
	CRM 4.0	1	3	NC ± NC	0.37 - 0.82	1	3	NC ± NC	0.36 - 0.61
	ERM REF	3	3	1.1 ± 0.5	0.5 - 1.4	1	3	NC ± NC	0.56 - 0.9
	ERM 4.5	0	3	NC ± NC	0.38 - 0.64	0	3	NC ± NC	0.32 - 0.41
	ERM 1.5	0	3	NC ± NC	0.77 - 0.83	1	3	NC ± NC	0.43 - 0.49
	ERM 3.0	1	3	NC ± NC	0.41 - 0.55	0	3	NC ± NC	0.46 - 0.5
	TRM REF	1	3	NC ± NC	0.47 - 1.32	2	3	NC ± NC	0.5 - 0.55
	TRM 567	0	3	NC ± NC	0.55 - 0.94	0	3	NC ± NC	0.38 - 0.5

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Table 2. Emergent and Shoreline Vegetation Summary Statistics for 2011

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Site	2011 Emergent Vegetation Results (mg/kg dw)				2011 Shoreline Vegetation Results (mg/kg dw)			
		Number of Detects	Number of Samples	Mean ± SD	Range	Number of Detects	Number of Samples	Mean ± SD	Range
Cobalt	CRM REF	3	3	0.4 ± 0.2	0.2 - 0.63	2	3	NC ± NC	0.07 - 0.12
	CRM 2.5	3	3	0.2 ± 0.1	0.06 - 0.28	2	3	NC ± NC	0.05 - 0.44
	CRM 4.0	3	3	0.3 ± 0.1	0.2 - 0.4	3	3	0.2 ± 0.2	0.09 - 0.39
	ERM REF	3	3	1.0 ± 0.5	0.43 - 1.4	3	3	0.3 ± 0.2	0.2 - 0.54
	ERM 4.5	3	3	0.7 ± 0.5	0.26 - 1.21	3	3	0.2 ± 0.2	0.07 - 0.37
	ERM 1.5	3	3	0.2 ± 0.1	0.09 - 0.32	3	3	0.3 ± 0.2	0.09 - 0.55
	ERM 3.0	3	3	0.3 ± 0.2	0.16 - 0.55	3	3	0.2 ± 0.1	0.14 - 0.33
	TRM REF	3	3	0.5 ± 0.6	0.07 - 1.22	3	3	0.2 ± 0.1	0.12 - 0.38
	TRM 567	3	3	0.4 ± 0.1	0.32 - 0.6	3	3	0.1 ± 0.0	0.07 - 0.14
Copper	CRM REF	3	3	9.8 ± 1.8	8.45 - 11.86	3	3	8.2 ± 2.5	5.782 - 10.85
	CRM 2.5	3	3	9.4 ± 2.6	6.45 - 11.11	3	3	6.8 ± 1.3	5.3 - 7.669
	CRM 4.0	3	3	8.0 ± 2.0	6.42 - 10.2	3	3	10.2 ± 2.8	7.164 - 12.55
	ERM REF	3	3	5.8 ± 2.9	2.76 - 8.59	3	3	8.4 ± 3.4	5.128 - 11.96
	ERM 4.5	3	3	5.7 ± 1.8	4.07 - 7.56	3	3	5.6 ± 0.7	4.89 - 6.169
	ERM 1.5	3	3	8.5 ± 0.4	8.33 - 8.97	3	3	8.0 ± 2.3	5.357 - 9.398
	ERM 3.0	3	3	4.8 ± 1.0	3.7 - 5.71	3	3	5.6 ± 0.4	5.426 - 6.05
	TRM REF	3	3	6.7 ± 2.0	4.88 - 8.87	3	3	17.4 ± 8.5	9.416 - 26.36
	TRM 567	3	3	6.9 ± 1.6	5.11 - 7.87	3	3	7.3 ± 1.0	6.406 - 8.397
Iron	CRM REF	3	3	344.2 ± 131.7	214.8 - 478	3	3	60.8 ± 15.0	49.66 - 77.83
	CRM 2.5	3	3	104.7 ± 20.1	82.26 - 121.1	3	3	187.1 ± 215.1	53.99 - 435.2
	CRM 4.0	3	3	133.0 ± 31.4	108.3 - 168.3	3	3	69.3 ± 12.3	55.15 - 76.72
	ERM REF	3	3	809.6 ± 420.0	325.8 - 1080	3	3	194.7 ± 106.6	71.76 - 262
	ERM 4.5	3	3	364.8 ± 243.0	220.1 - 645.3	3	3	119.5 ± 61.6	57.14 - 180.3
	ERM 1.5	3	3	109.5 ± 9.4	99.31 - 117.9	3	3	136.1 ± 112.0	66.92 - 265.3
	ERM 3.0	3	3	159.4 ± 67.1	109.8 - 235.7	3	3	66.6 ± 7.7	59.53 - 74.81
	TRM REF	3	3	123.9 ± 103.8	55.65 - 243.4	3	3	214.5 ± 12.5	206.5 - 228.9
	TRM 567	3	3	232.6 ± 162.8	122.9 - 419.7	3	3	64.0 ± 8.0	56.52 - 72.52
Lead	CRM REF	3	3	0.5 ± 0.3	0.26 - 0.79	1	3	NC ± NC	0.1 - 0.13
	CRM 2.5	3	3	0.2 ± 0.0	0.13 - 0.19	3	3	0.5 ± 0.7	0.1 - 1.24
	CRM 4.0	2	3	NC ± NC	0.18 - 0.34	3	3	0.1 ± 0.0	0.09 - 0.16
	ERM REF	3	3	0.8 ± 0.4	0.35 - 1.02	2	3	NC ± NC	0.11 - 0.24
	ERM 4.5	3	3	0.3 ± 0.2	0.2 - 0.58	3	3	0.1 ± 0.0	0.1 - 0.19
	ERM 1.5	0	3	NC ± NC	0.17 - 0.19	2	3	NC ± NC	0.09 - 0.12
	ERM 3.0	2	3	NC ± NC	0.12 - 0.22	2	3	NC ± NC	0.107 - 0.109
	TRM REF	1	3	NC ± NC	0.1 - 0.13	3	3	0.4 ± 0.3	0.25 - 0.74
	TRM 567	2	3	NC ± NC	0.16 - 0.41	2	3	NC ± NC	0.08 - 0.34
Manganese	CRM REF	3	3	269.1 ± 155.8	97.18 - 400.9	3	3	87.9 ± 22.6	67.92 - 112.5
	CRM 2.5	3	3	356.6 ± 30.2	326.3 - 386.6	3	3	39.6 ± 19.0	19.43 - 57.25
	CRM 4.0	3	3	385.9 ± 259.1	98.17 - 600.7	3	3	199.8 ± 75.3	118.6 - 267.2
	ERM REF	3	3	501.2 ± 50.1	443.6 - 535	3	3	264.5 ± 74.7	206.7 - 348.9
	ERM 4.5	3	3	864.6 ± 638.4	392.4 - 1591	3	3	410.8 ± 206.6	247.1 - 642.9
	ERM 1.5	3	3	223.4 ± 101.2	135.1 - 333.8	3	3	111.7 ± 55.4	48.5 - 152
	ERM 3.0	3	3	576.5 ± 278.6	310.8 - 866.4	3	3	491.3 ± 340.9	268.1 - 883.7
	TRM REF	3	3	473.4 ± 359.6	242.7 - 887.8	3	3	556.4 ± 178.5	418.8 - 758.1
	TRM 567	3	3	314.1 ± 107.0	192.8 - 395.3	3	3	289.6 ± 106.9	167.5 - 366.5
Mercury	CRM REF	0	3	NC ± NC	0.08 - 0.1	0	3	NC ± NC	0.04 - 0.05
	CRM 2.5	0	3	NC ± NC	0.04 - 0.06	0	3	NC ± NC	0.03 - 0.04
	CRM 4.0	0	3	NC ± NC	0.04 - 0.07	0	3	NC ± NC	0.03 - 0.05
	ERM REF	0	3	NC ± NC	0.03 - 0.09	0	3	NC ± NC	0.04 - 0.06
	ERM 4.5	0	3	NC ± NC	0.03 - 0.06	0	3	NC ± NC	0.03 - 0.04
	ERM 1.5	0	3	NC ± NC	0.07 - 0.08	0	3	NC ± NC	0.03 - 0.05
	ERM 3.0	0	3	NC ± NC	0.04 - 0.05	0	3	NC ± NC	0.043 - 0.043
	TRM REF	0	3	NC ± NC	0.04 - 0.05	0	3	NC ± NC	0.039 - 0.047
	TRM 567	0	3	NC ± NC	0.05 - 0.09	0	3	NC ± NC	0.03 - 0.04
Molybdenum	CRM REF	3	3	0.8 ± 0.3	0.53 - 0.99	3	3	0.9 ± 0.5	0.28 - 1.43
	CRM 2.5	3	3	1.5 ± 0.2	1.25 - 1.71	2	3	NC ± NC	0.95 - 1.55
	CRM 4.0	3	3	1.0 ± 0.5	0.46 - 1.47	3	3	1.5 ± 1.2	0.26 - 4.32
	ERM REF	3	3	0.8 ± 0.2	0.55 - 0.94	3	3	3.2 ± 0.7	0.19 - 0.51
	ERM 4.5	3	3	0.8 ± 0.2	0.57 - 0.99	3	3	2.0 ± 0.3	0.28 - 1.69
	ERM 1.5	3	3	1.0 ± 0.4	0.58 - 1.28	3	3	1.6 ± 0.7	0.09 - 0.79
	ERM 3.0	3	3	1.2 ± 0.3	0.89 - 1.43	3	3	1.4 ± 0.3	0.61 - 1.05
	TRM REF	2	3	NC ± NC	0.26 - 1.51	3	3	2.3 ± 2.3	0.19 - 1.98
	TRM 567	3	3	0.8 ± 0.3	0.55 - 1.1	3	3	1.1 ± 0.4	0.17 - 2.9
Nickel	CRM REF	3	3	2.8 ± 2.0	1.24 - 5.07	3	3	0.9 ± 0.5	0.58 - 1.42
	CRM 2.5	3	3	1.0 ± 0.5	0.52 - 1.55	2	3	NC ± NC	0.29 - 0.88
	CRM 4.0	3	3	1.9 ± 0.8	1.24 - 2.78	3	3	1.5 ± 1.2	0.6 - 2.84
	ERM REF	3	3	2.6 ± 1.4	1 - 3.83	3	3	3.2 ± 0.7	2.34 - 3.59
	ERM 4.5	3	3	1.4 ± 0.6	0.87 - 2.09	3	3	2.0 ± 0.3	1.7 - 2.18
	ERM 1.5	3	3	1.3 ± 0.4	0.83 - 1.72	3	3	1.6 ± 0.7	0.83 - 2.16
	ERM 3.0	3	3	1.0 ± 0.4	0.71 - 1.43	3	3	1.4 ± 0.3	1.24 - 1.78
	TRM REF	2	3	NC ± NC	0.37 - 0.69	3	3	2.3 ± 2.3	0.81 - 5.04
	TRM 567	3	3	1.2 ± 0.8	0.47 - 2.05	3	3	1.1 ± 0.4	0.61 - 1.49

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Table 2. Emergent and Shoreline Vegetation Summary Statistics for 2011

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Site	2011 Emergent Vegetation Results (mg/kg dw)				2011 Shoreline Vegetation Results (mg/kg dw)			
		Number of Detects	Number of Samples	Mean ± SD	Range	Number of Detects	Number of Samples	Mean ± SD	Range
Selenium	CRM REF	0	3	NC ± NC	0.46 - 0.57	0	3	NC ± NC	0.22 - 0.31
	CRM 2.5	3	3	0.6 ± 0.2	0.4 - 0.75	0	3	NC ± NC	0.17 - 0.24
	CRM 4.0	1	3	NC ± NC	0.01 - 0.01	0	3	NC ± NC	0.19 - 0.28
	ERM REF	0	3	NC ± NC	0.21 - 0.44	0	3	NC ± NC	0.26 - 0.36
	ERM 4.5	0	3	NC ± NC	0.17 - 0.54	0	3	NC ± NC	0.16 - 0.22
	ERM 1.5	1	3	NC ± NC	0.39 - 0.7	0	3	NC ± NC	0.17 - 0.26
	ERM 3.0	0	3	NC ± NC	0.42 - 0.83	0	3	NC ± NC	0.24 - 0.26
	TRM REF	0	3	NC ± NC	0.44 - 0.59	0	3	NC ± NC	0.22 - 0.27
	TRM 567	0	3	NC ± NC	0.5 - 0.63	0	3	NC ± NC	0.19 - 0.26
Silver	CRM REF	0	3	NC ± NC	0.59 - 1	0	3	NC ± NC	0.01 - 0.31
	CRM 2.5	0	3	NC ± NC	0.02 - 0.024	0	3	NC ± NC	0.01 - 0.24
	CRM 4.0	0	3	NC ± NC	0.01 - 0.02	1	3	NC ± NC	0.01 - 0.28
	ERM REF	0	3	NC ± NC	0.01 - 0.02	1	3	NC ± NC	0.01 - 0.36
	ERM 4.5	0	3	NC ± NC	0.01 - 0.02	0	3	NC ± NC	0.01 - 0.22
	ERM 1.5	0	3	NC ± NC	0.018 - 0.02	0	3	NC ± NC	0.01 - 0.26
	ERM 3.0	0	3	NC ± NC	0.009 - 0.012	0	3	NC ± NC	0.01 - 0.26
	TRM REF	1	3	NC ± NC	0.01 - 0.02	0	3	NC ± NC	0.01 - 0.27
	TRM 567	0	3	NC ± NC	0.01 - 0.02	0	3	NC ± NC	0.01 - 0.26
Strontium	CRM REF	3	3	46.6 ± 17.3	26.76 - 58.68	3	3	15.3 ± 4.3	11.32 - 19.93
	CRM 2.5	3	3	44.7 ± 17.4	24.6 - 55.61	3	3	15.2 ± 2.9	12.27 - 18.02
	CRM 4.0	3	3	29.4 ± 6.9	25.08 - 37.41	3	3	20.7 ± 4.2	15.95 - 23.58
	ERM REF	3	3	28.0 ± 26.3	7.769 - 57.81	3	3	35.2 ± 14.3	22.75 - 50.85
	ERM 4.5	3	3	31.9 ± 19.2	12.21 - 50.58	3	3	19.0 ± 3.0	16.87 - 22.45
	ERM 1.5	3	3	55.4 ± 16.7	36.9 - 69.23	3	3	30.0 ± 3.8	27.07 - 34.21
	ERM 3.0	3	3	22.4 ± 12.3	11.75 - 35.94	3	3	21.8 ± 3.0	18.29 - 23.64
	TRM REF	3	3	24.3 ± 17.6	4.348 - 37.56	3	3	18.8 ± 14.2	6.494 - 34.27
	TRM 567	3	3	40.8 ± 17.2	23.83 - 58.27	3	3	12.1 ± 0.7	11.39 - 12.75
Thallium	CRM REF	0	3	NC ± NC	0.1 - 0.12	0	3	NC ± NC	0.04 - 0.06
	CRM 2.5	0	3	NC ± NC	0.05 - 0.07	0	3	NC ± NC	0.04 - 0.05
	CRM 4.0	0	3	NC ± NC	0.04 - 0.09	0	3	NC ± NC	0.04 - 0.06
	ERM REF	0	3	NC ± NC	0.03 - 0.11	0	3	NC ± NC	0.05 - 0.08
	ERM 4.5	1	3	NC ± NC	0.04 - 0.07	0	3	NC ± NC	0.03 - 0.04
	ERM 1.5	0	3	NC ± NC	0.08 - 0.1	0	3	NC ± NC	0.04 - 0.05
	ERM 3.0	0	3	NC ± NC	0.04 - 0.06	0	3	NC ± NC	0.05 - 0.054
	TRM REF	0	3	NC ± NC	0.05 - 0.06	0	3	NC ± NC	0.045 - 0.054
	TRM 567	0	3	NC ± NC	0.06 - 0.1	0	3	NC ± NC	0.04 - 0.05
Vanadium	CRM REF	3	3	0.7 ± 0.3	0.39 - 1.02	0	3	NC ± NC	0.15 - 0.21
	CRM 2.5	0	3	NC ± NC	0.18 - 0.24	1	3	NC ± NC	0.14 - 0.83
	CRM 4.0	1	3	NC ± NC	0.14 - 0.33	0	3	NC ± NC	0.13 - 0.19
	ERM REF	3	3	1.1 ± 0.6	0.4 - 1.6	1	3	NC ± NC	0.18 - 0.29
	ERM 4.5	3	3	0.4 ± 0.3	0.17 - 0.76	2	3	NC ± NC	0.13 - 0.21
	ERM 1.5	0	3	NC ± NC	0.28 - 0.32	1	3	NC ± NC	0.15 - 0.28
	ERM 3.0	1	3	NC ± NC	0.15 - 0.31	0	3	NC ± NC	0.16 - 0.17
	TRM REF	1	3	NC ± NC	0.17 - 0.26	3	3	0.3 ± 0.0	0.28 - 0.31
	TRM 567	2	3	NC ± NC	0.27 - 0.65	0	3	NC ± NC	0.13 - 0.17
Zinc	CRM REF	3	3	62.3 ± 18.3	43.8 - 80.49	3	3	34.7 ± 6.8	30.66 - 42.57
	CRM 2.5	3	3	43.6 ± 9.8	34.27 - 53.8	3	3	32.9 ± 3.6	29.33 - 36.5
	CRM 4.0	3	3	32.9 ± 12.7	18.35 - 41.5	3	3	34.5 ± 5.4	28.36 - 38.46
	ERM REF	3	3	46.2 ± 11.5	32.83 - 53.13	3	3	60.5 ± 15.8	45.1 - 76.63
	ERM 4.5	3	3	44.1 ± 11.3	36.34 - 57.05	2	3	NC ± NC	37.01 - 47.28
	ERM 1.5	3	3	35.3 ± 4.5	30.34 - 39.1	2	3	NC ± NC	19.9 - 38.35
	ERM 3.0	3	3	37.1 ± 9.8	28.28 - 47.62	2	3	NC ± NC	35.27 - 55.16
	TRM REF	3	3	39.1 ± 8.2	30.73 - 47.18	1	3	NC ± NC	30.84 - 60.48
	TRM 567	3	3	36.6 ± 5.8	32.53 - 43.31	3	3	71.6 ± 8.5	61.83 - 76.87

[1] Mean calculations include reporting limits substituted for non-detects.
CRM - Clinch River Mile.
mg/kg dw - Milligrams per kilogram dry weight.
NC - Not calculated; not enough detections to calculate mean. Range includes reporting limits.
SD - Standard deviation.
TRM - Tennessee River Mile.

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Table 3. Emergent Aquatic Vegetation ANOVAs

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Number of Samples	FOD	All Sample Reaches[1]		Reaches Grouped By River[2]			
			R^2	P-Value[3]	P-Value[3]	Clinch[4]	Emory[4]	Tennessee[4]
Aluminum	27	100%	0.76	0.0003	0.37	1.00	0.98	0.80
Arsenic	27	59%	0.20	0.795	0.97	0.87	0.88	0.71
Barium	27	100%	0.24	0.688	0.35	0.59	0.33	0.11
Boron	27	100%	0.48	0.091	0.58	0.20	0.47	0.56
Calcium	27	100%	0.44	0.149	0.82	0.48	0.82	0.57
Cobalt	27	100%	0.45	0.141	0.29	1.00	0.97	0.80
Copper	27	100%	0.49	0.080	0.37	0.31	0.96	0.80
Iron	27	100%	0.70	0.002	0.16	1.00	0.99	0.95
Lead	27	70%	0.71	0.001	0.30	1.00	1.00	0.97
Magnesium	27	100%	0.50	0.069	0.76	0.52	0.86	0.51
Manganese	27	100%	0.38	0.259	0.79	0.86	0.52	0.90
Molybdenum	27	100%	0.30	0.493	0.22	0.07	0.19	0.61
Nickel	27	96%	0.54	0.044	0.92	0.84	0.92	0.93
Potassium	27	100%	0.38	0.266	0.94	0.61	0.71	0.56
Strontium	27	100%	0.32	0.424	0.73	0.39	0.50	0.38
Vanadium	27	52%	0.63	0.009	0.09	1.00	1.00	0.93
Zinc	27	100%	0.41	0.202	0.25	1.00	1.00	0.99

Notes: One-way ANOVAs were conducted on log-transformed metal concentrations, with full reporting limit substituted for non-detects.

[1] - ANOVA conducted on individual sample reaches identified by river mile (N=3 samples per reach, 9 reaches).

[2] - ANOVA conducted on reaches grouped by river and reference locations.

[3] - P-value from F-test.

[4] - Post-hoc Dunnett's p-value comparing all impact reaches within a river to all reference locations.

Shading denotes statistical significance ($p<0.05$).

ANOVA - Analysis of variance.

FOD - Frequency of detection.

R^2 - Correlation coefficient.

ARCADIS

Table 4. Shoreline Aquatic Vegetation ANOVAs

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Number of Samples	FOD	All Sample Reaches[1]		Reaches Grouped By River[2]			
			R^2	P-Value[3]	P-Value[3]	Clinch[4]	Emory[4]	Tennessee[4]
Aluminum	27	100%	0.57	0.02	0.18	0.93	0.99	1.00
Barium	27	100%	0.42	0.18	0.40	0.99	0.58	0.80
Boron	27	100%	0.66	0.005	0.07	0.60	0.92	1.00
Calcium	27	100%	0.52	0.06	0.12	0.84	0.99	1.00
Cobalt	27	93%	0.32	0.43	0.48	0.94	0.63	0.98
Copper	27	100%	0.60	0.01	0.07	0.98	1.00	0.99
Iron	27	100%	0.47	0.11	0.39	0.98	0.98	1.00
Lead	27	78%	0.39	0.25	0.38	0.89	1.00	0.91
Magnesium	27	100%	0.43	0.17	0.02	1.00	1.00	1.00
Manganese	27	100%	0.83	<0.0001	0.08	1.00	0.69	0.66
Molybdenum	27	96%	0.25	0.65	0.35	0.15	0.82	0.60
Nickel	27	96%	0.56	0.03	0.11	1.00	0.80	0.98
Potassium	27	100%	0.19	0.82	0.70	0.94	0.98	0.95
Strontium	27	100%	0.56	0.03	0.15	0.92	0.43	1.00
Zinc	27	81%	0.69	0.002	0.005	1.00	0.99	0.02

Notes: One-way ANOVAs were conducted on log-transformed metal concentrations, with full reporting limit substituted for non-detects.

[1] - ANOVA conducted on individual sample reaches identified by river mile (N=3 samples per reach, 9 reaches).

[2] - ANOVA conducted on reaches grouped by river and reference locations.

[3] - P-value from F-test.

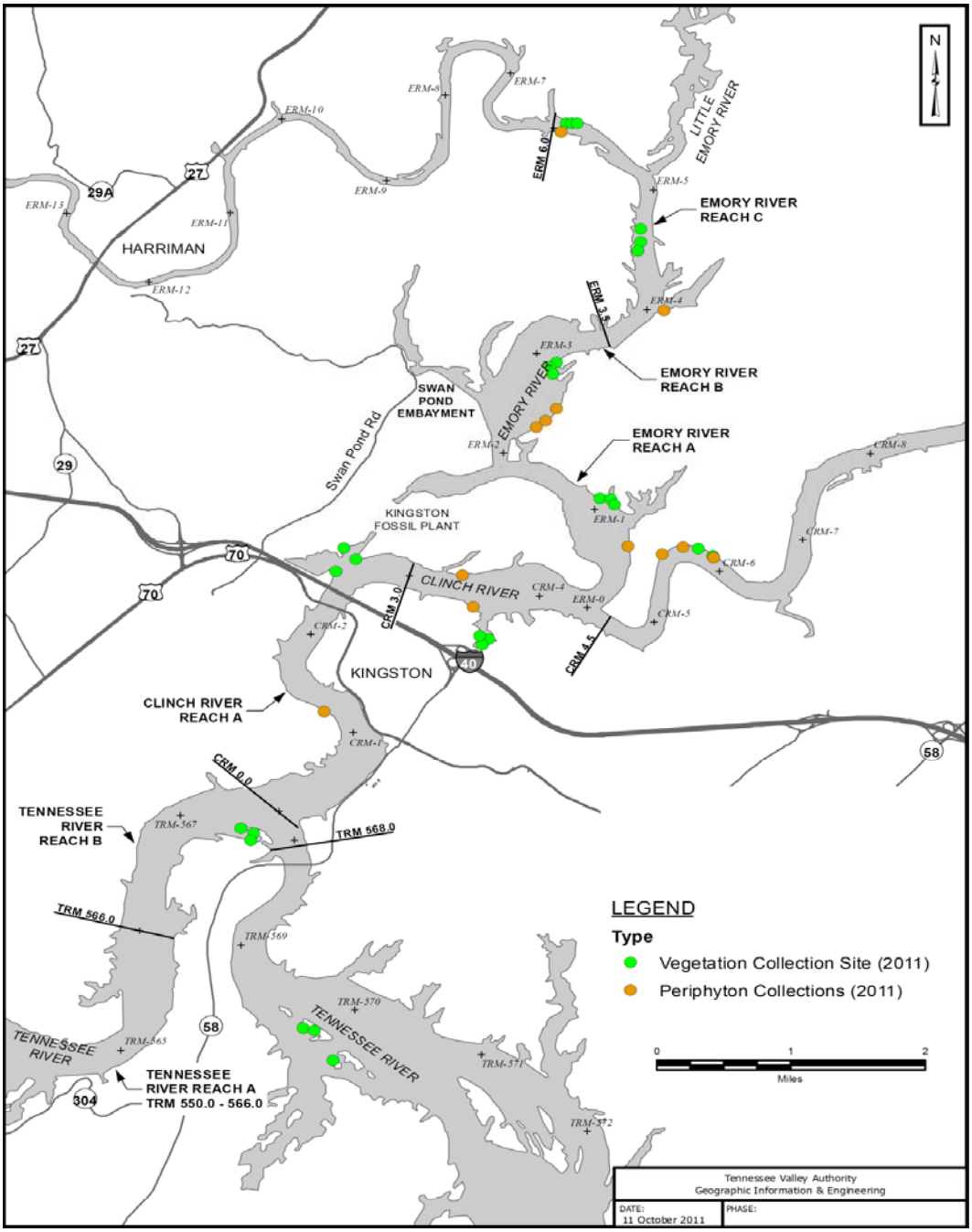
[4] - Post-hoc Dunnett's p-value comparing all impact reaches within a river to all reference locations.

Shading denotes statistical significance ($p<0.05$).

ANOVA - Analysis of variance.

FOD - Frequency of detection.

R^2 - Correlation coefficient.



TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

AQUATIC VEGETATION AND PERIPHYTON SAMPLING LOCATIONS - 2011

ARCADIS

FIGURE
1

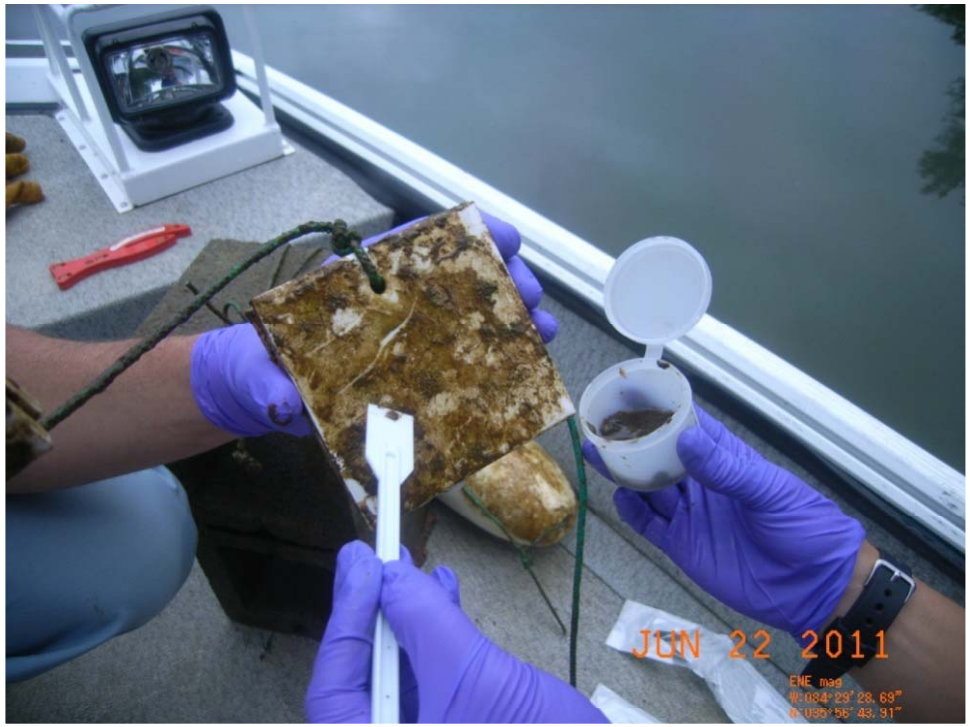
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

AQUATIC VEGETATION SAMPLING

ARCADIS

FIGURE
2



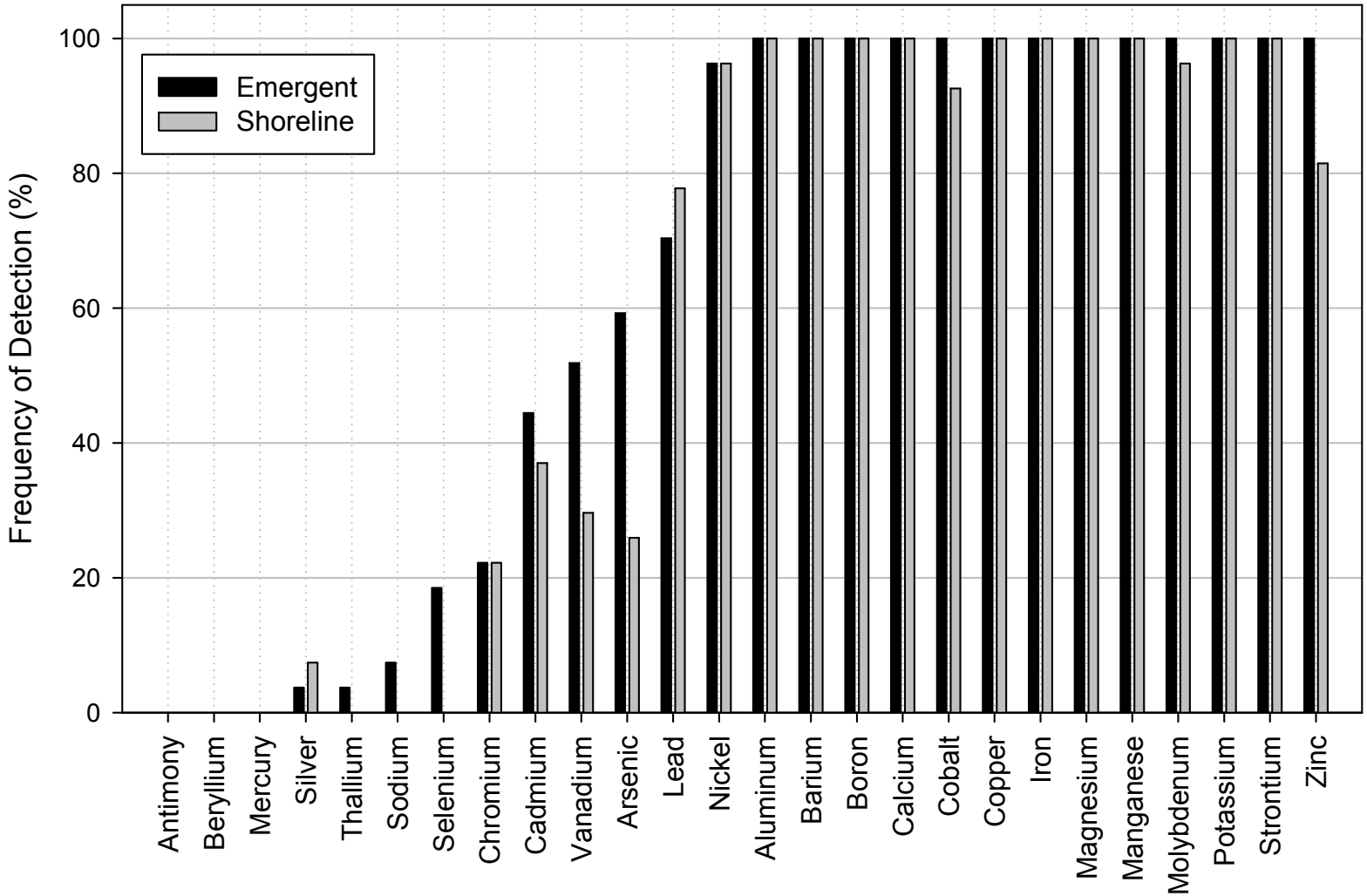
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

FIELD CREW SAMPLING PERIPHYTON

ARCADIS

FIGURE
3



Note: Totals samples = 27 for each constituent

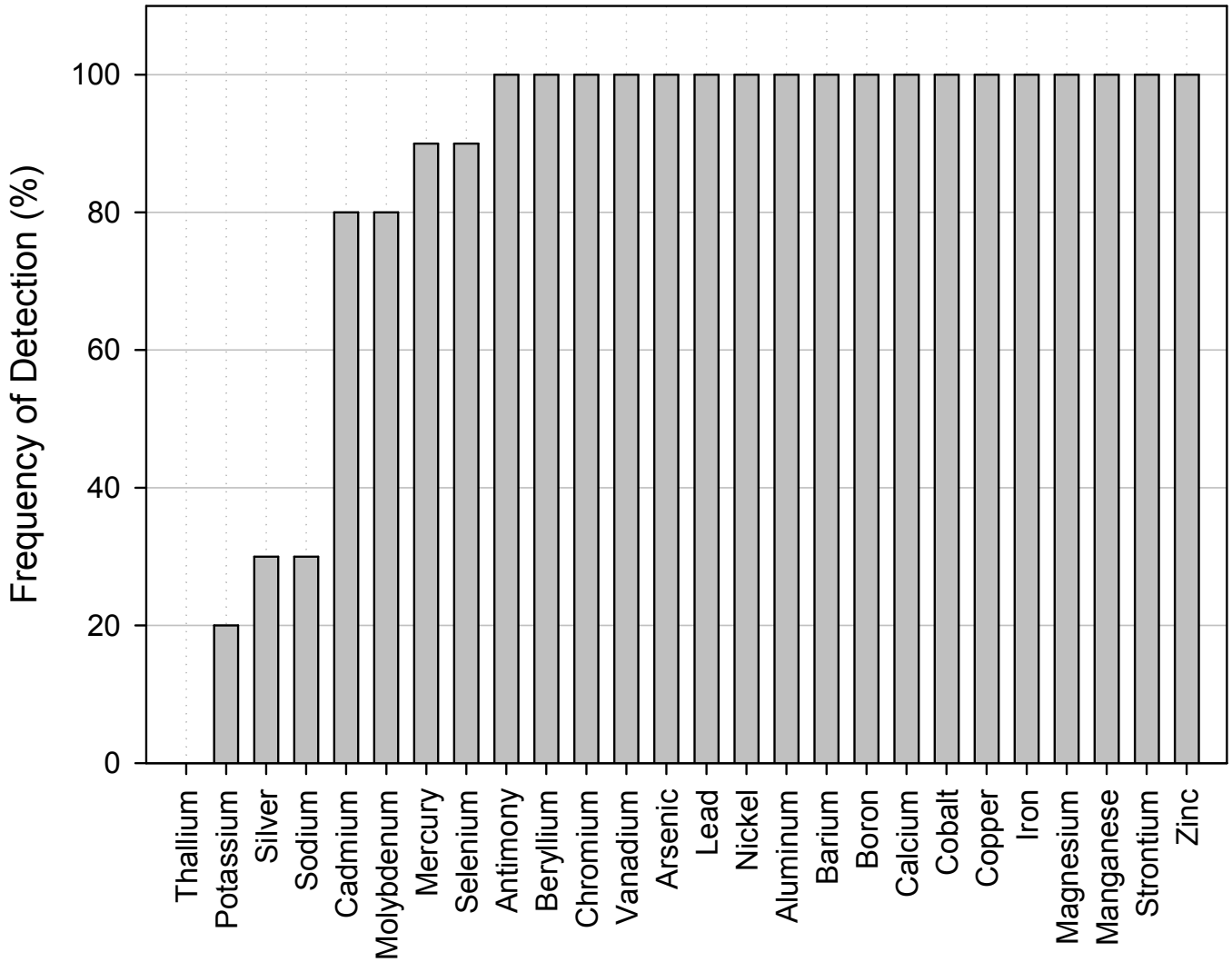
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

FREQUENCY OF DETECTED TRACE ELEMENTS IN EMERGENT AND SHORELINE VEGETATION

ARCADIS

FIGURE
4



Note: Totals samples = 10 for each constituent

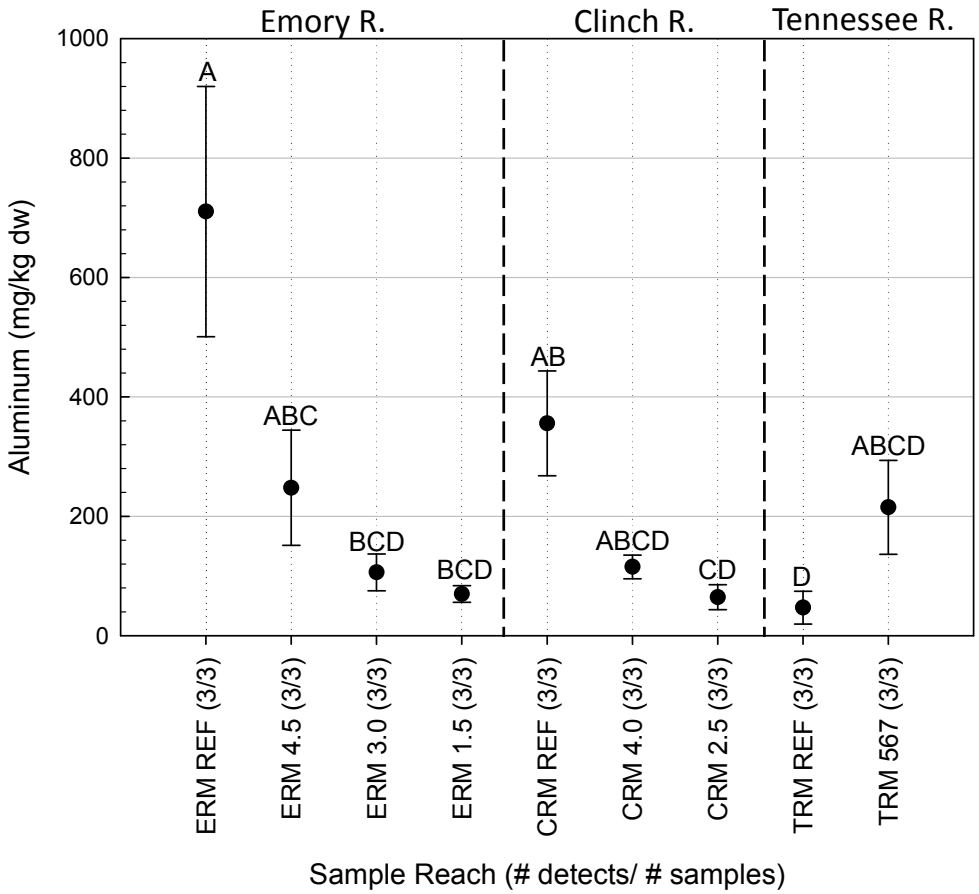
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

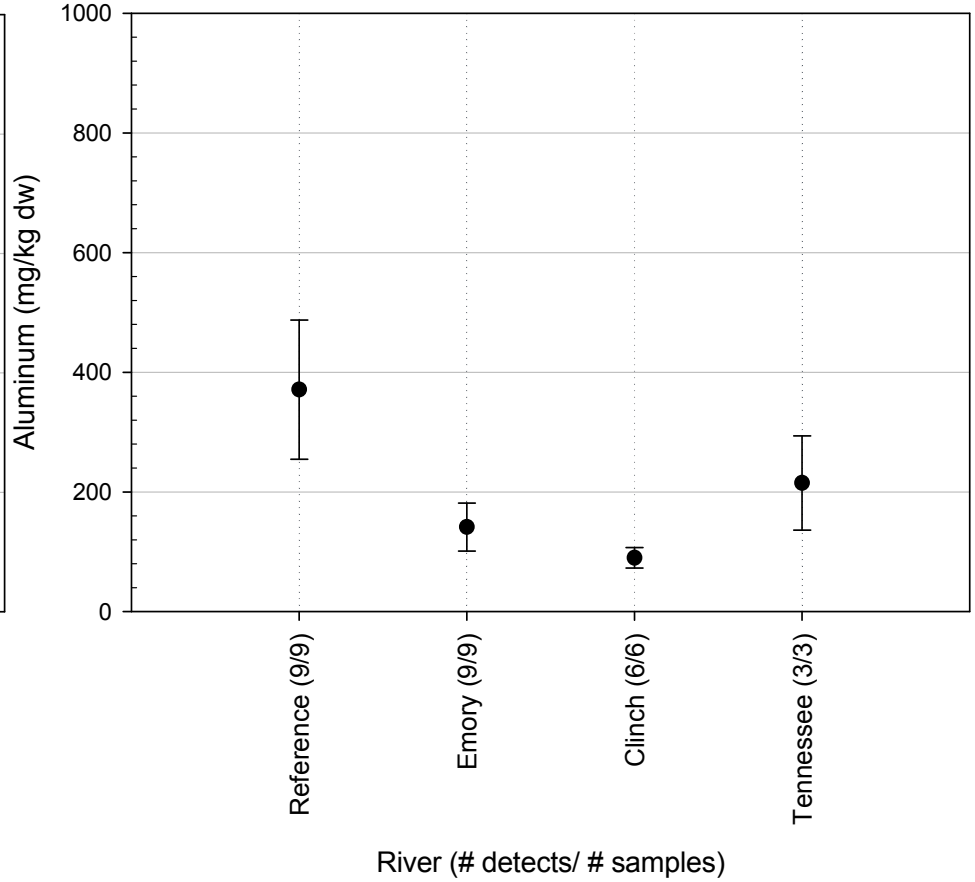
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

FREQUENCY OF DETECTED TRACE ELEMENTS IN PERIPHYTON

ARCADIS

FIGURE
5





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
CRM = Clinch River Mile.
ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

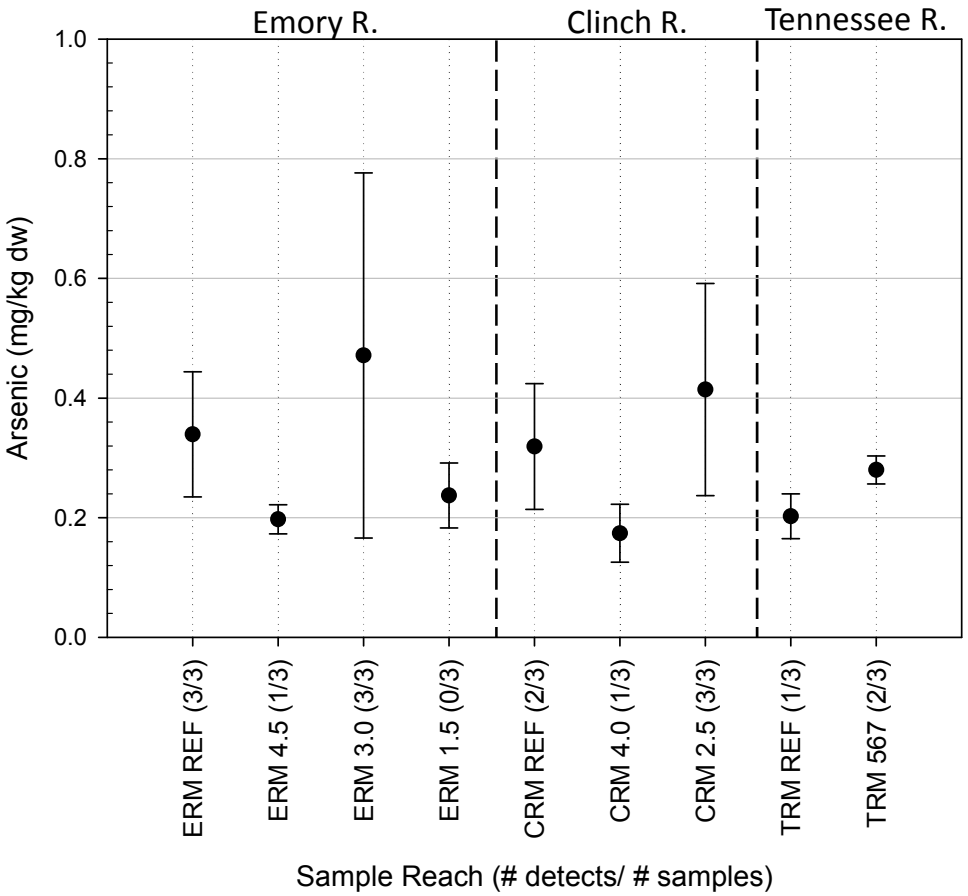
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

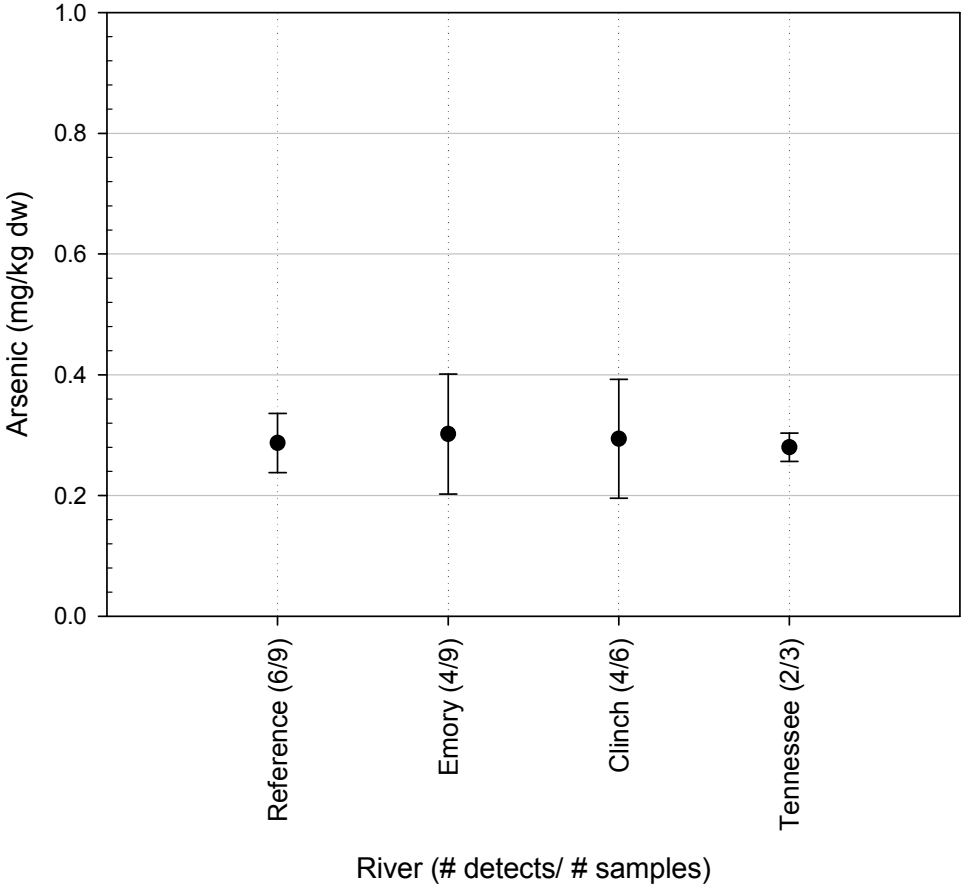
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN ALUMINUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
6





Note: Mean ± standard error.
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Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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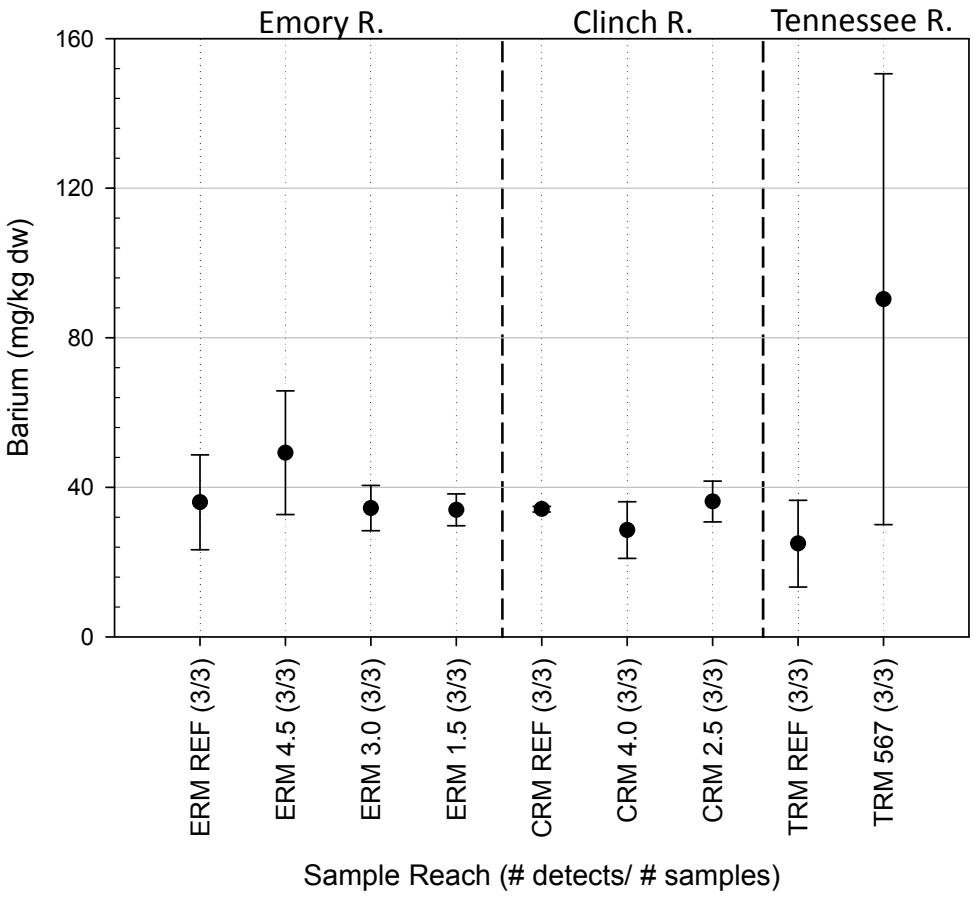
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

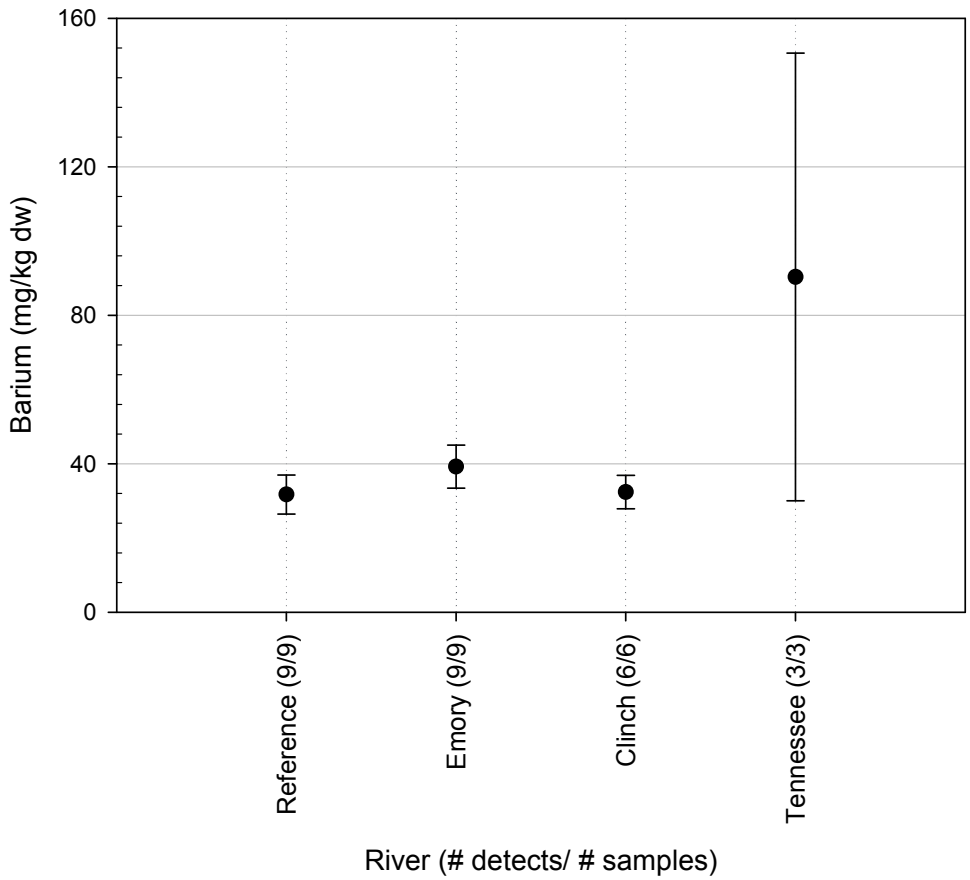
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN ARSENIC CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
7





Note: Mean ± standard error.
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Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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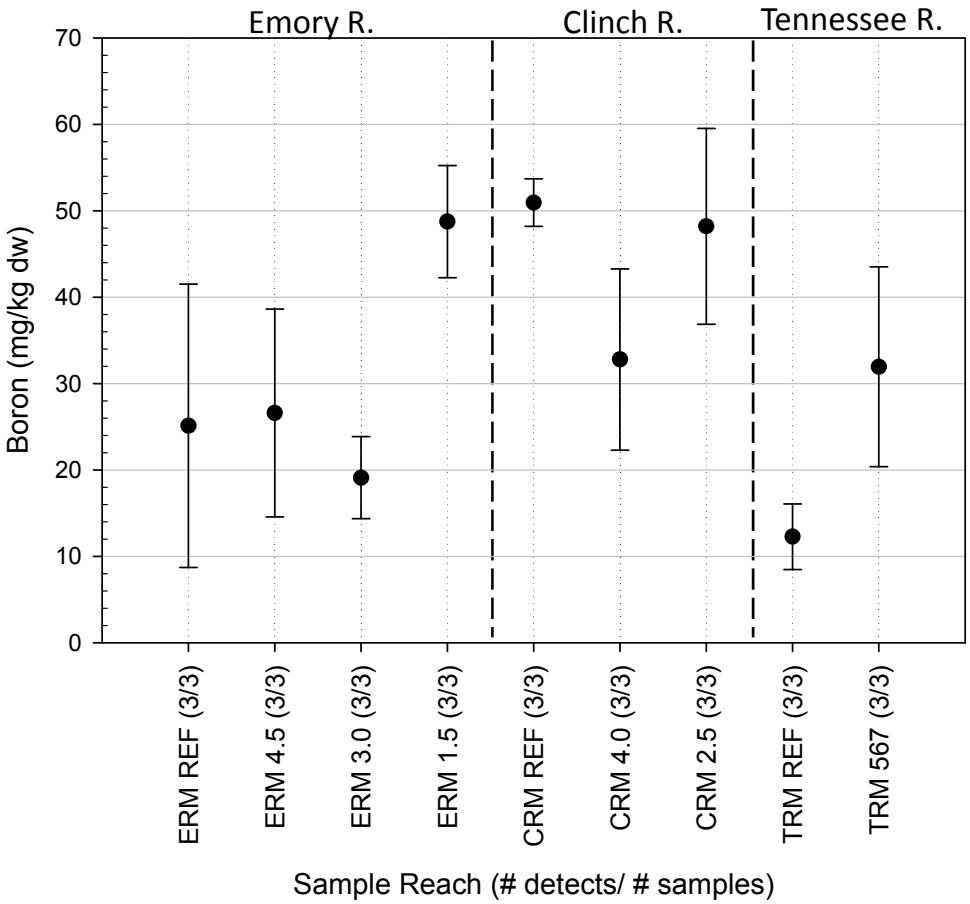
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

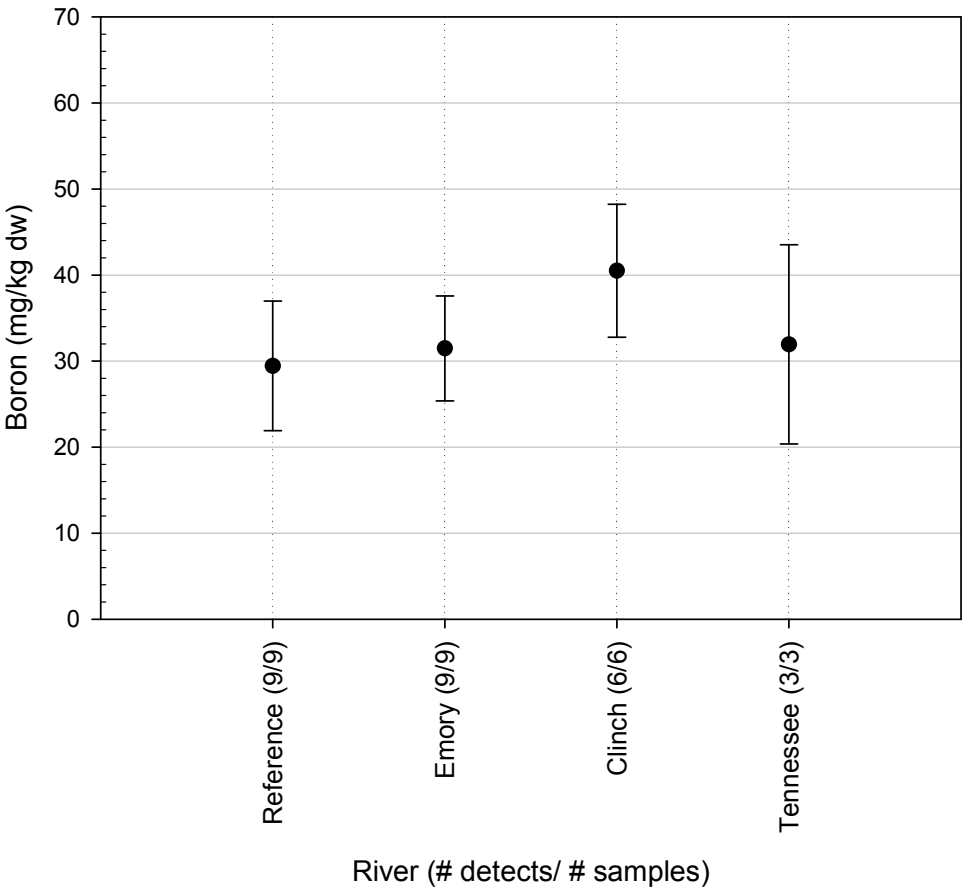
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN BARIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
8





Note: Mean ± standard error.
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Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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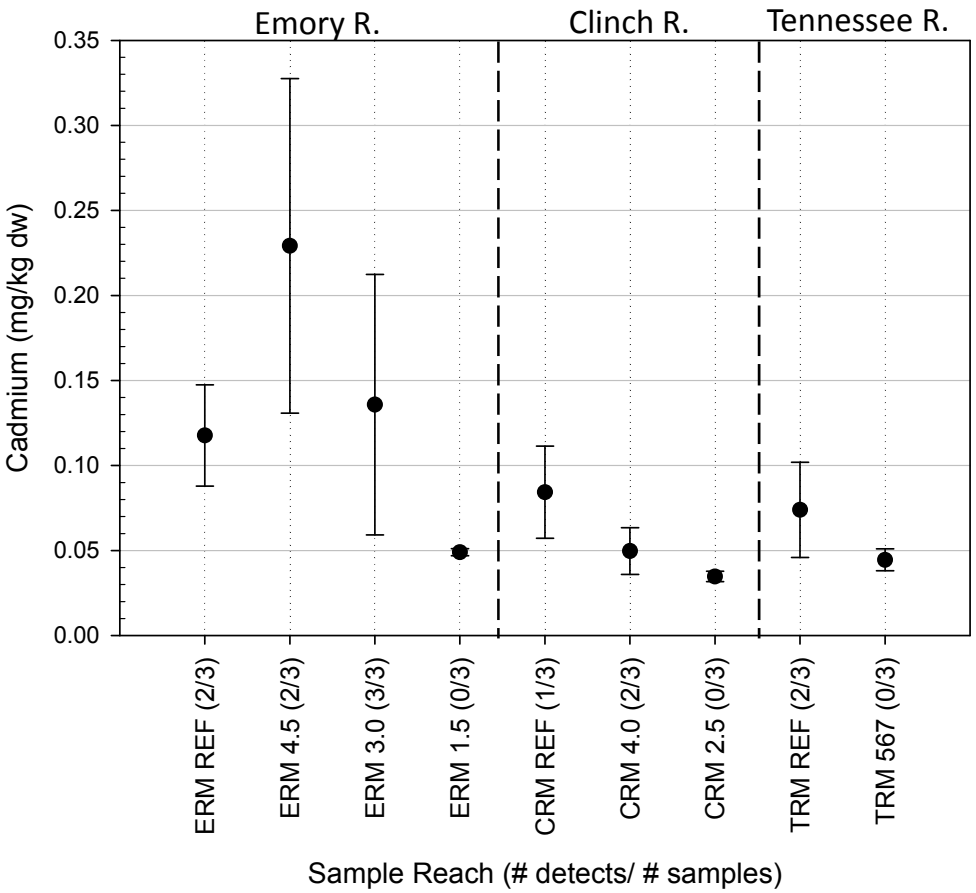
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

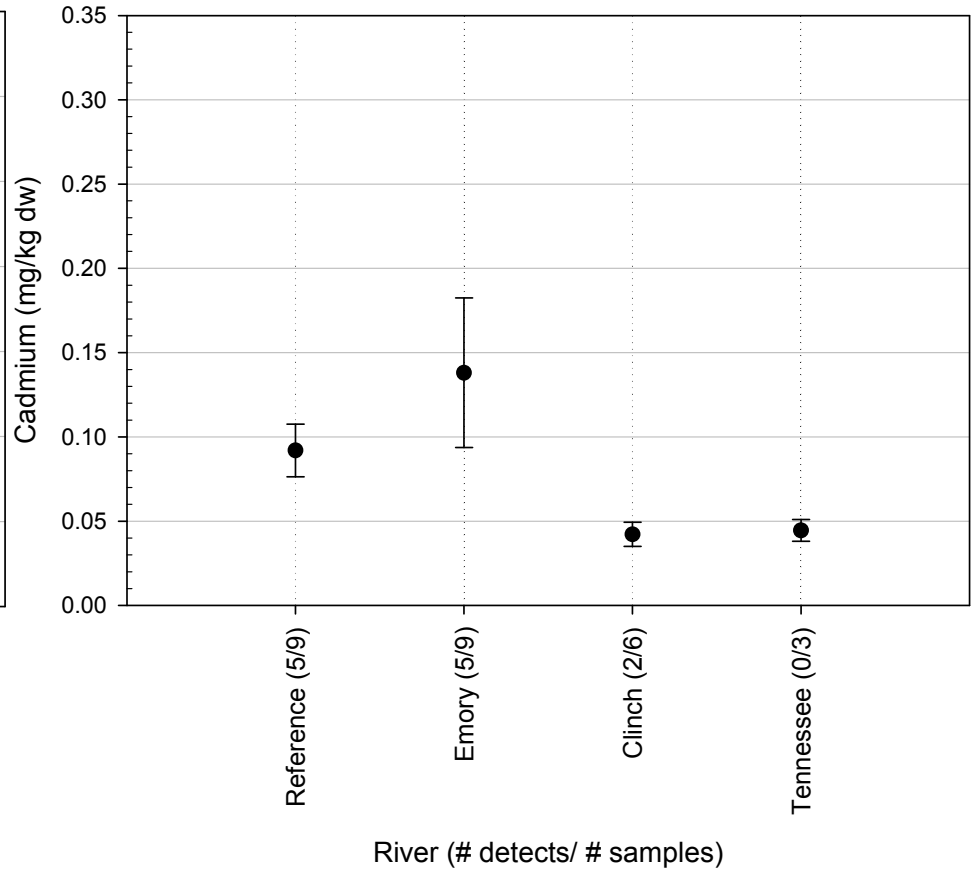
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN BORON CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
9





Note: Mean ± standard error.
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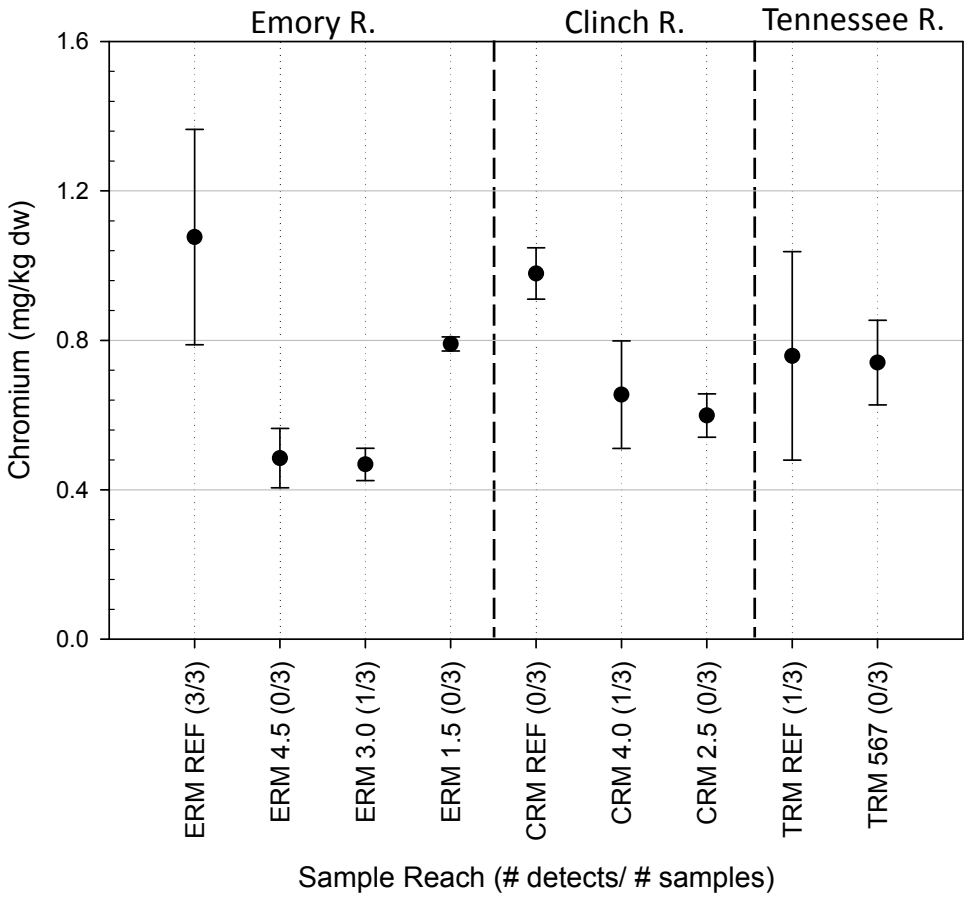
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

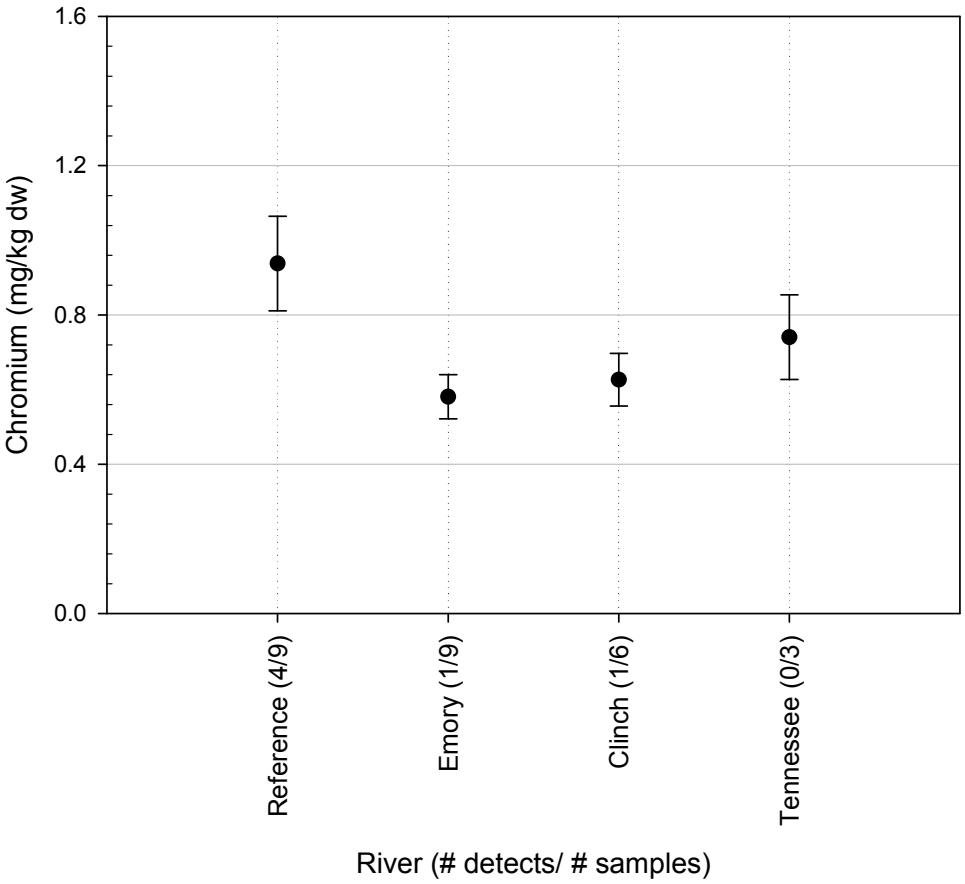
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN CADMIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
10





Note: Mean ± standard error.
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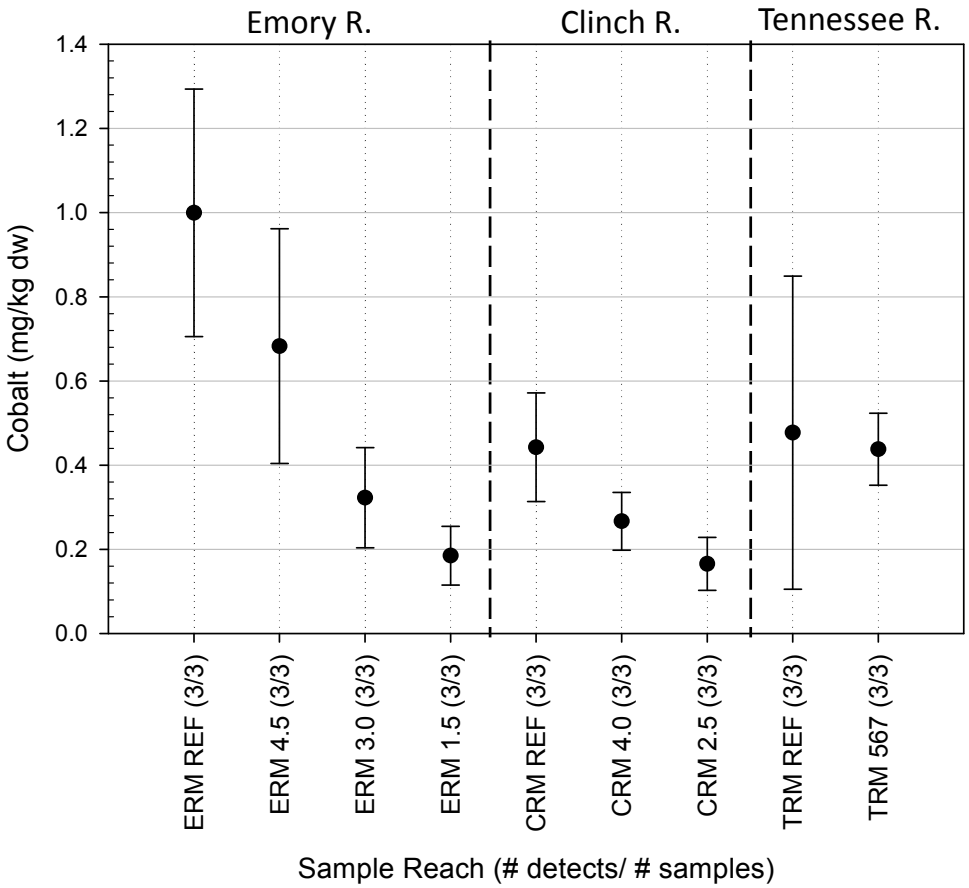
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

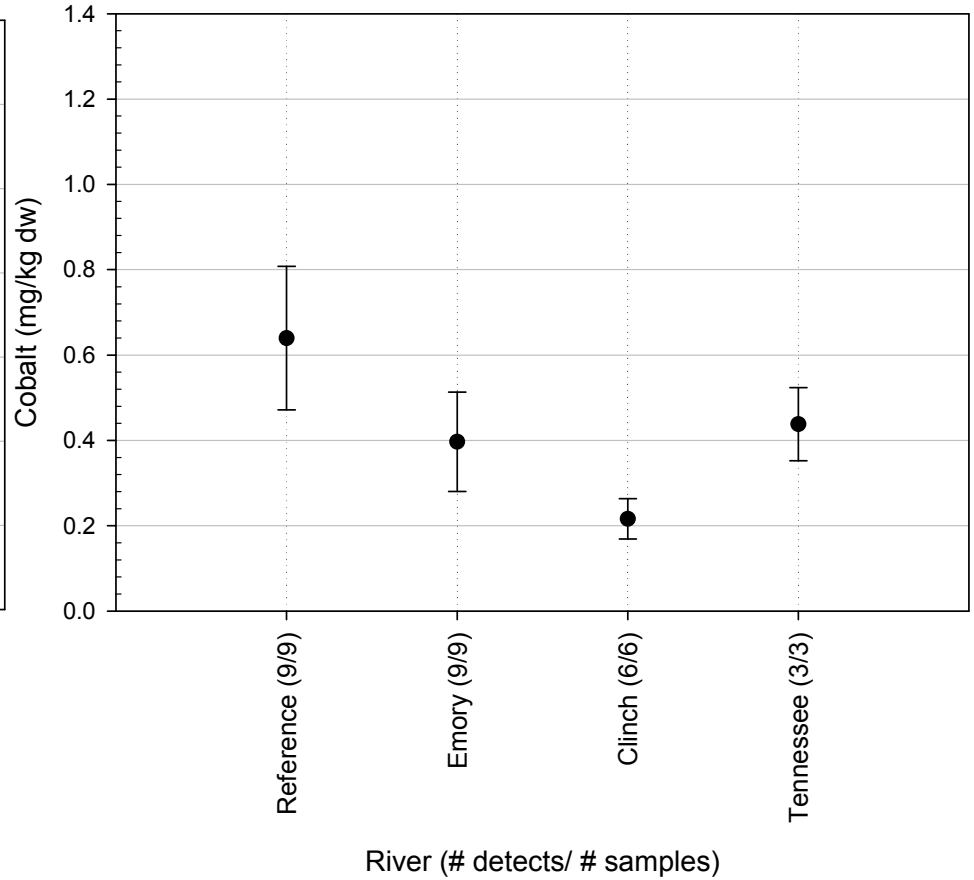
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN CHROMIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
11





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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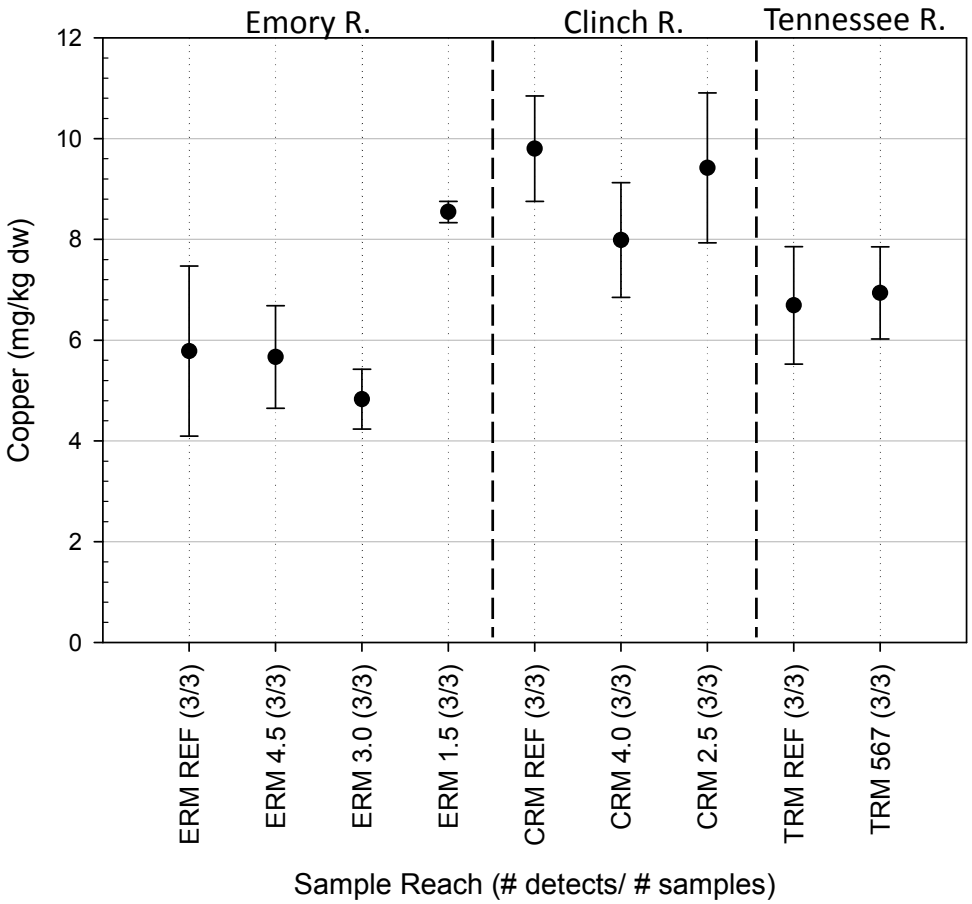
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

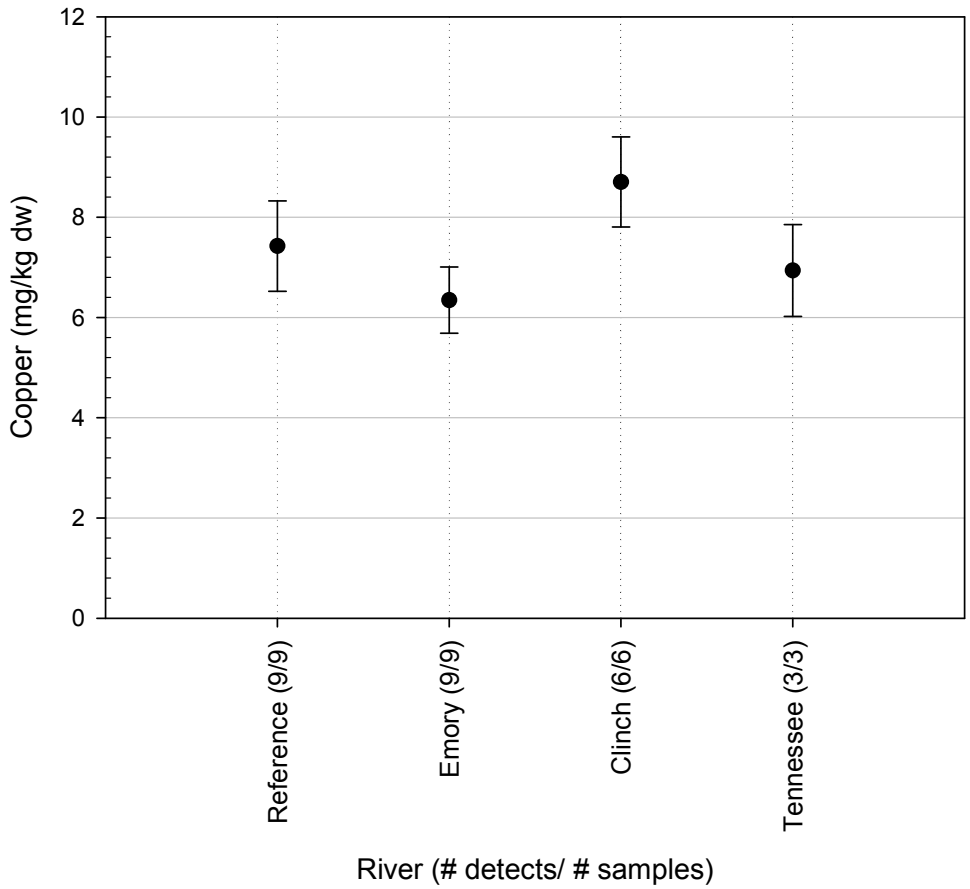
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN COBALT CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
12





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

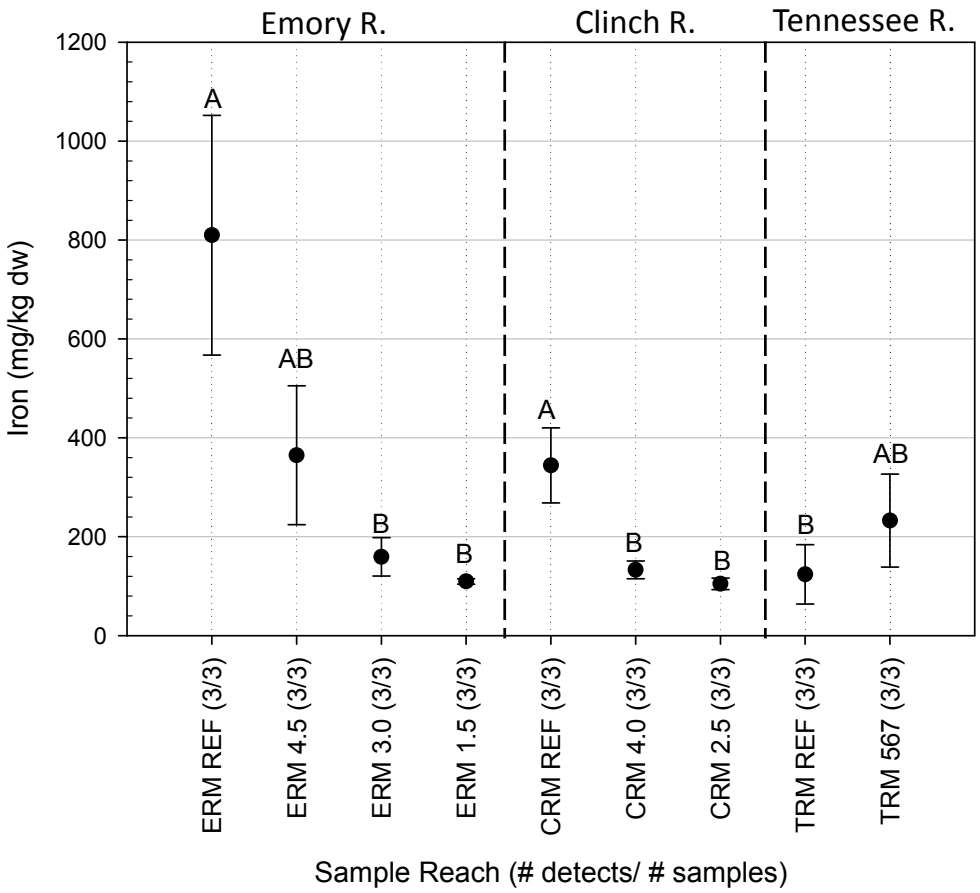
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

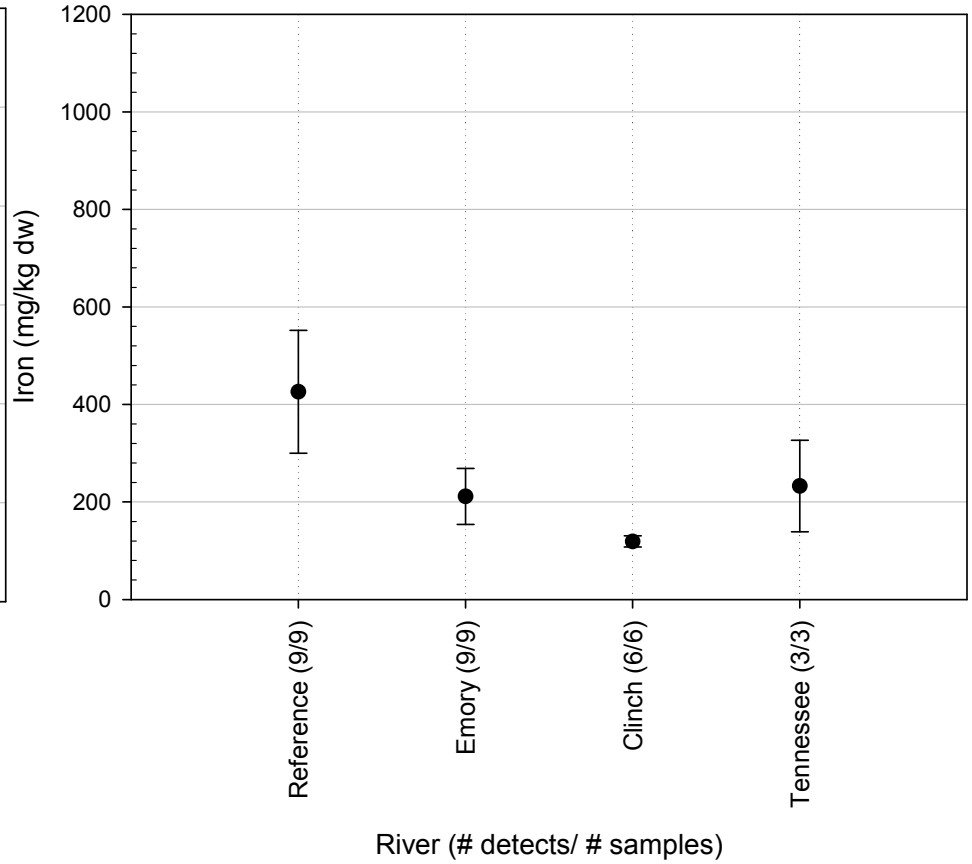
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN COPPER CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
13





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
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ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

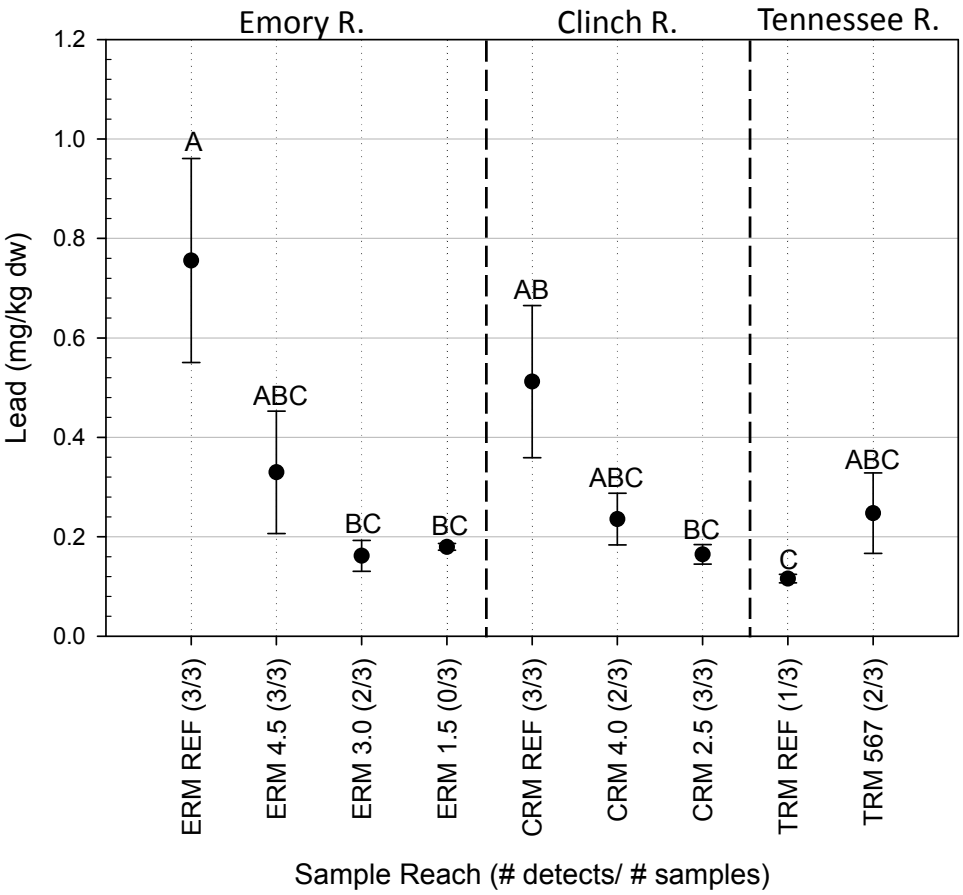
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

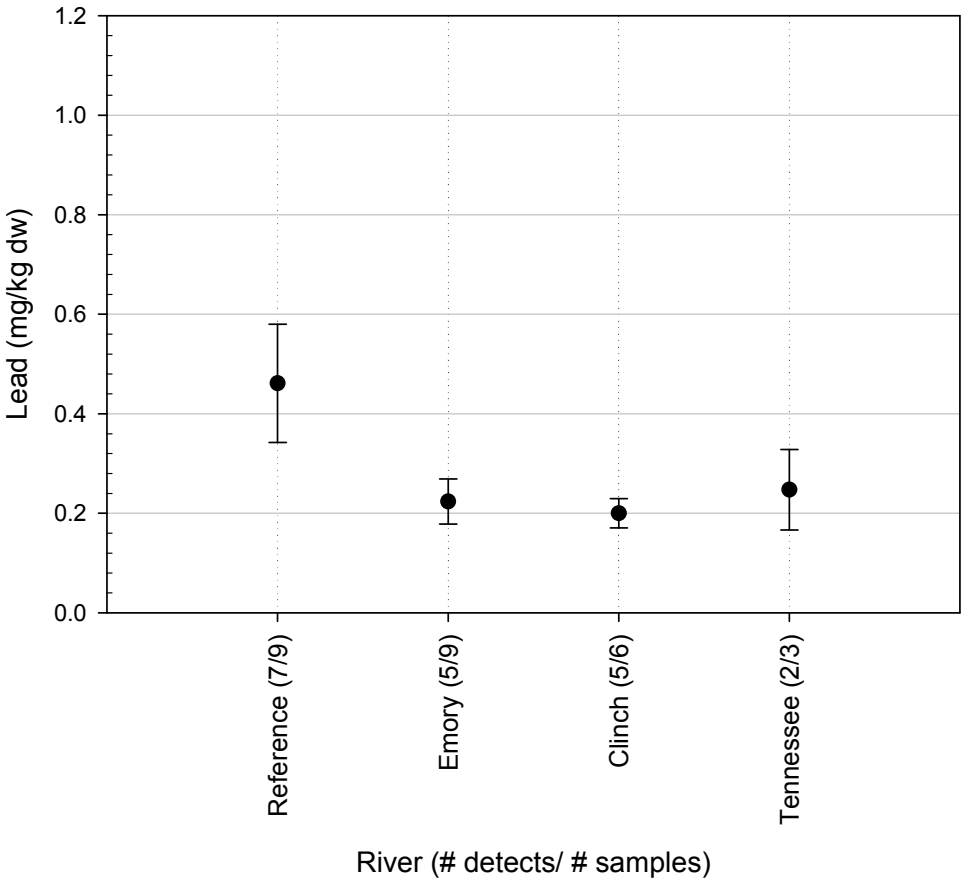
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN IRON CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
14





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

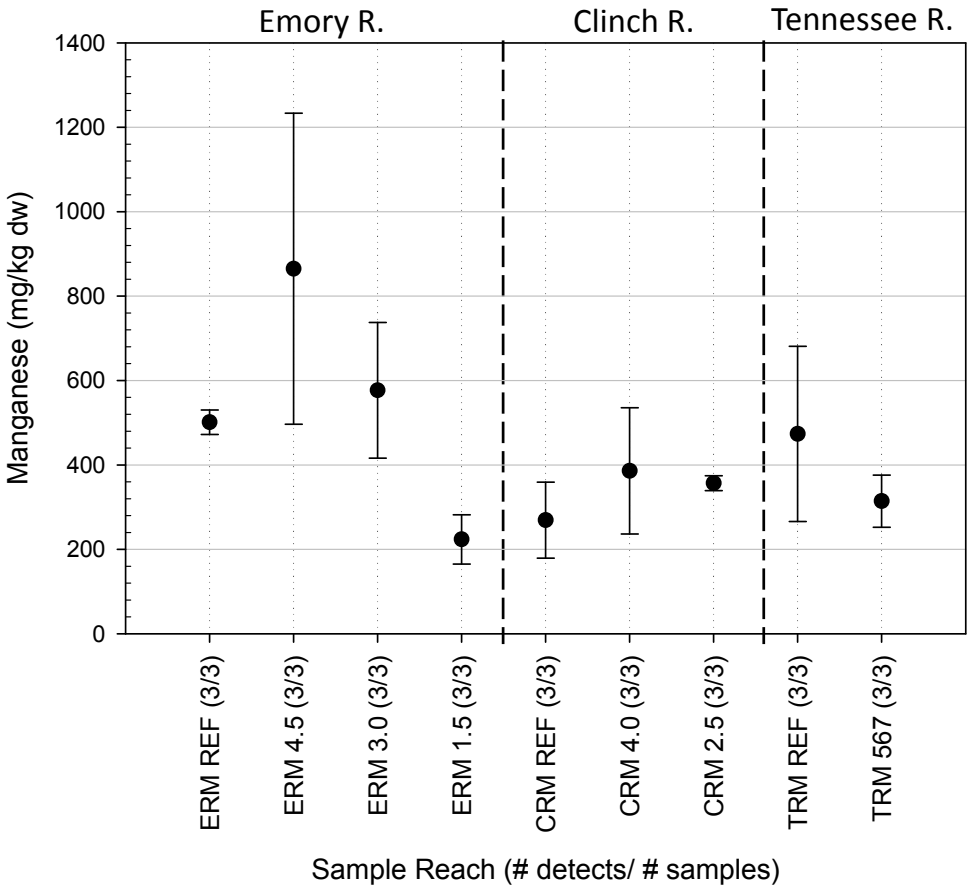
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

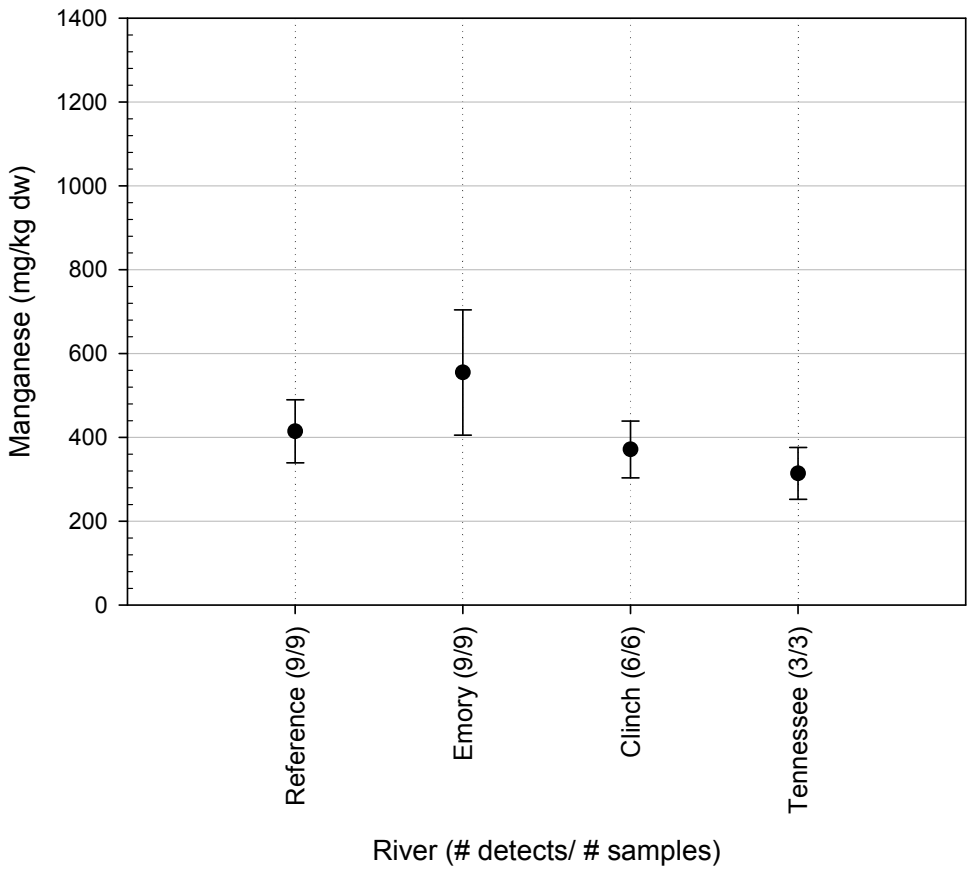
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN LEAD CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
15





Note: Mean ± standard error.
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Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

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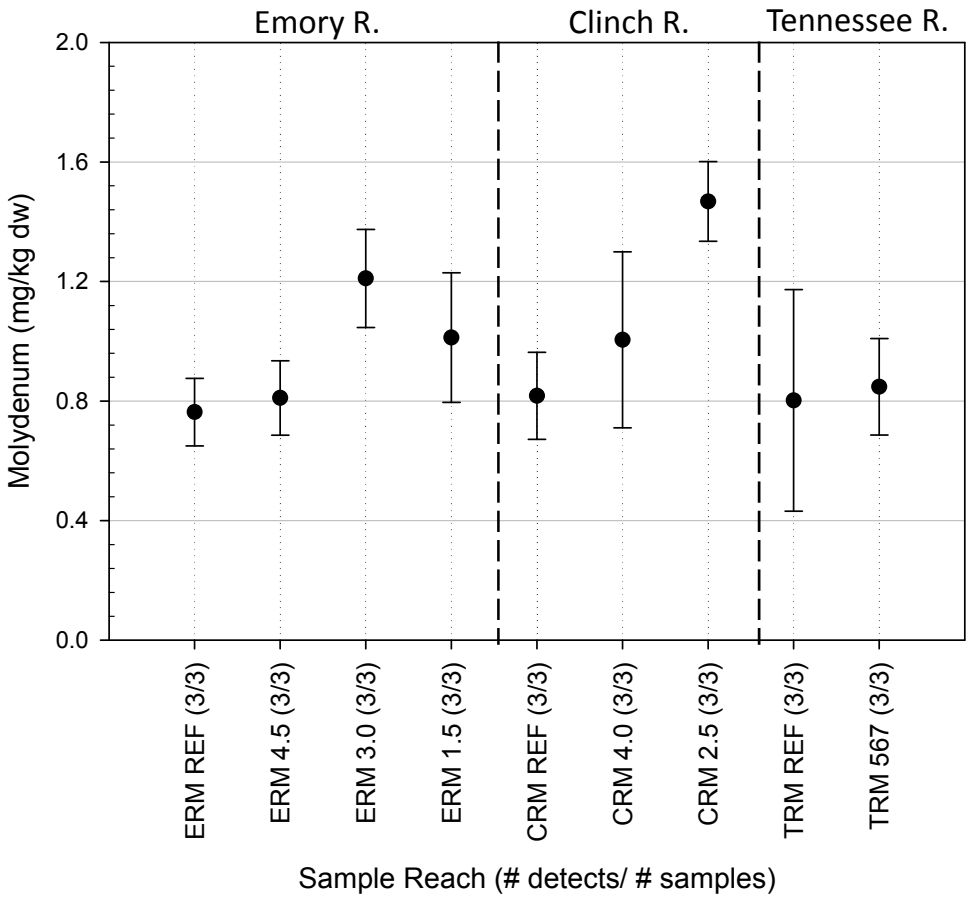
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

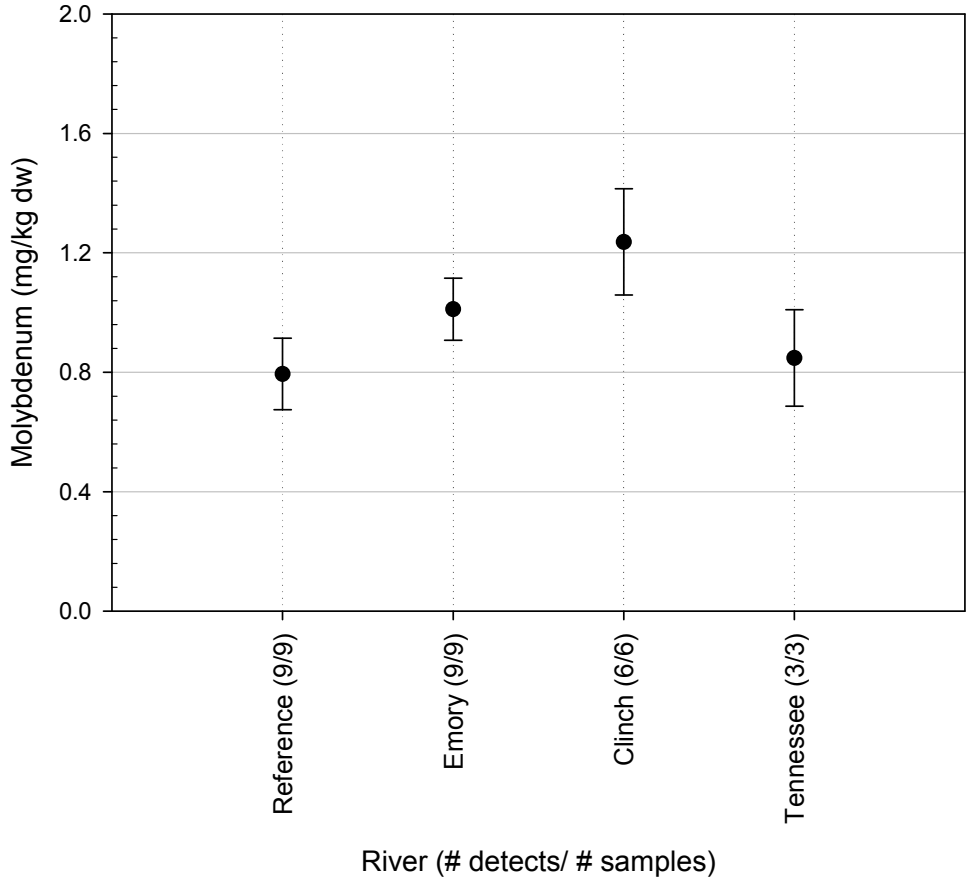
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN MANGANESE CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
16





Note: Mean ± standard error.
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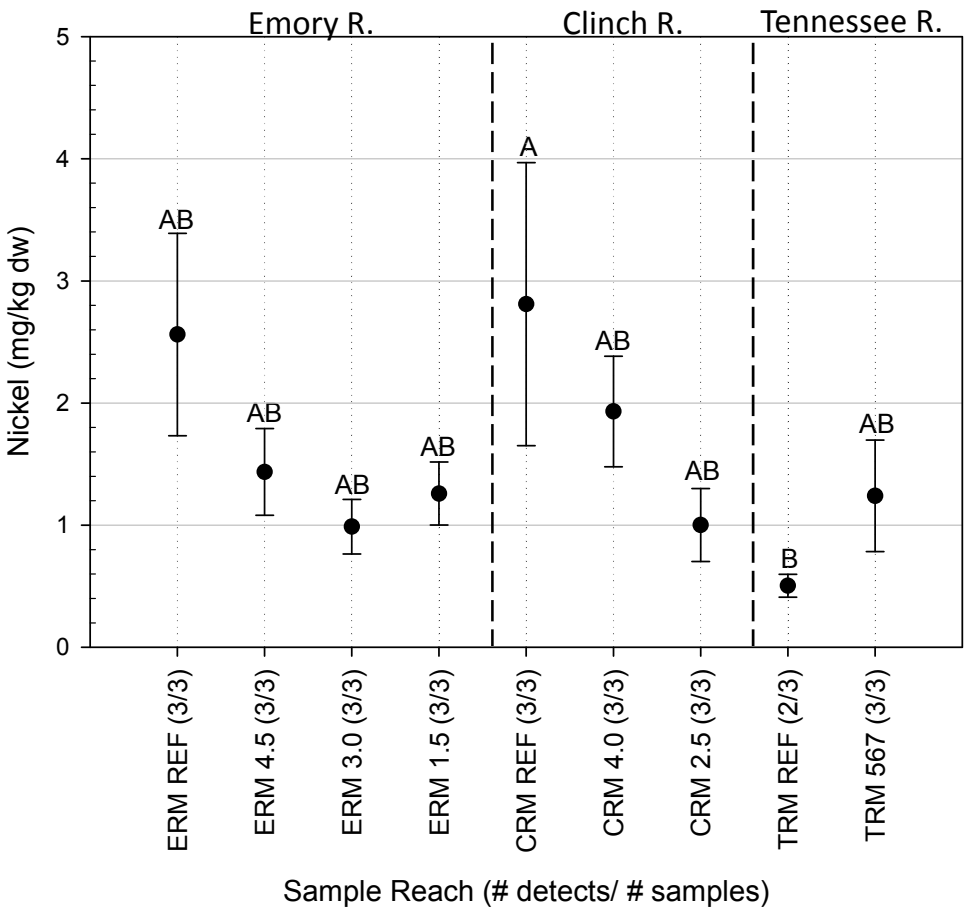
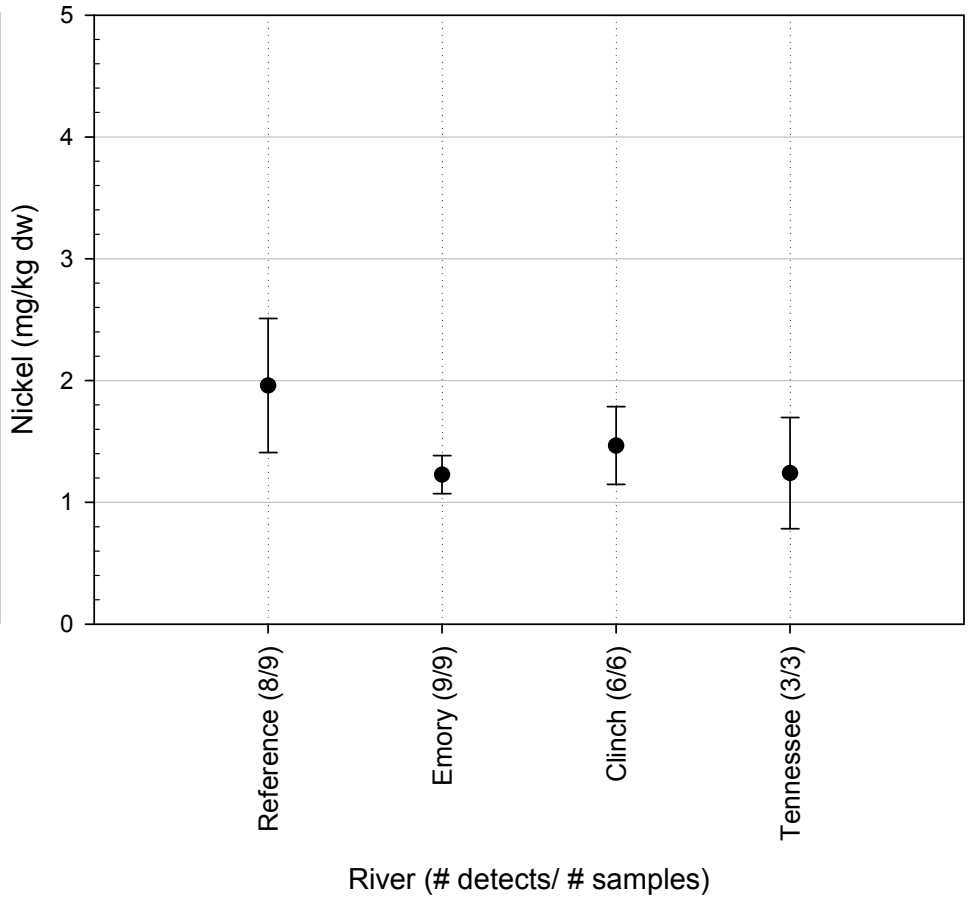
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN MOLYBDENUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
17





Note: Mean ± standard error.
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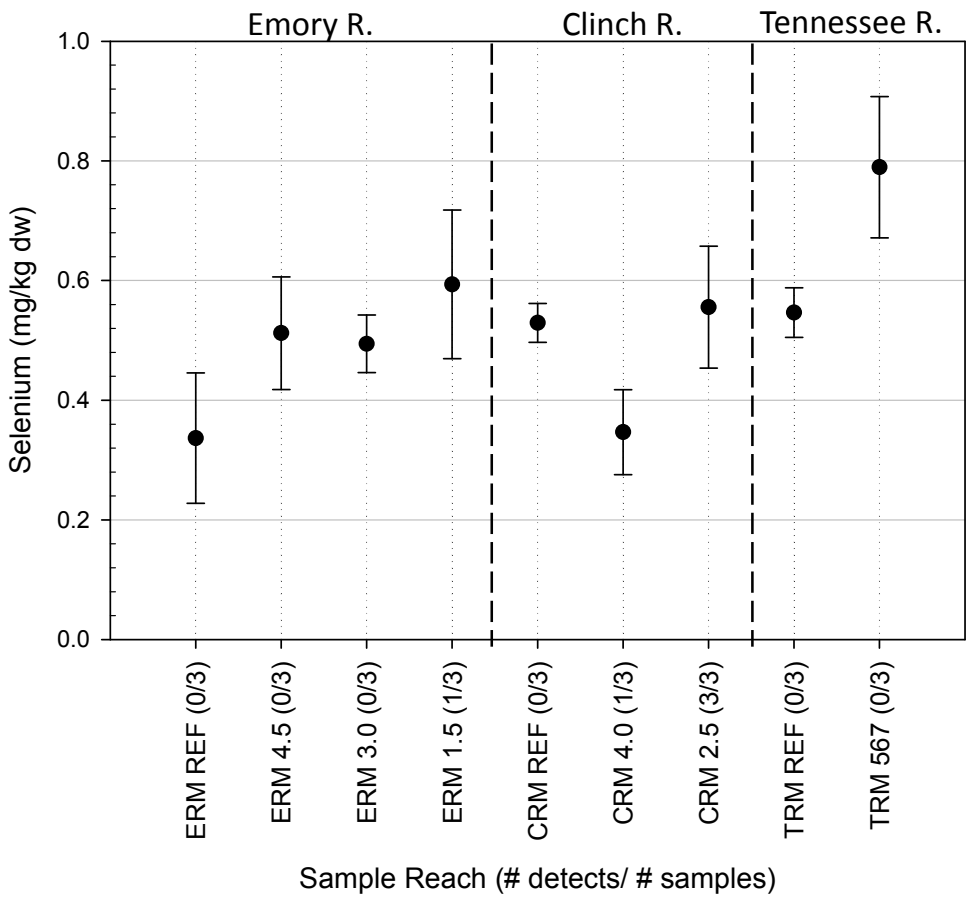
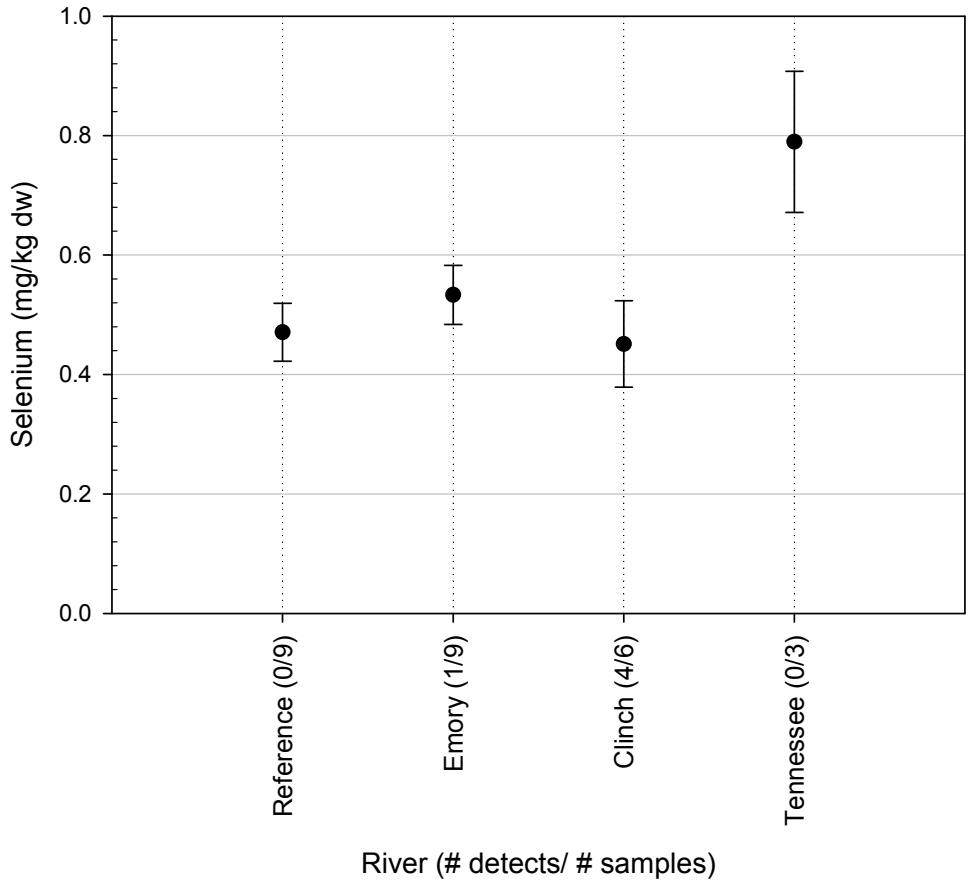
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN NICKEL CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
18





Note: Mean ± standard error.
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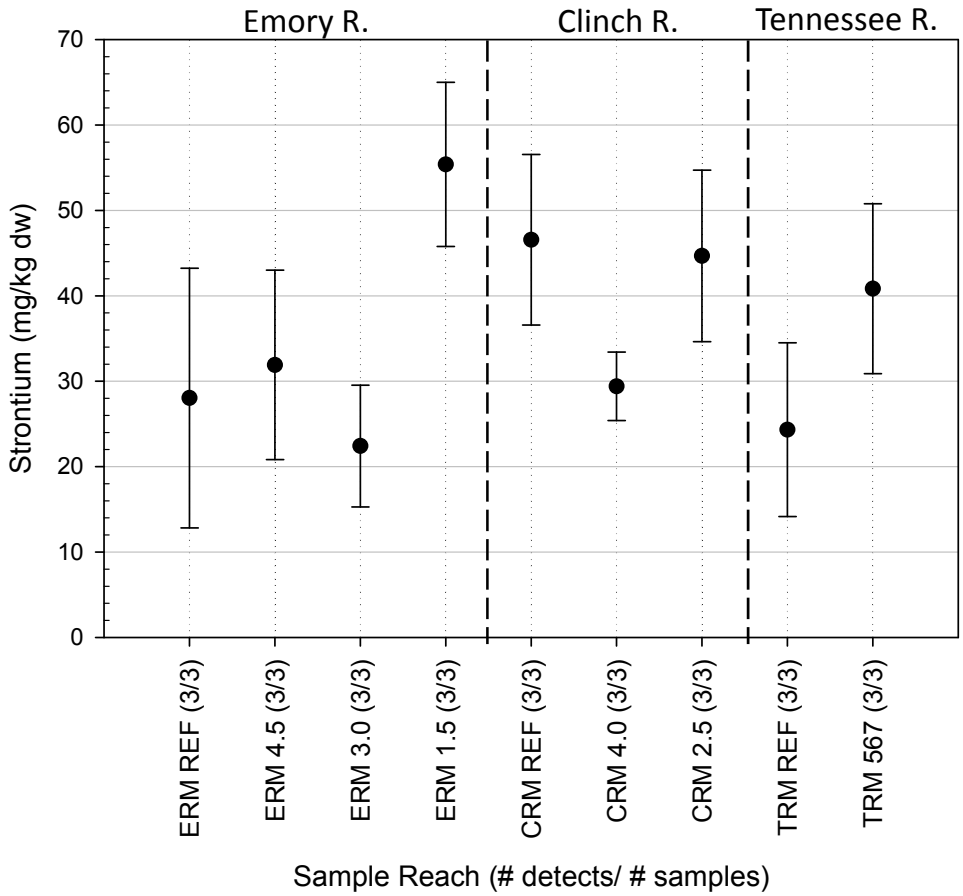
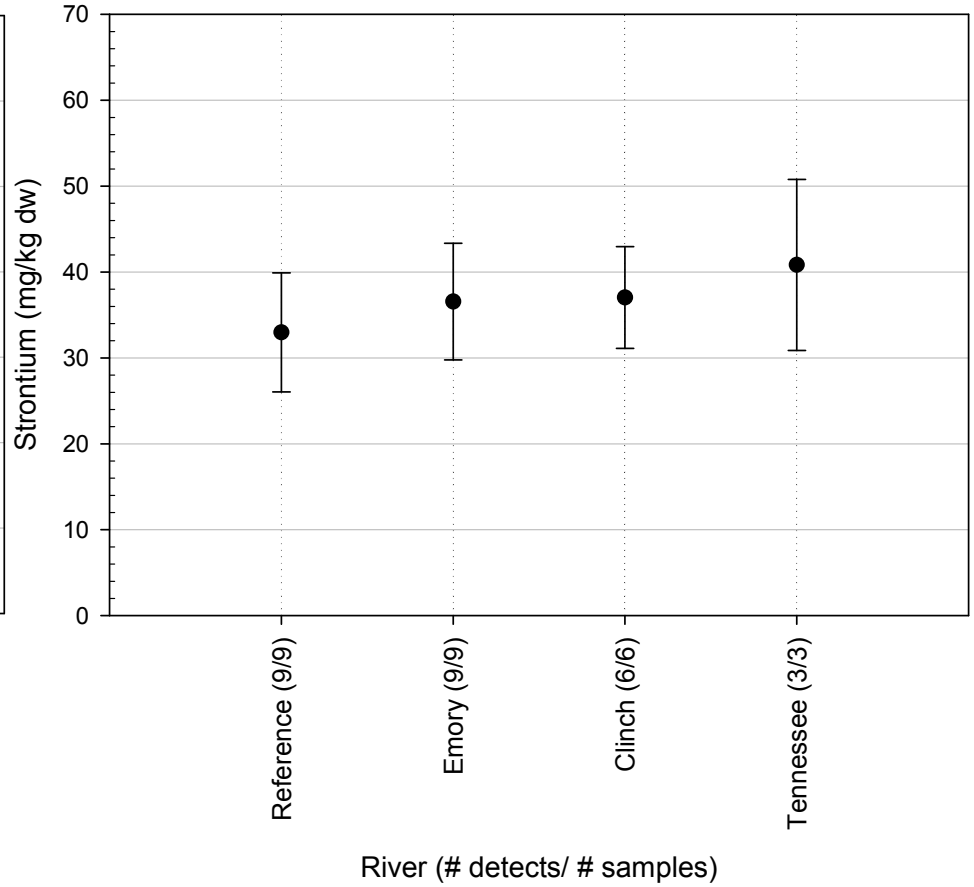
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN SELENIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
19





Note: Mean ± standard error.
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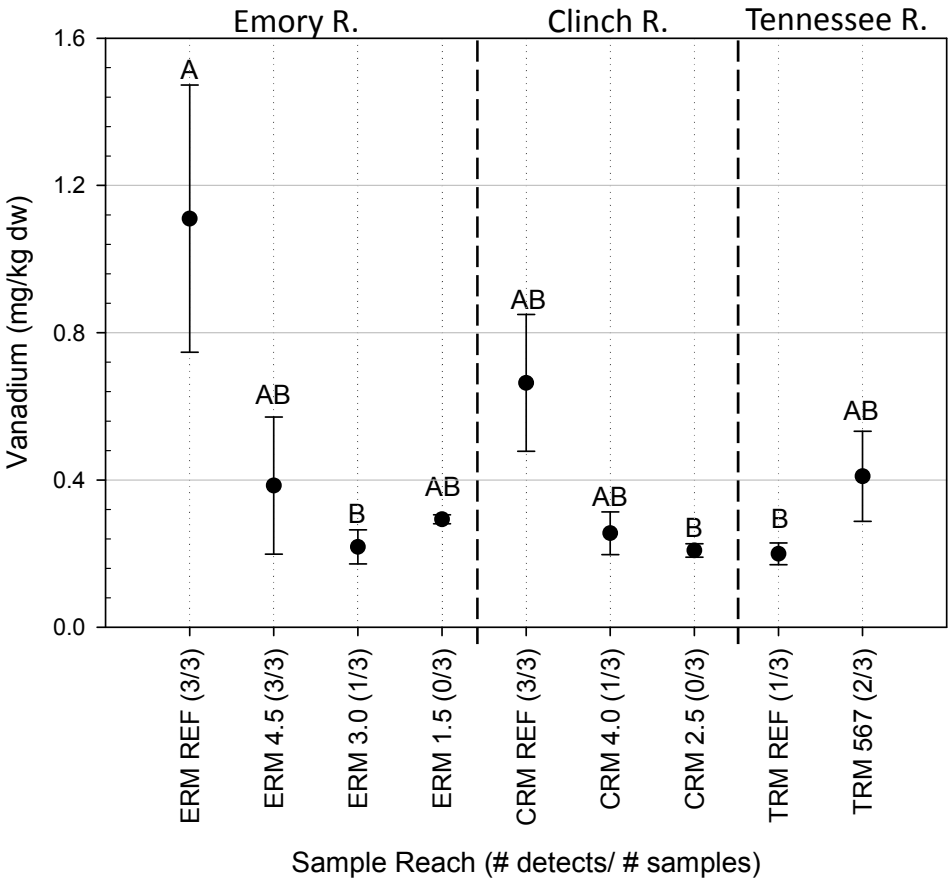
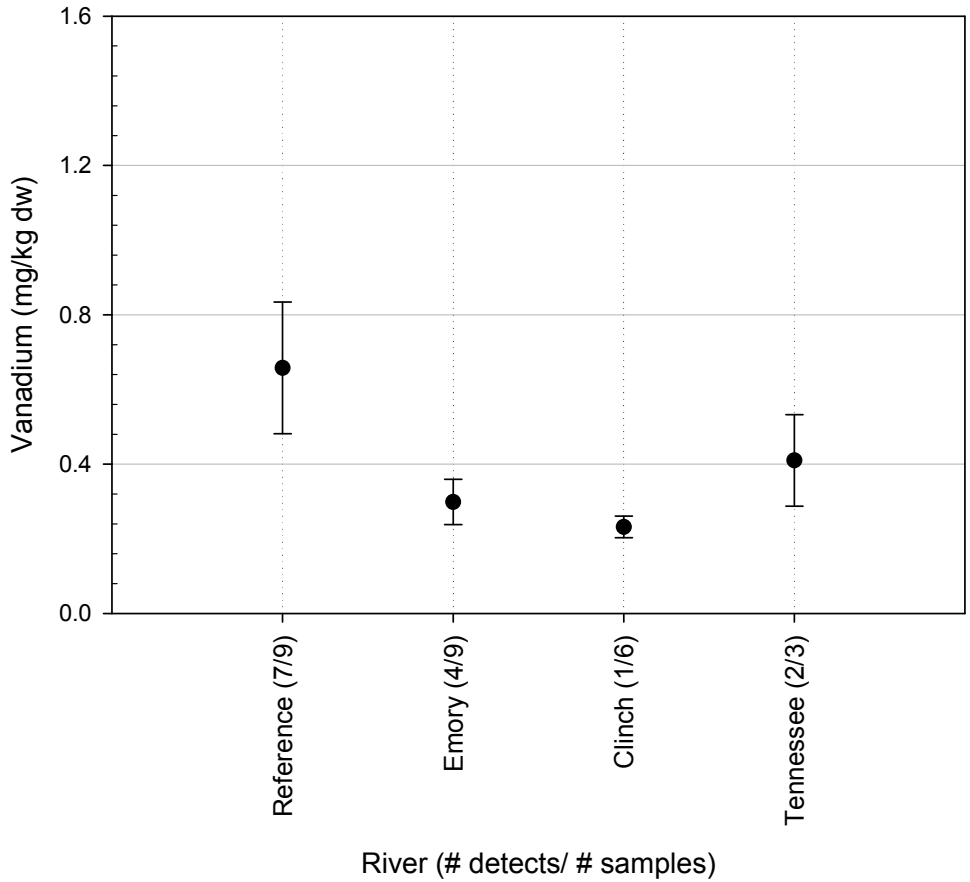
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN STRONTIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
20





Note: Mean ± standard error.
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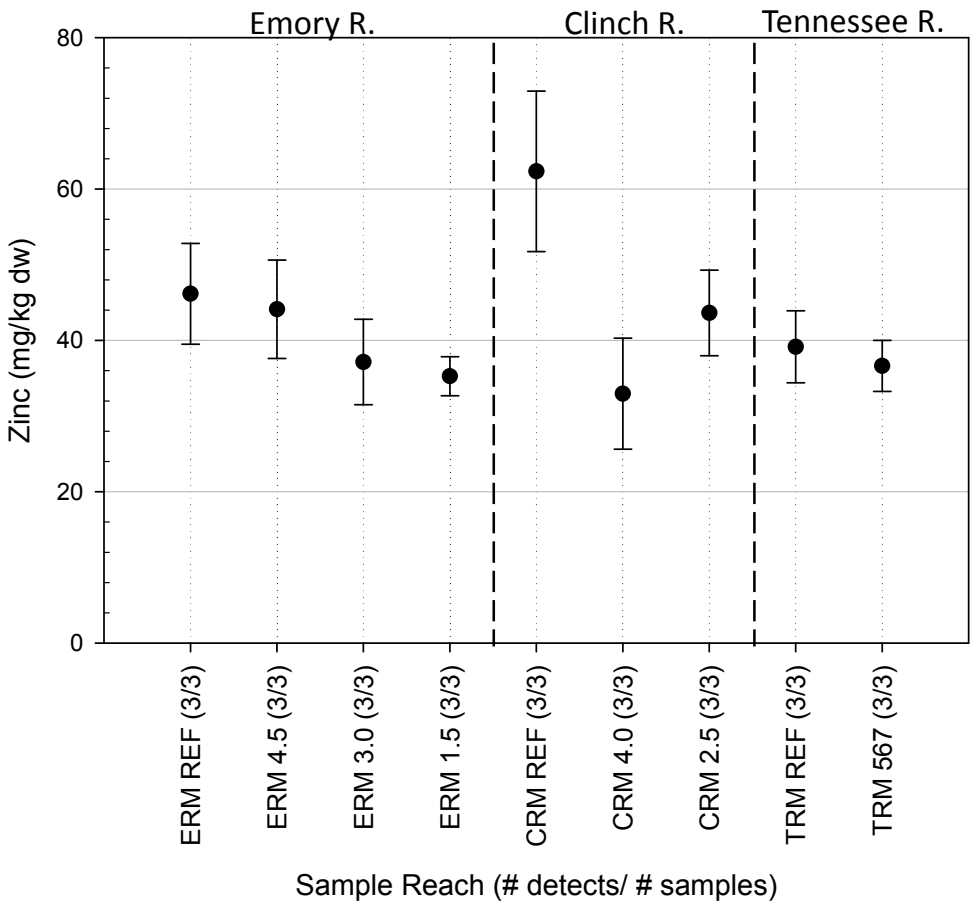
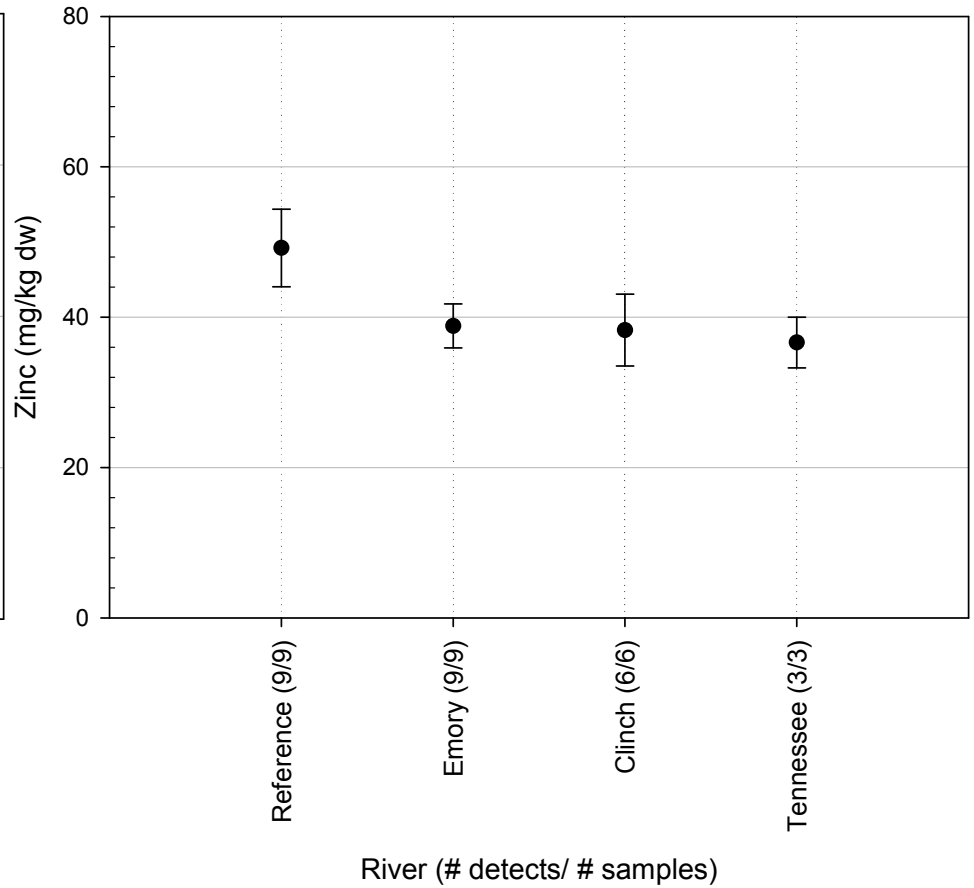
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN VANADIUM CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
21





Note: Mean ± standard error.
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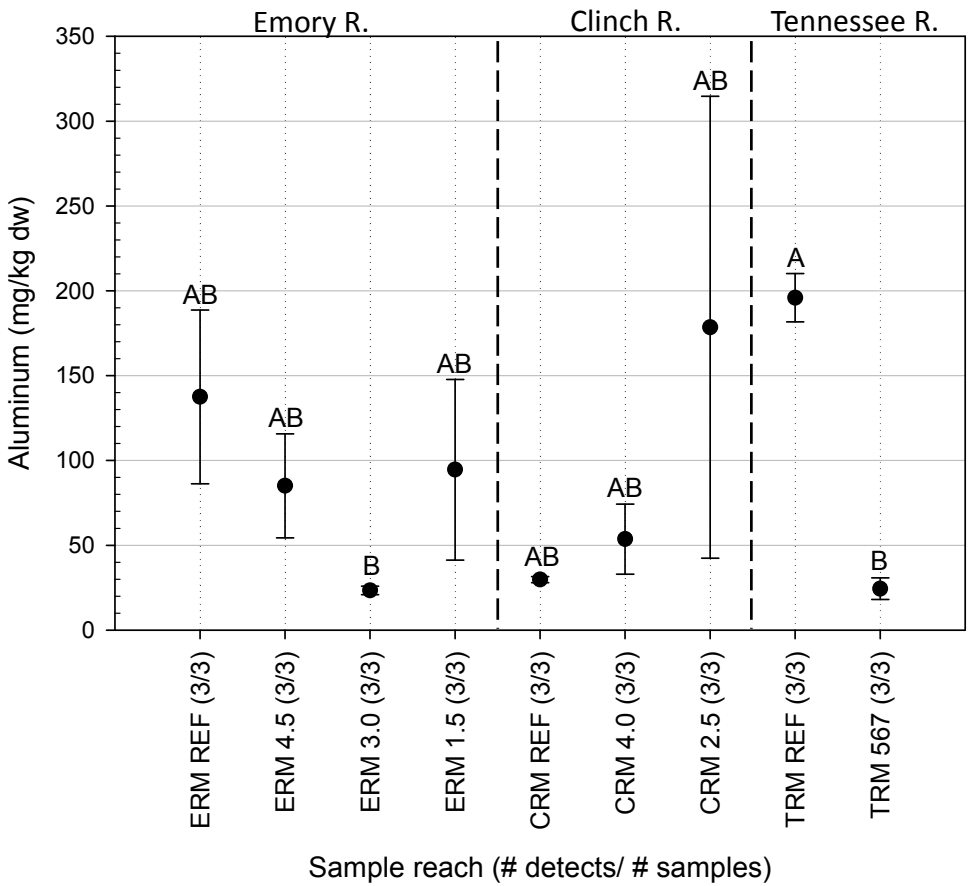
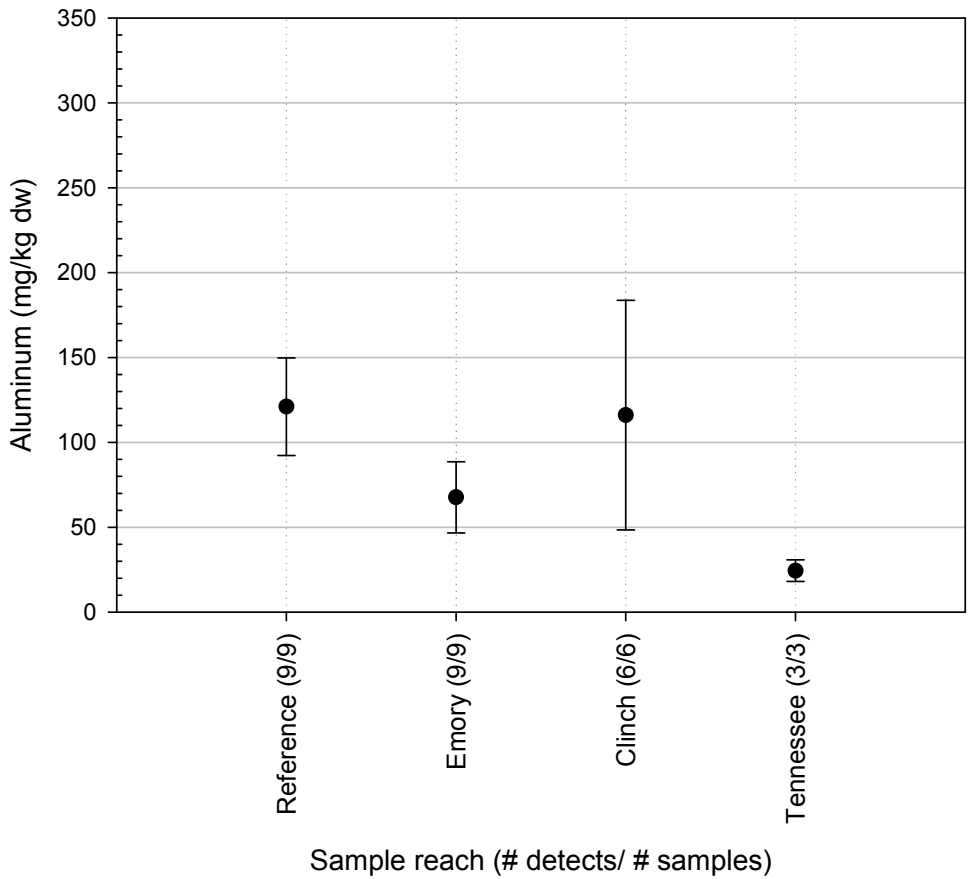
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN ZINC CONCENTRATIONS IN EMERGENT AQUATIC VEGETATION

ARCADIS

FIGURE
22





Note: Mean ± standard error.
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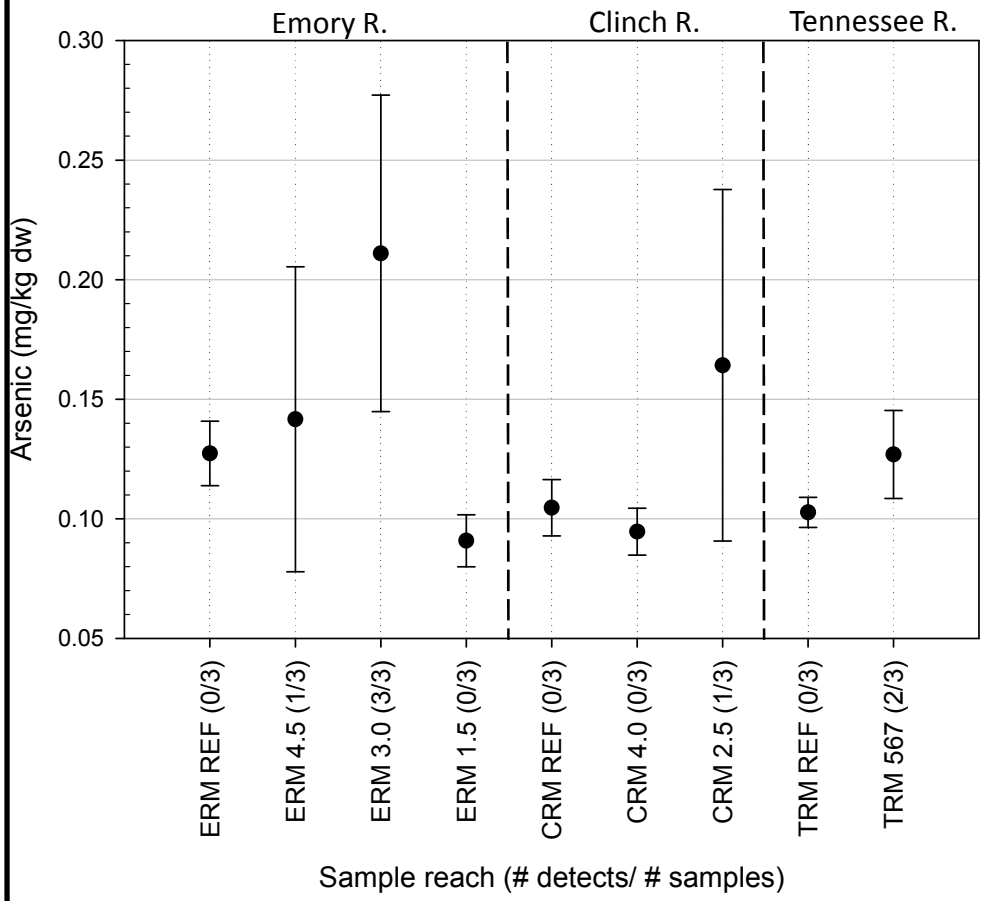
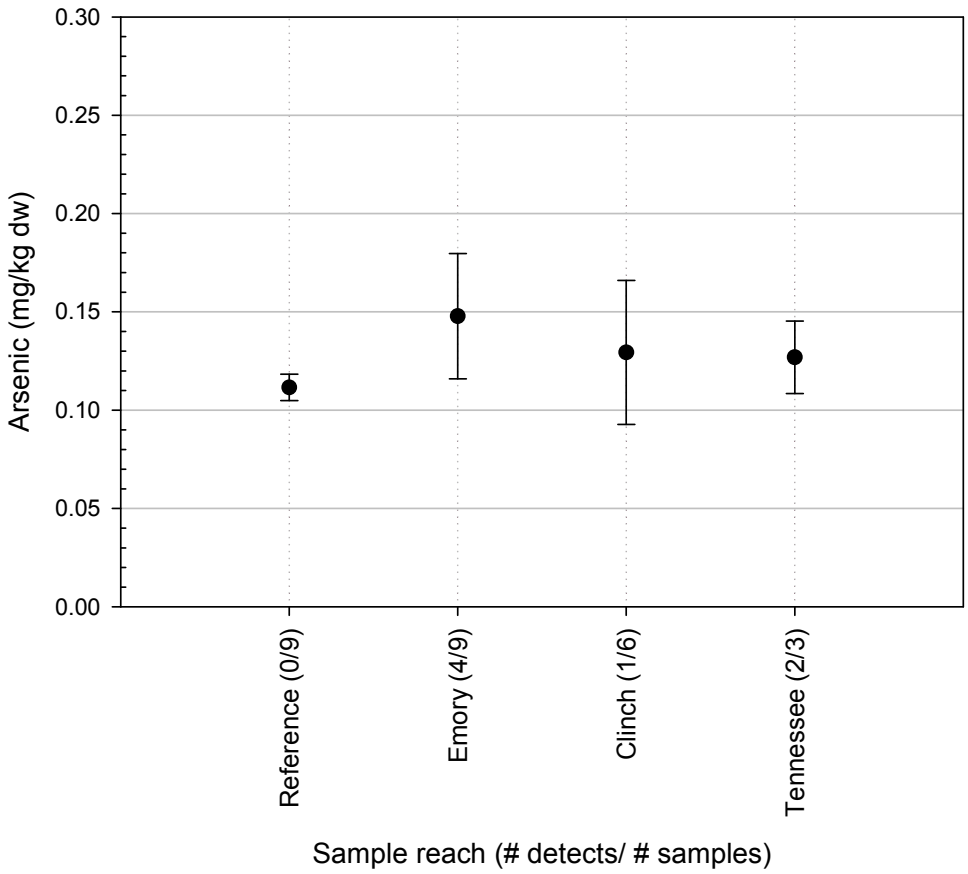
TRACE ELEMENT CONCENTRATIONS IN SHORELINE VEGETATION

MEAN ALUMINUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
23





Note: Mean ± standard error.
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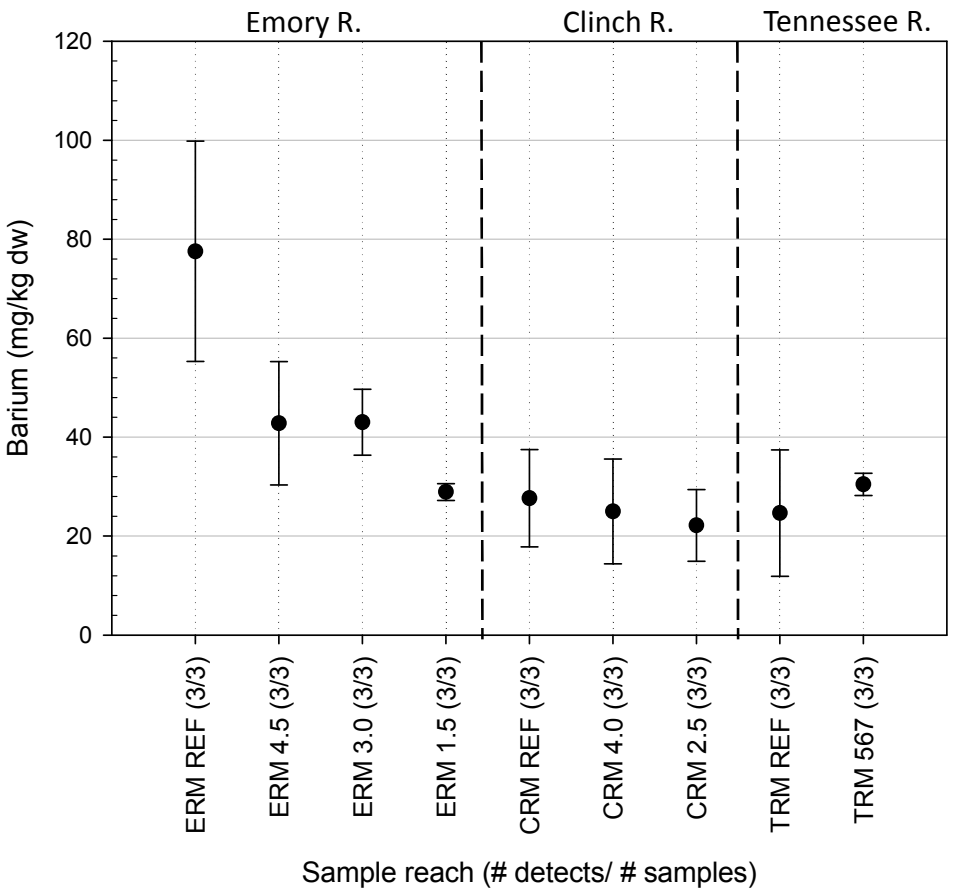
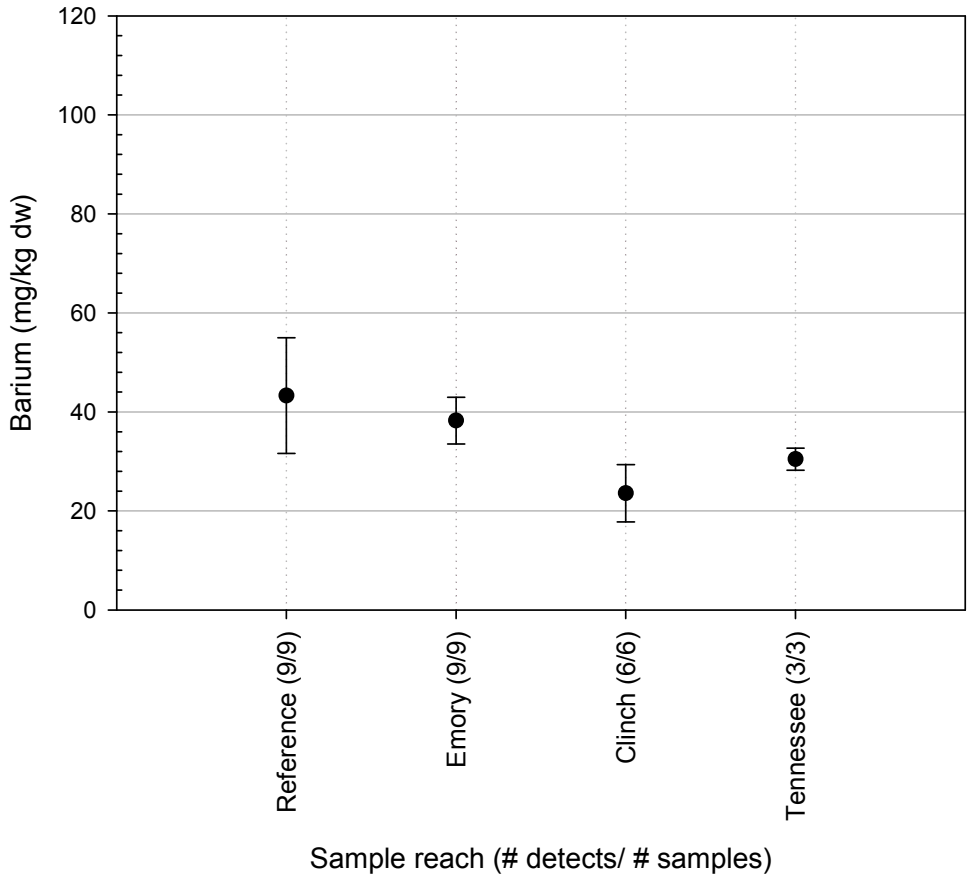
TRACE ELEMENT CONCENTRATIONS IN SHORELINE VEGETATION

MEAN ARSENIC CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
24





Note: Mean ± standard error.
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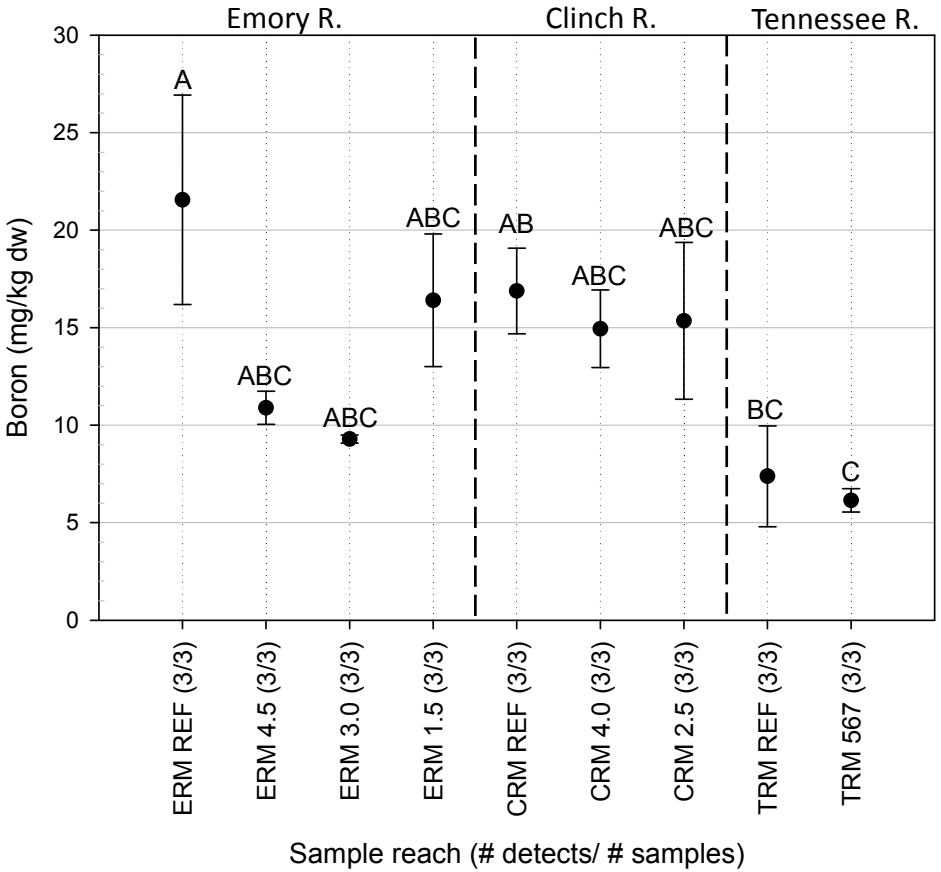
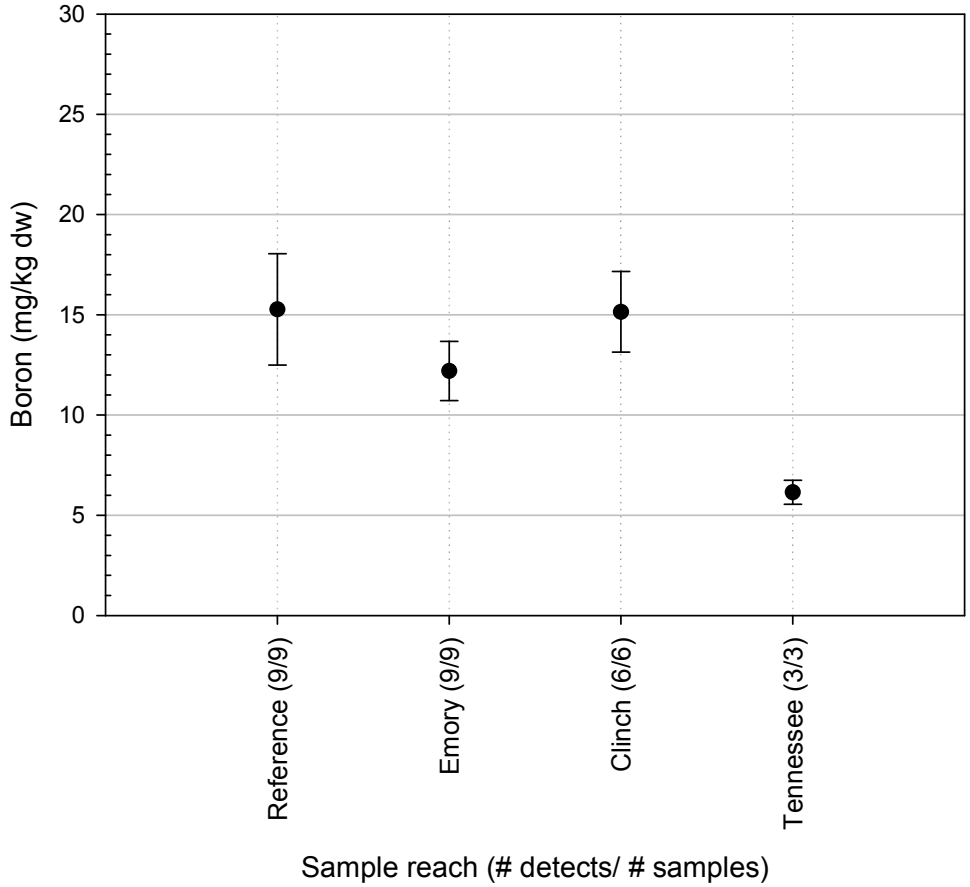
TRACE ELEMENT CONCENTRATIONS IN SHORELINE VEGETATION

MEAN BARIUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
25





Note: Mean ± standard error.
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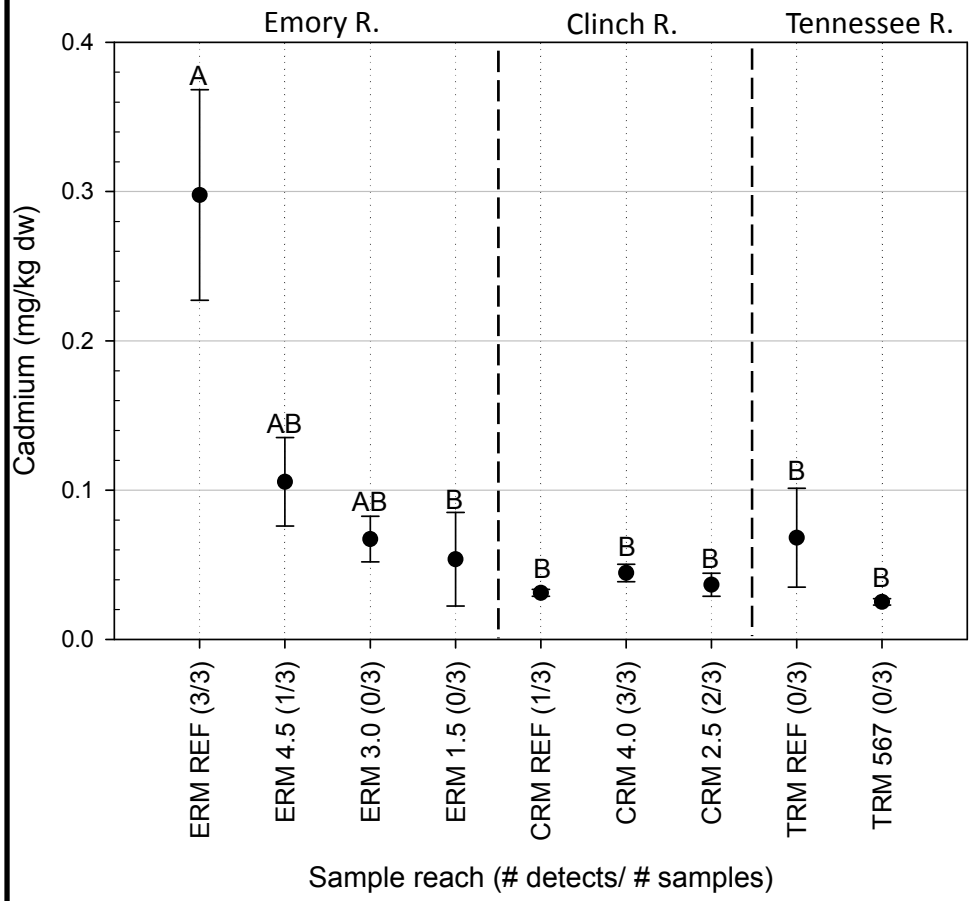
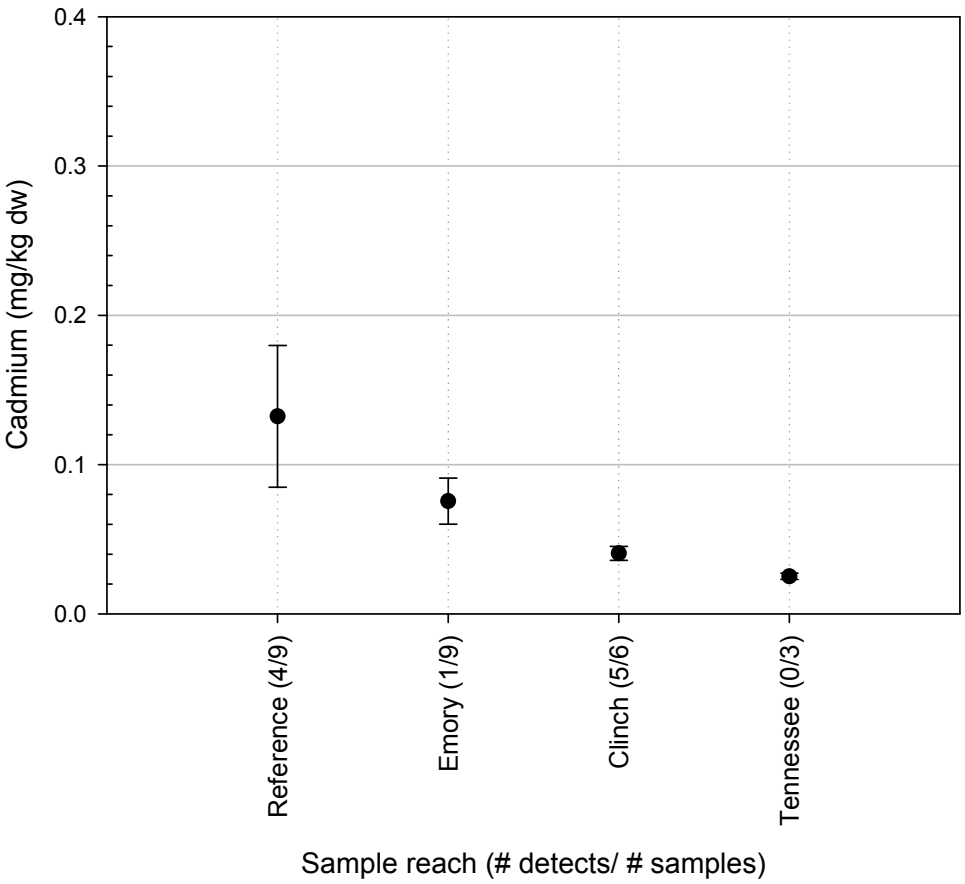
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN BORON CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
26





Note: Mean ± standard error.
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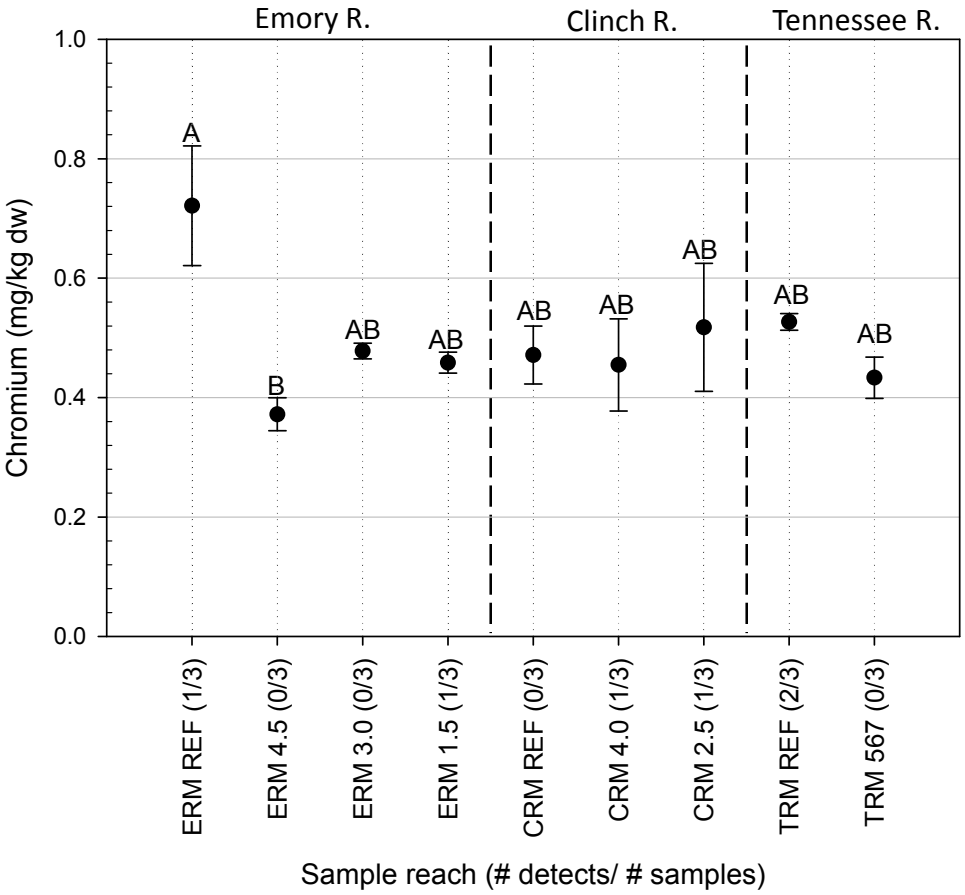
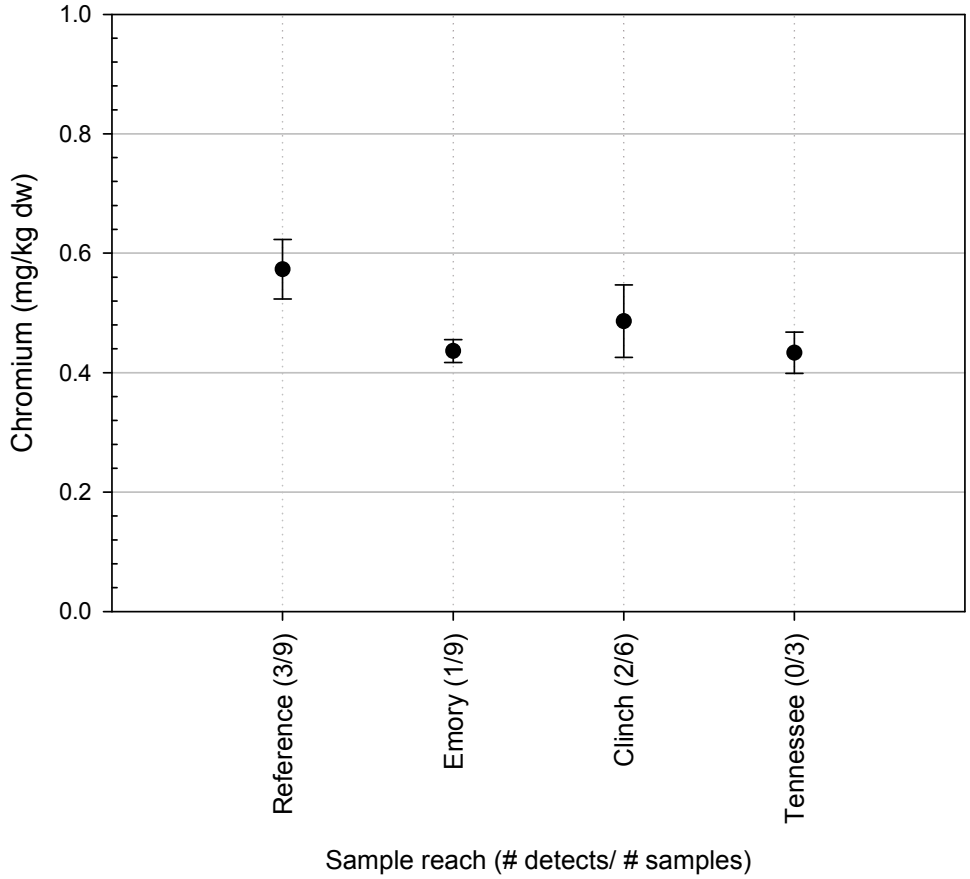
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN CADMIUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
27





Note: Mean ± standard error.
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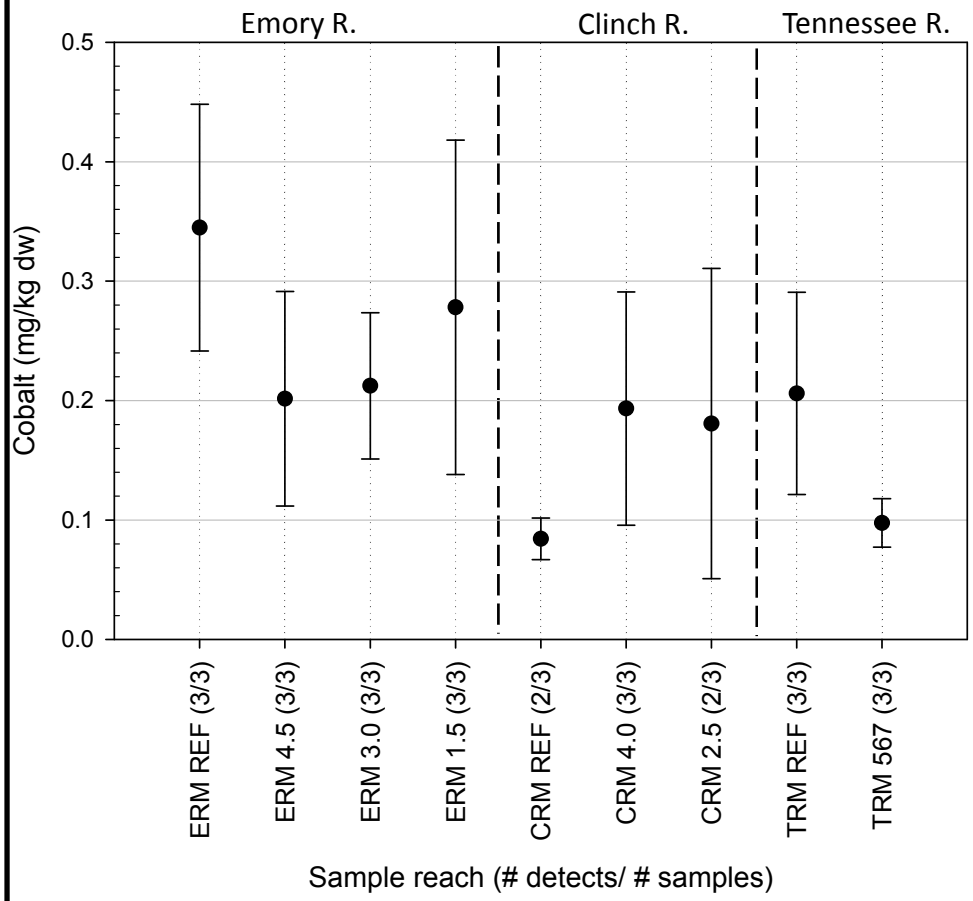
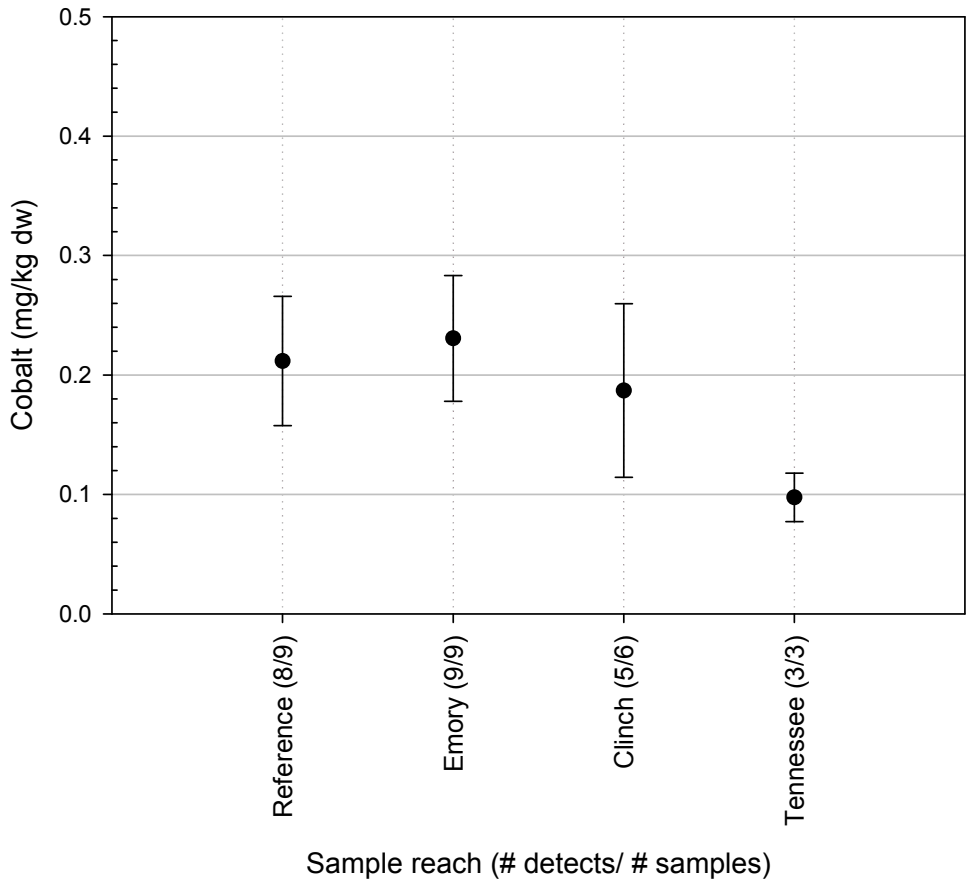
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN CHROMIUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
28





Note: Mean ± standard error.
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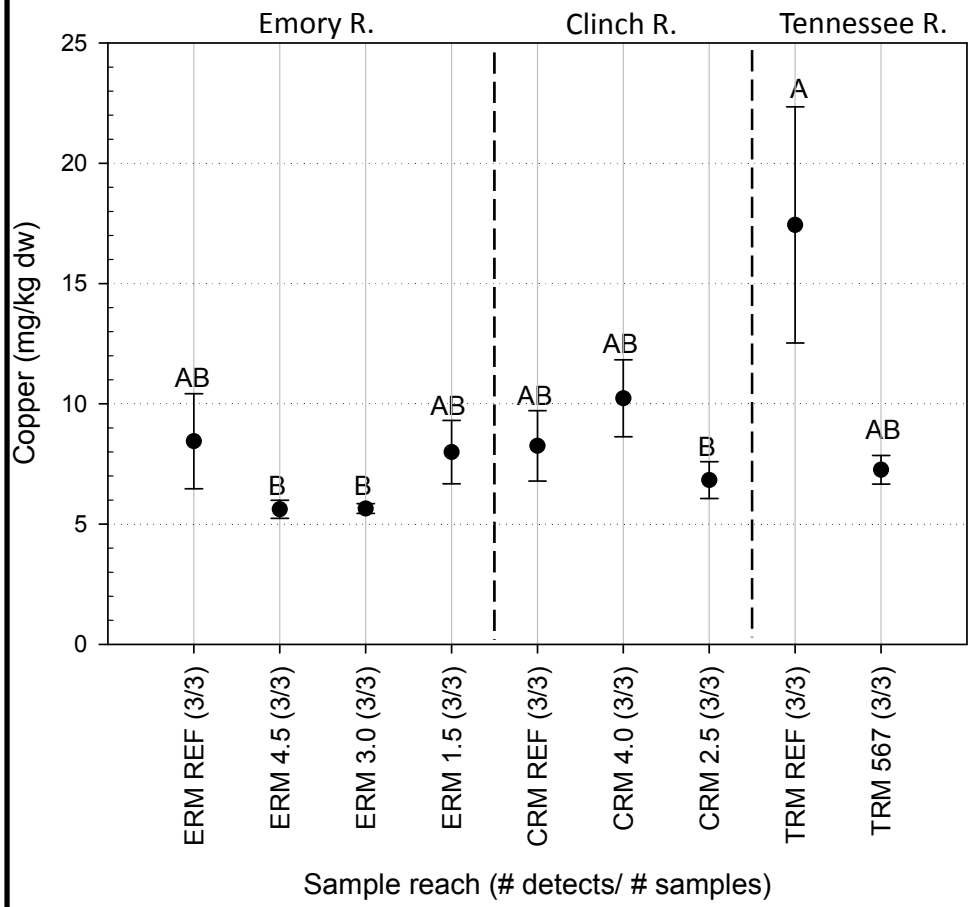
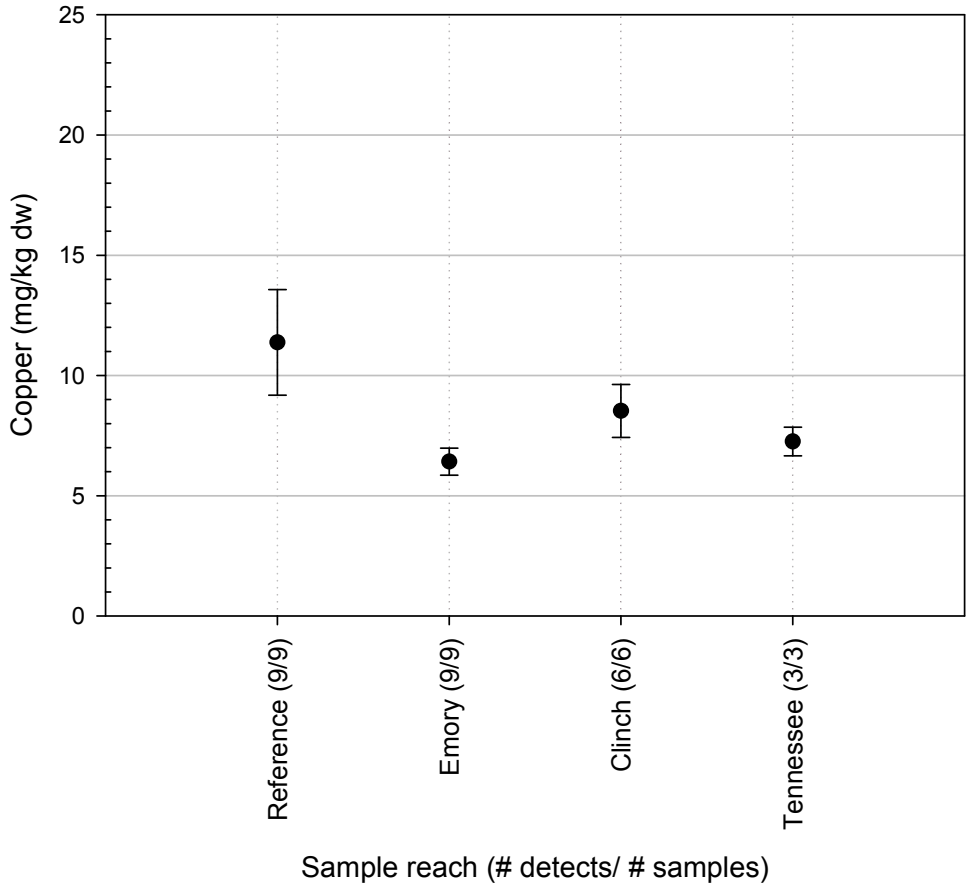
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN COBALT CONCENTRATIONS IN SHORELINEVEGETATION

ARCADIS

FIGURE
29





Note: Mean ± standard error.
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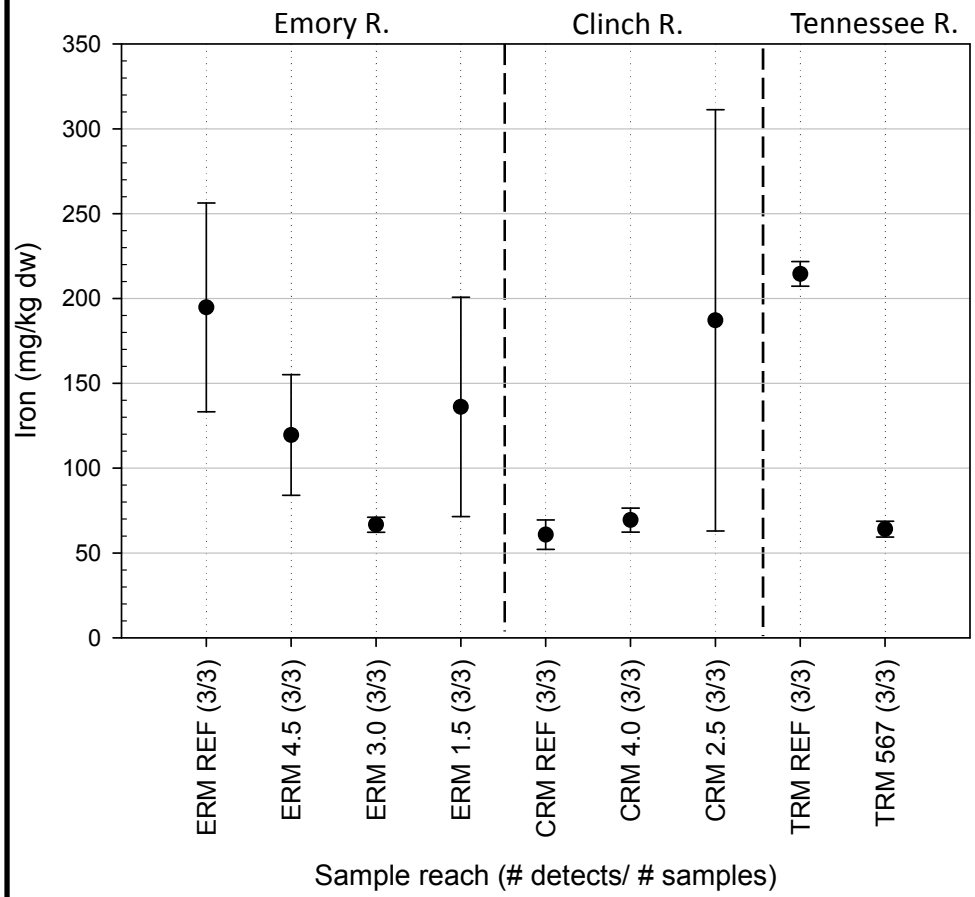
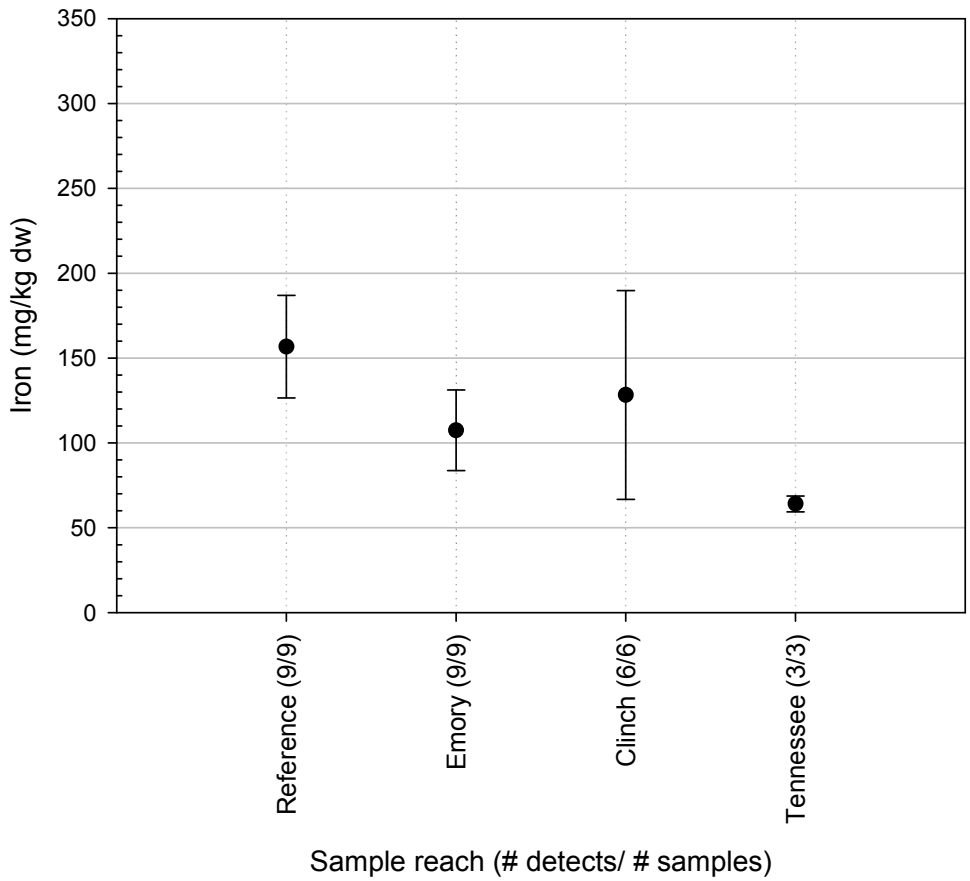
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN COPPER CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
30





Note: Mean ± standard error.
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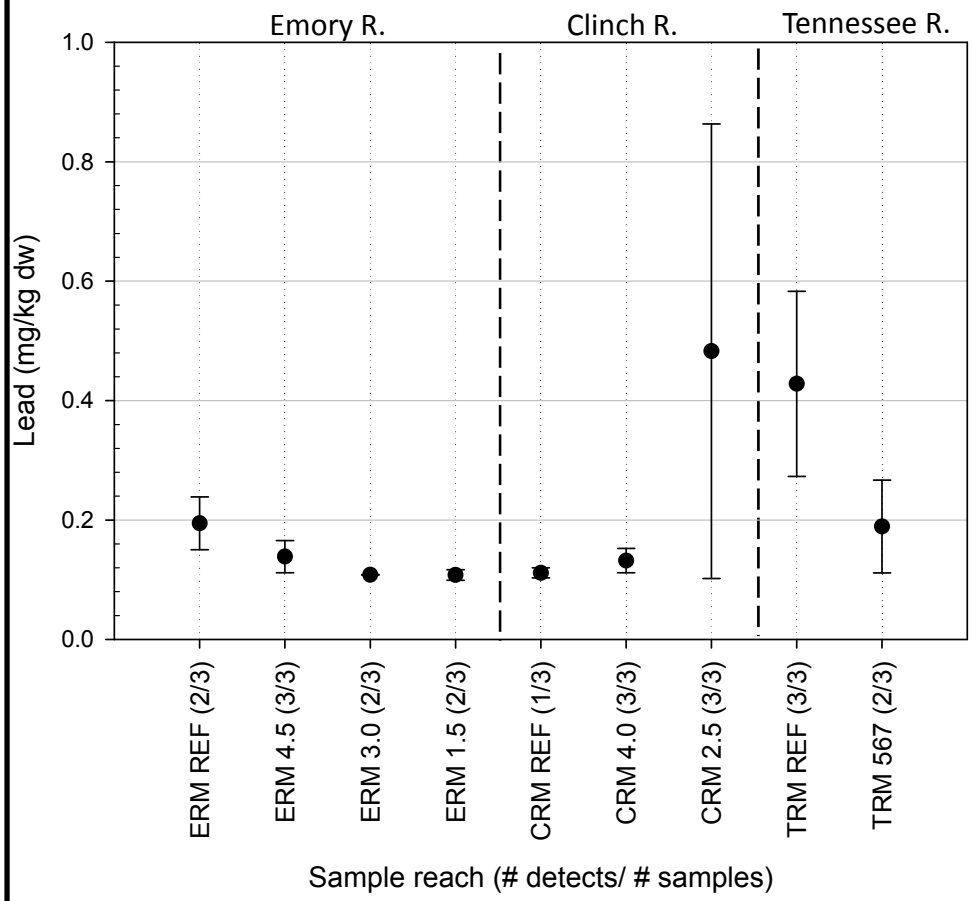
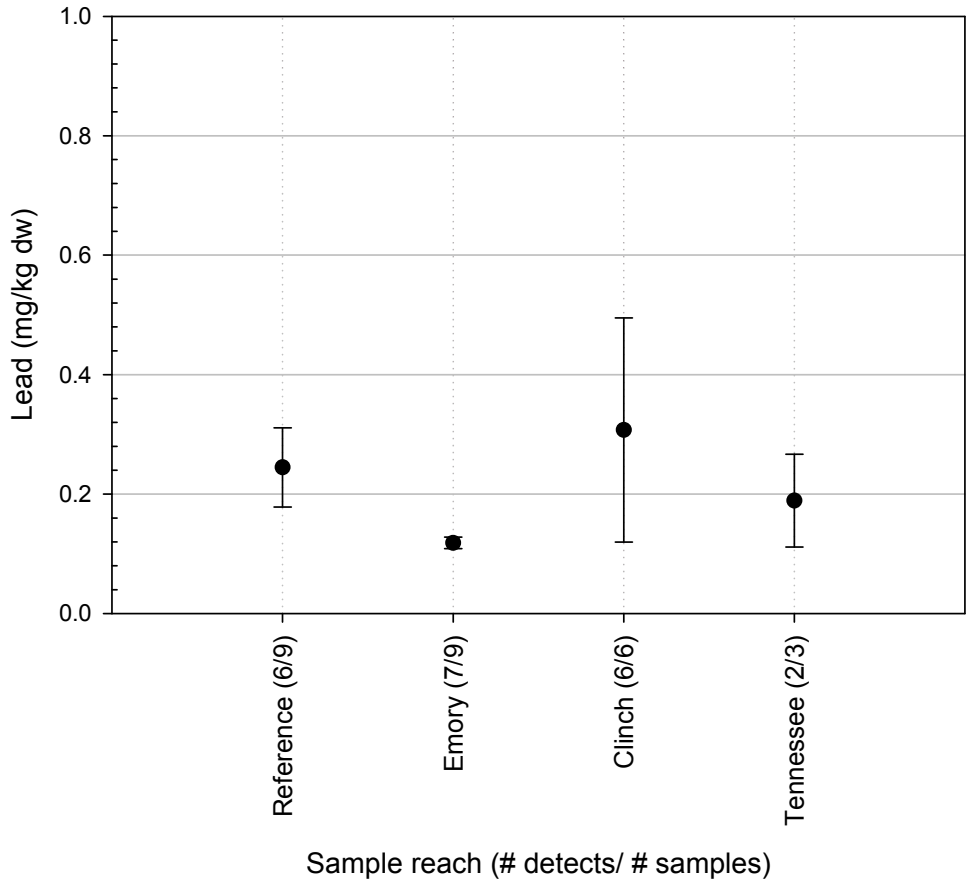
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN IRON CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
31





Note: Mean ± standard error.
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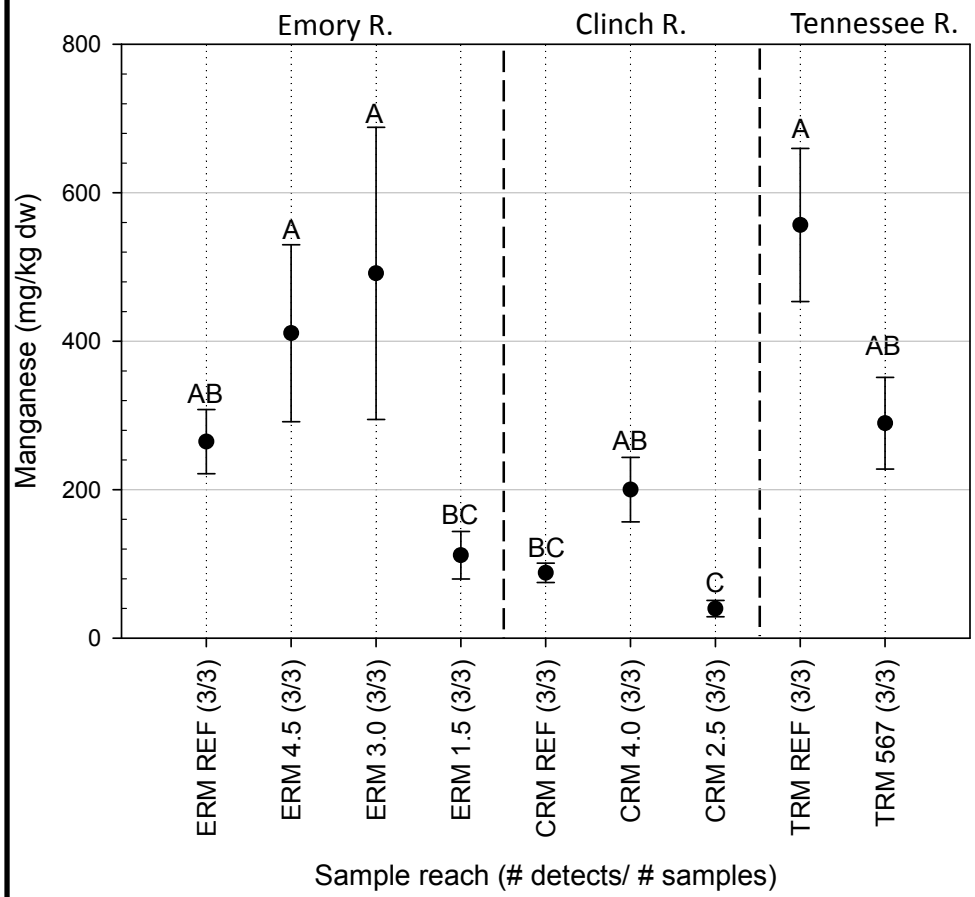
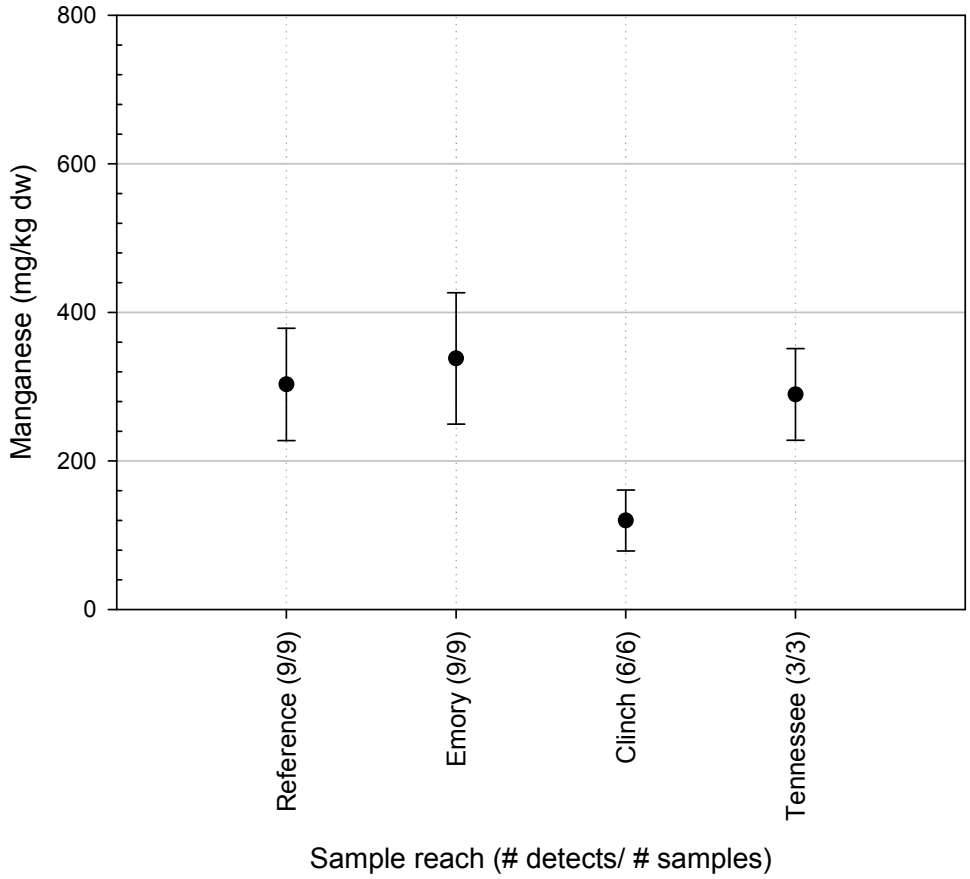
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN LEAD CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
32





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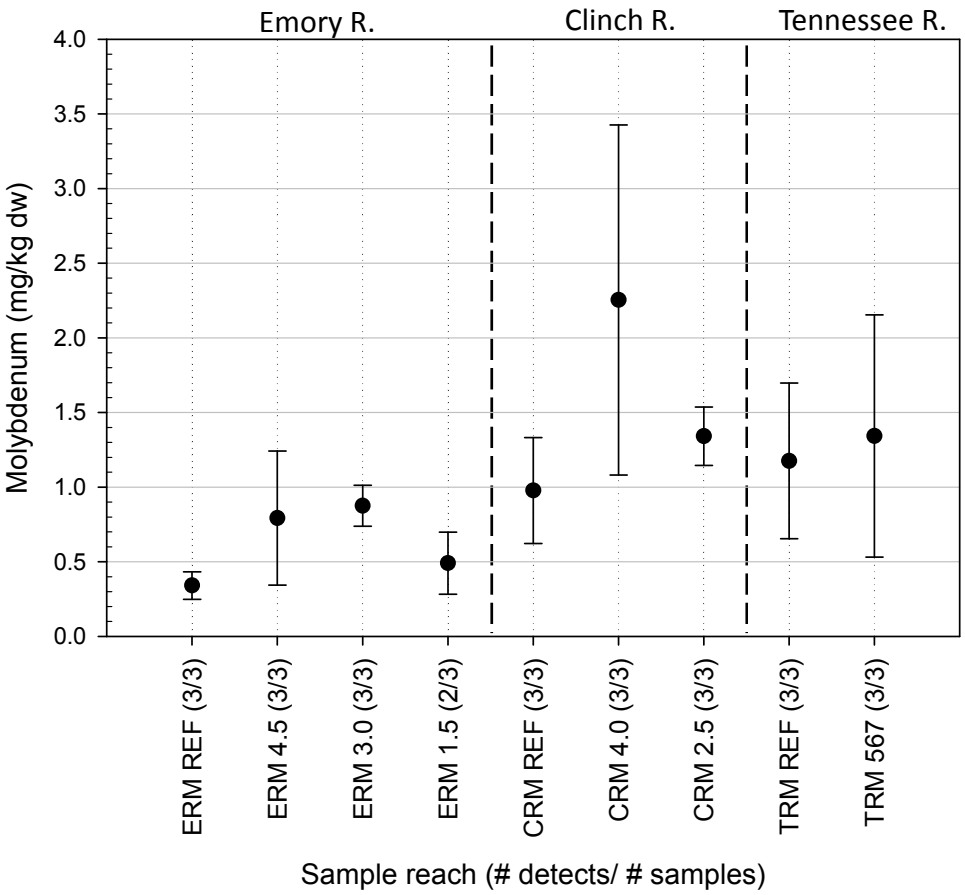
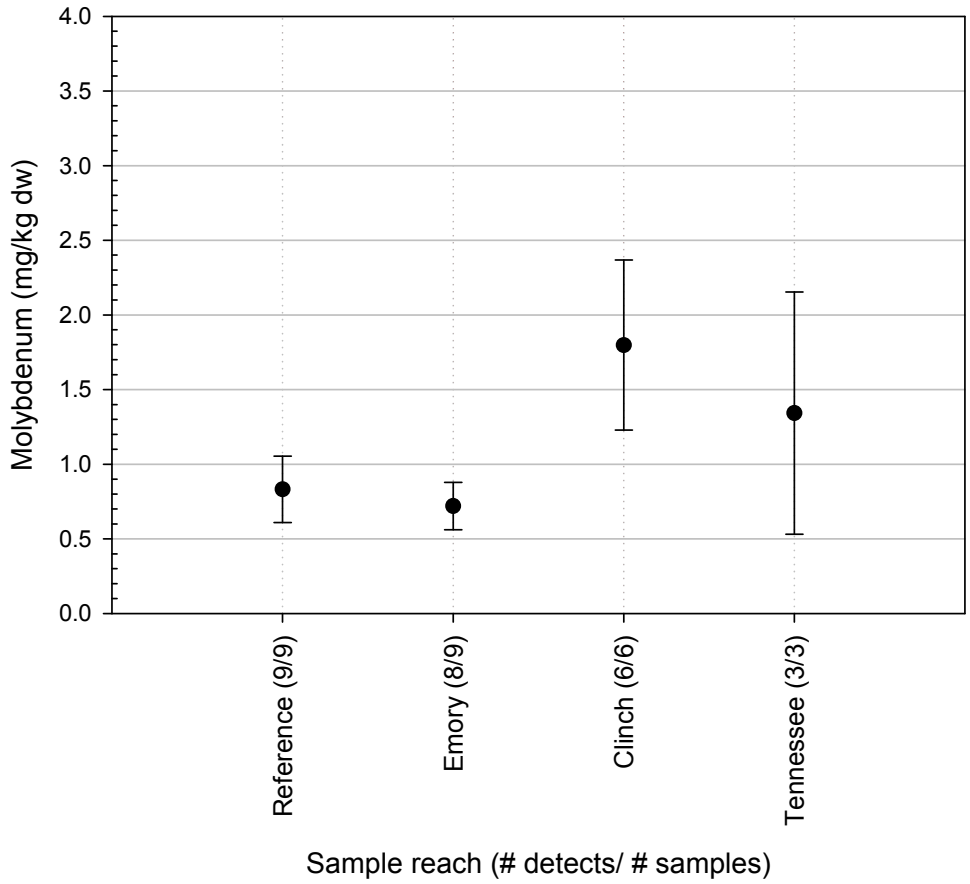
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN MANGANESE CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
33





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
CRM = Clinch River Mile.
ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

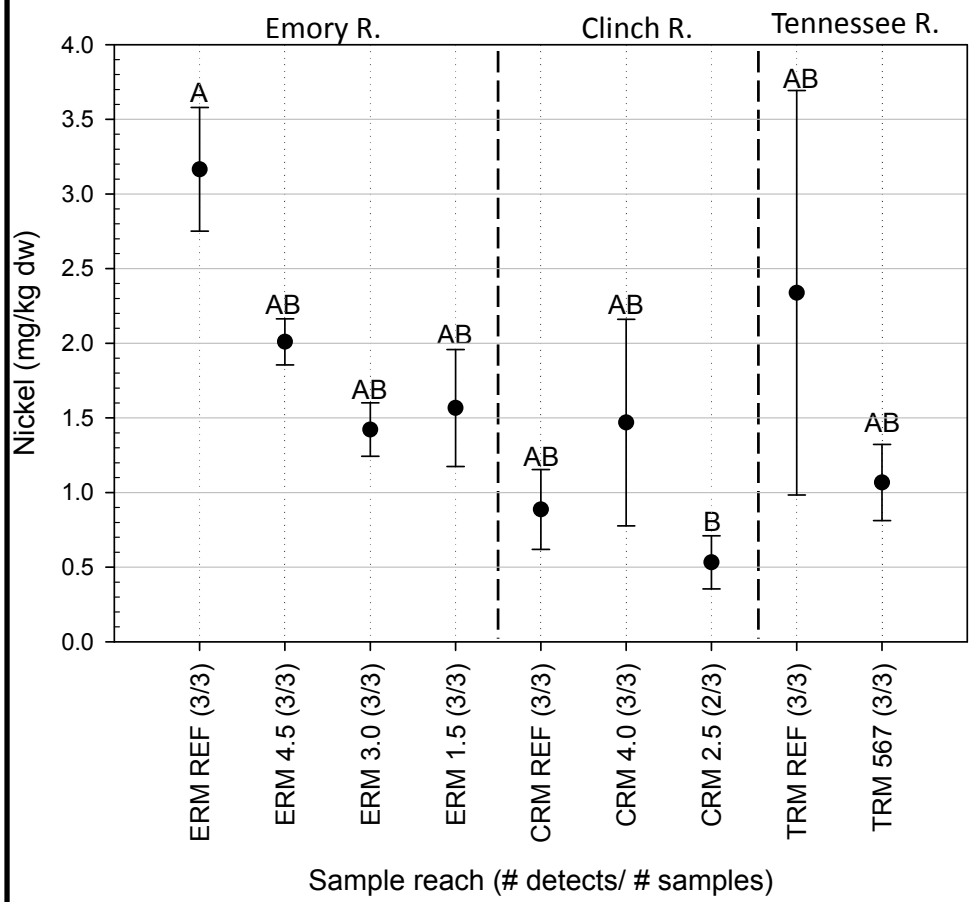
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

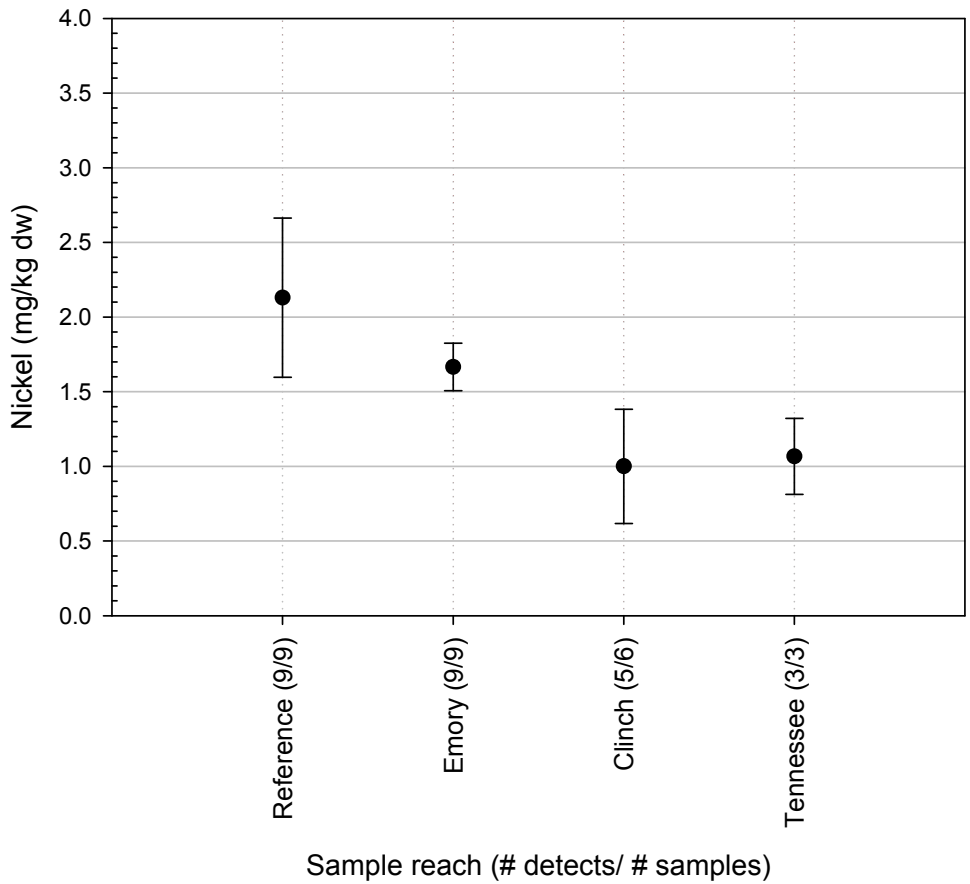
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN MOLYBDENUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
34





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
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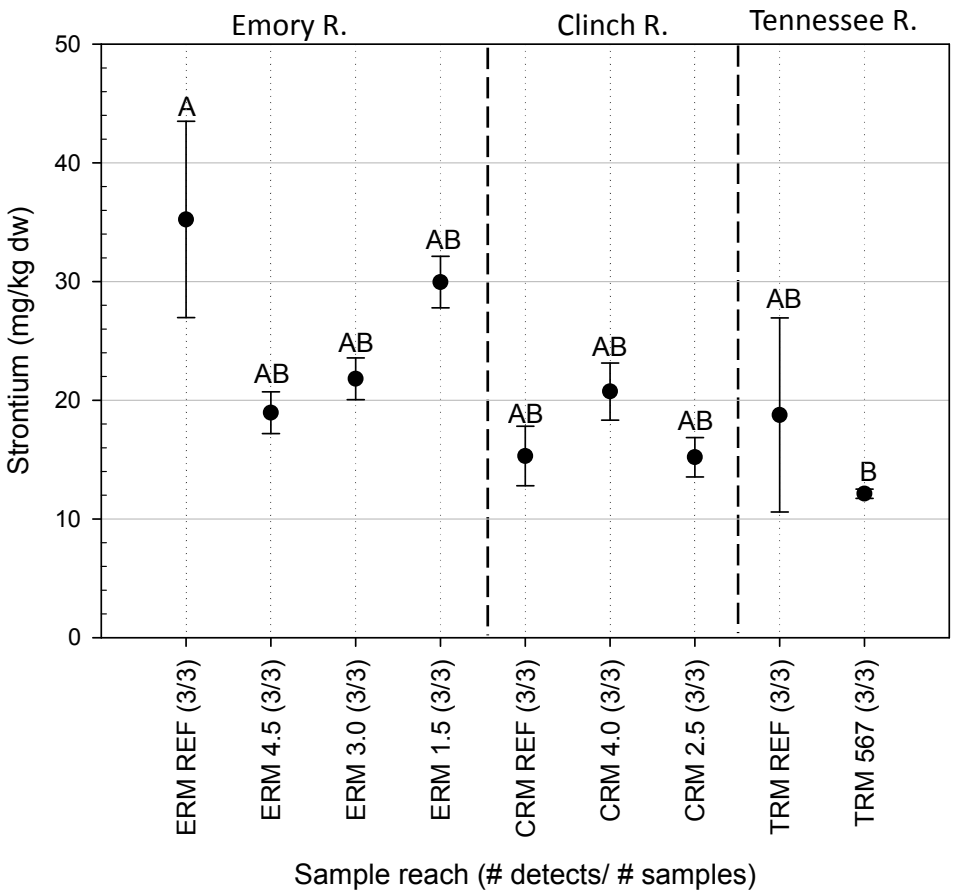
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

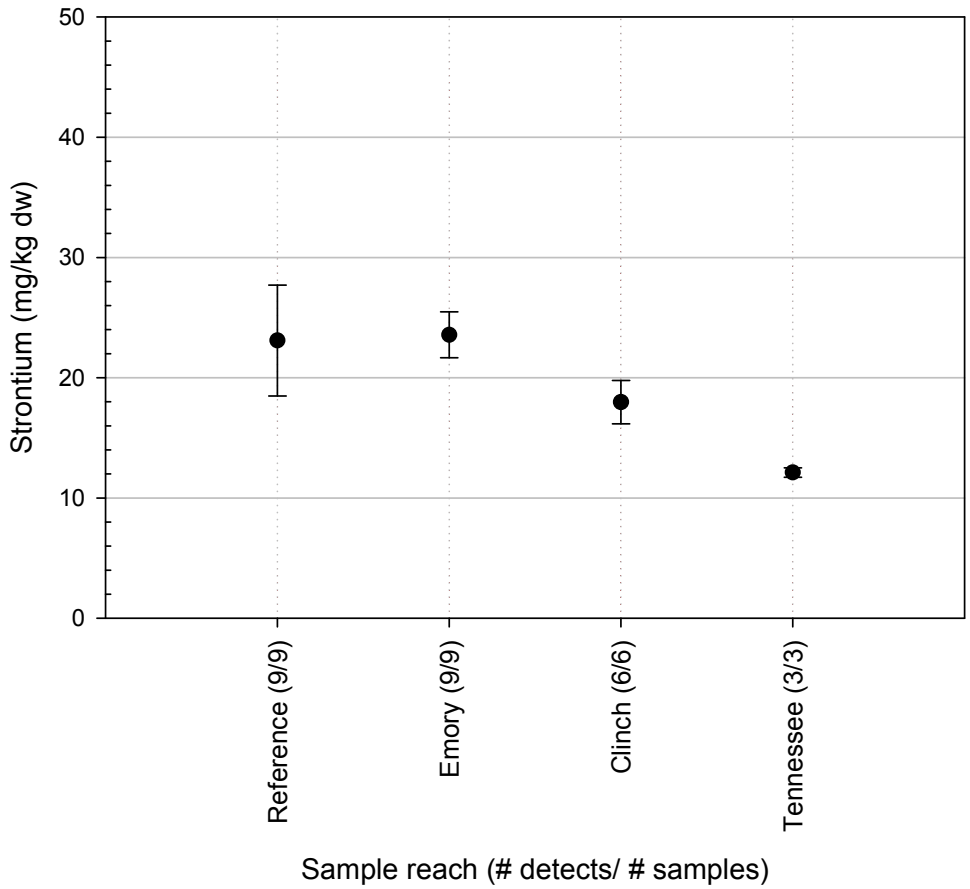
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN NICKEL CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
35





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
CRM = Clinch River Mile.
ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

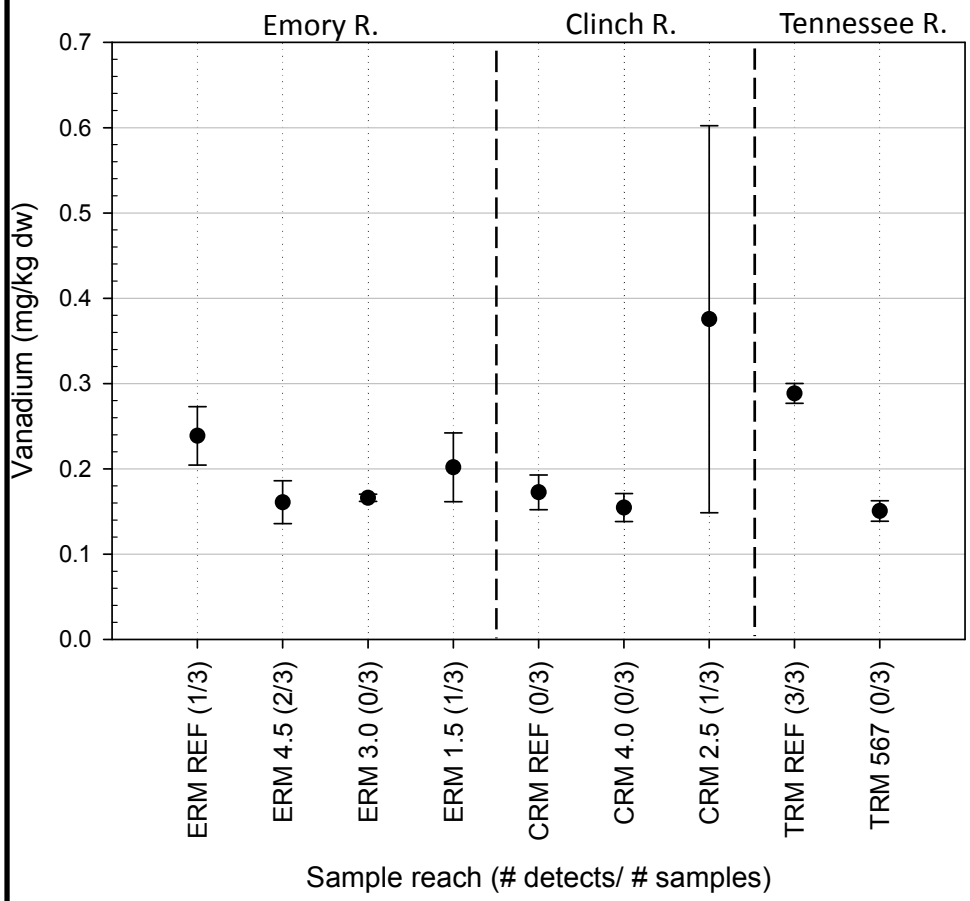
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

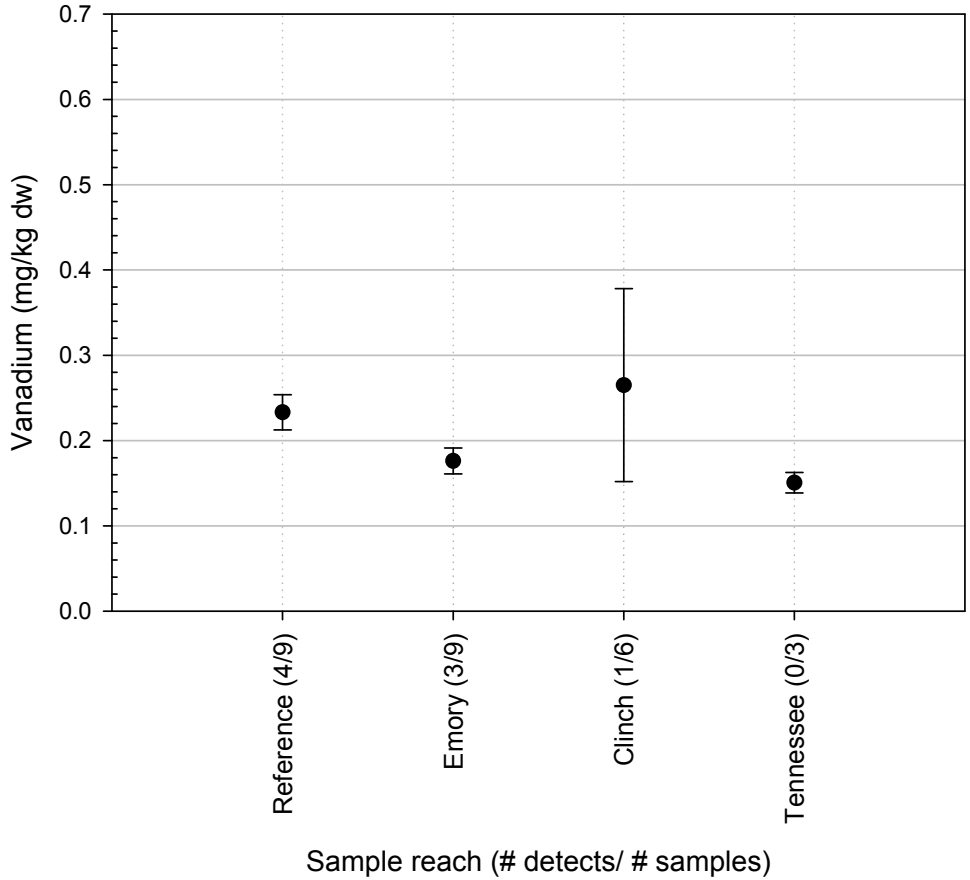
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN STRONTIUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
36





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
CRM = Clinch River Mile.
ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

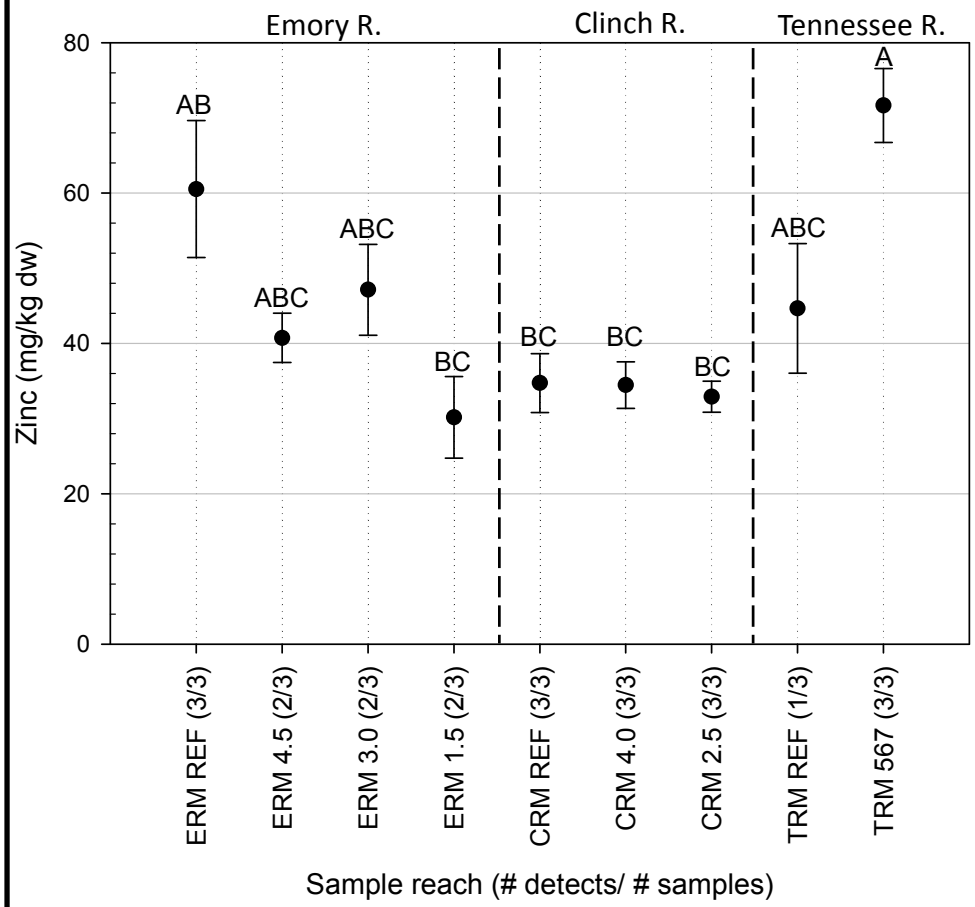
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

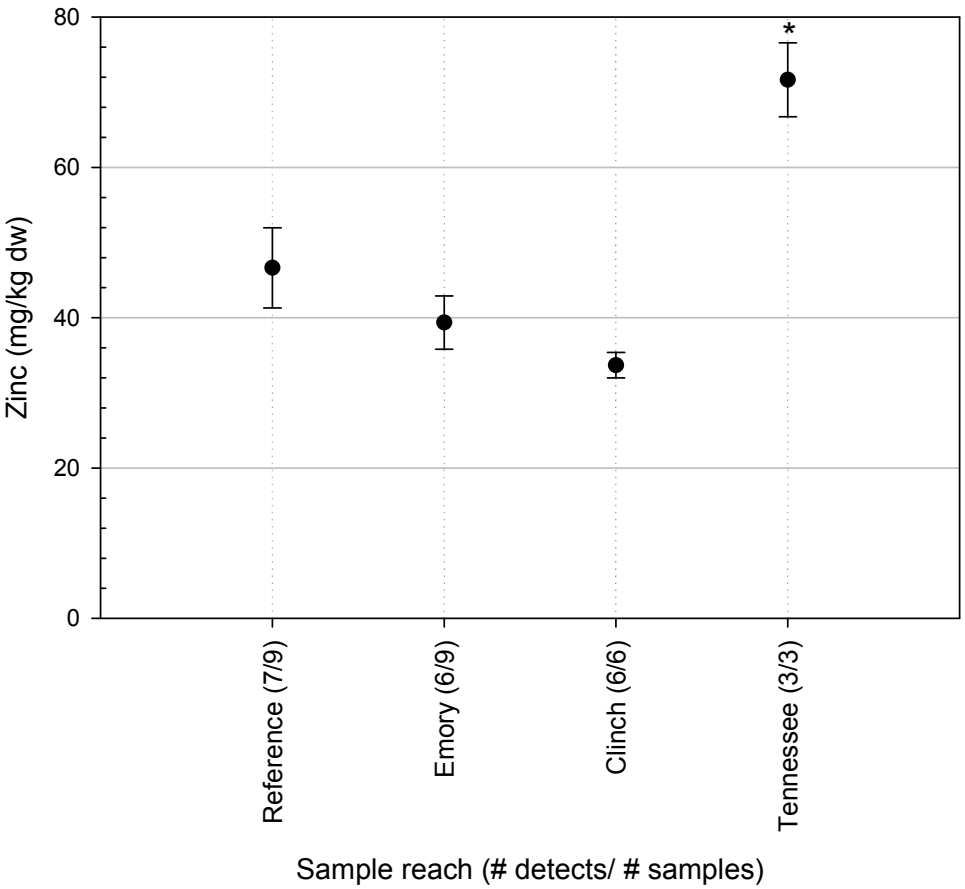
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN VANADIUM CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
37





Note: Mean ± standard error.
Means with the same letter, or no letters, are not significantly different (Tukey-Kramer post-hoc; α=0.05);
Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

α = Specified level of significance.
CRM = Clinch River Mile.
ERM = Emory River Mile.
TRM = Tennessee River Mile.
REF = Reference Location.

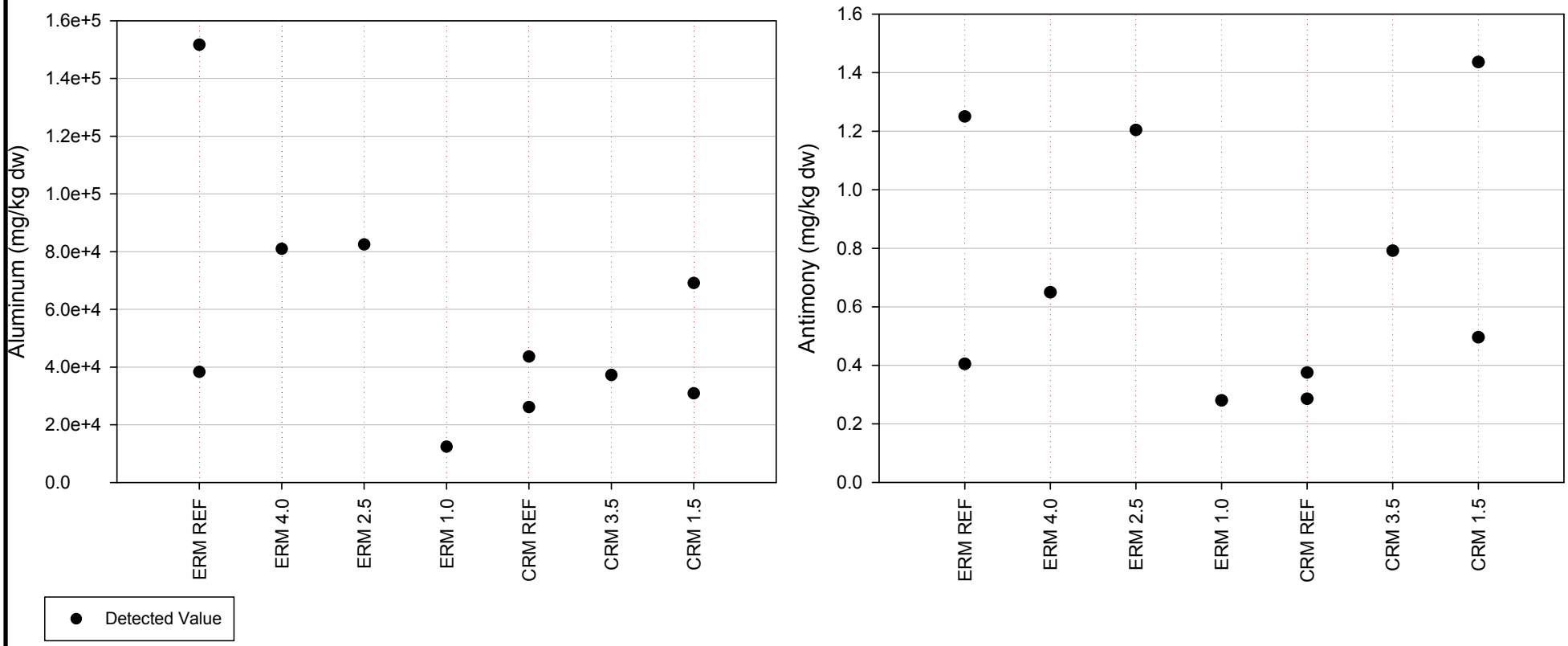
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MEAN ZINC CONCENTRATIONS IN SHORELINE VEGETATION

ARCADIS

FIGURE
38



Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

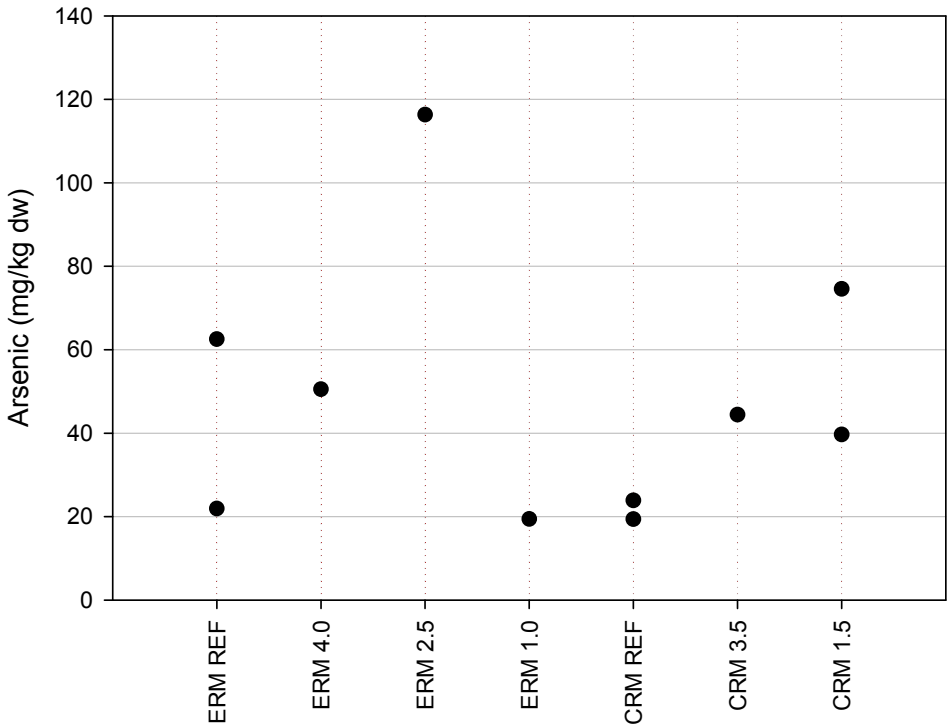
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

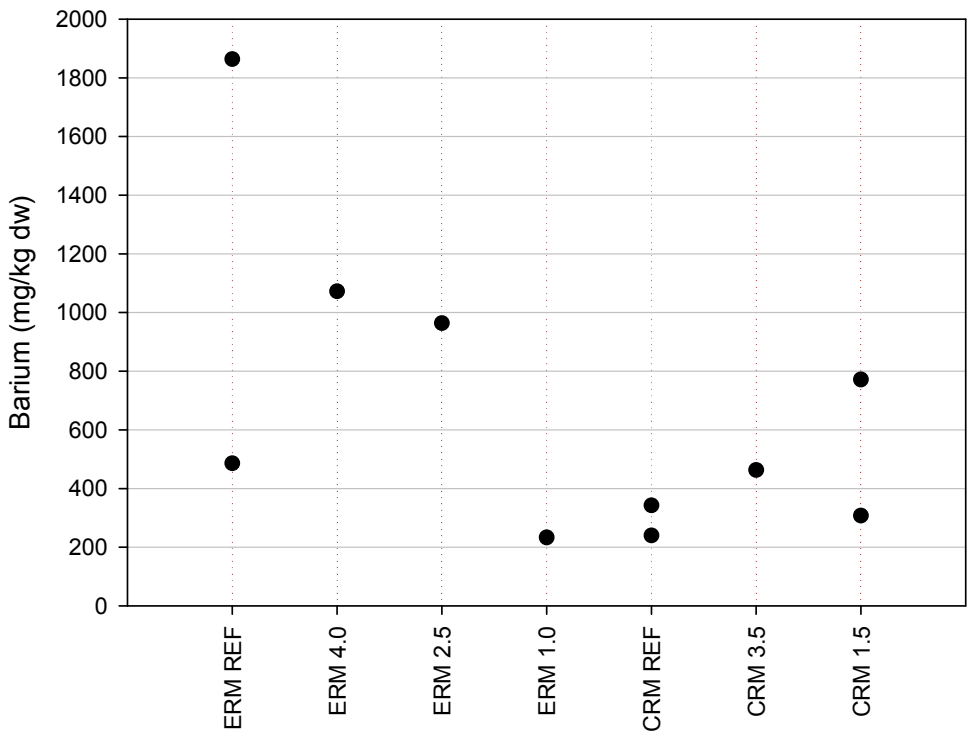
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

ALUMINUM AND ANTIMONY CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
39





Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

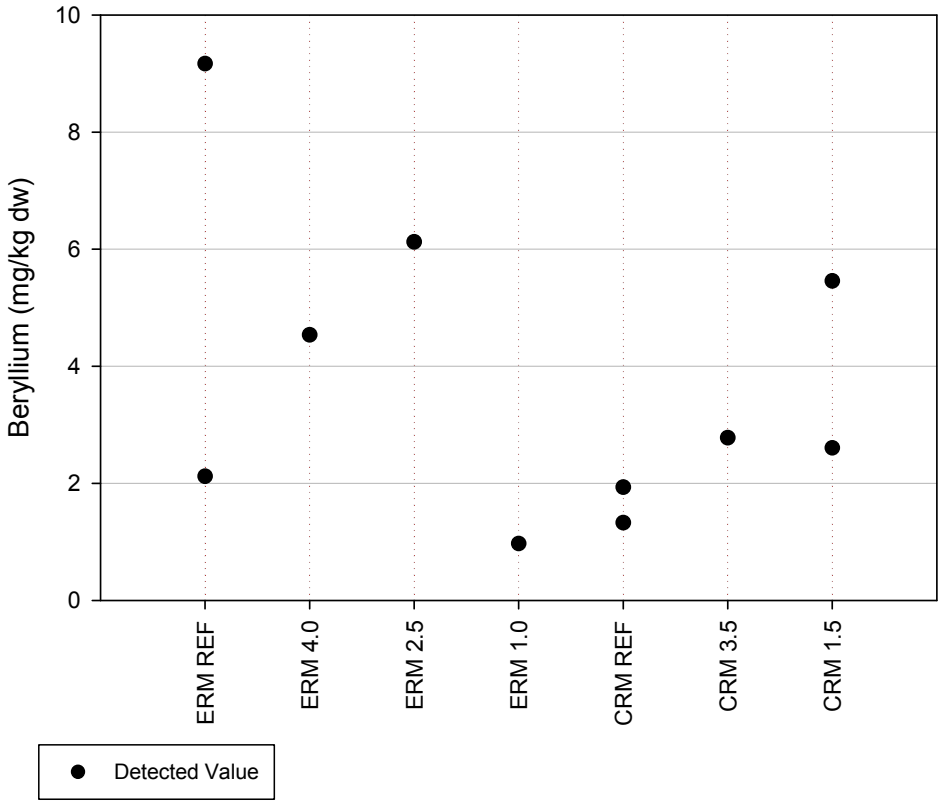
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

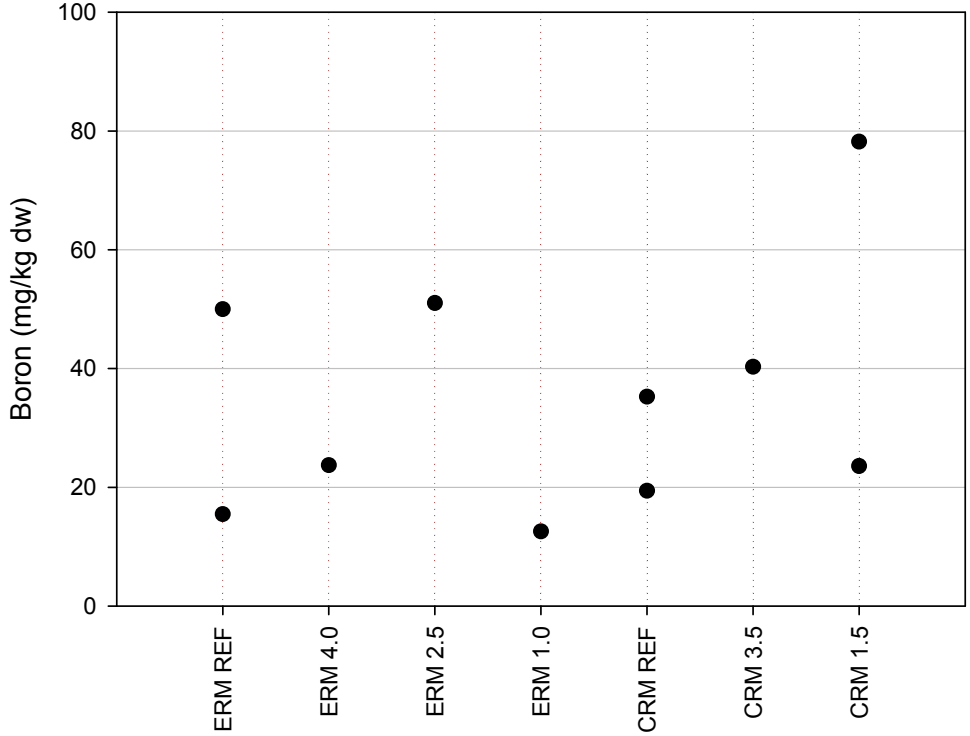
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

ARSENIC AND BARIUM CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
40





Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

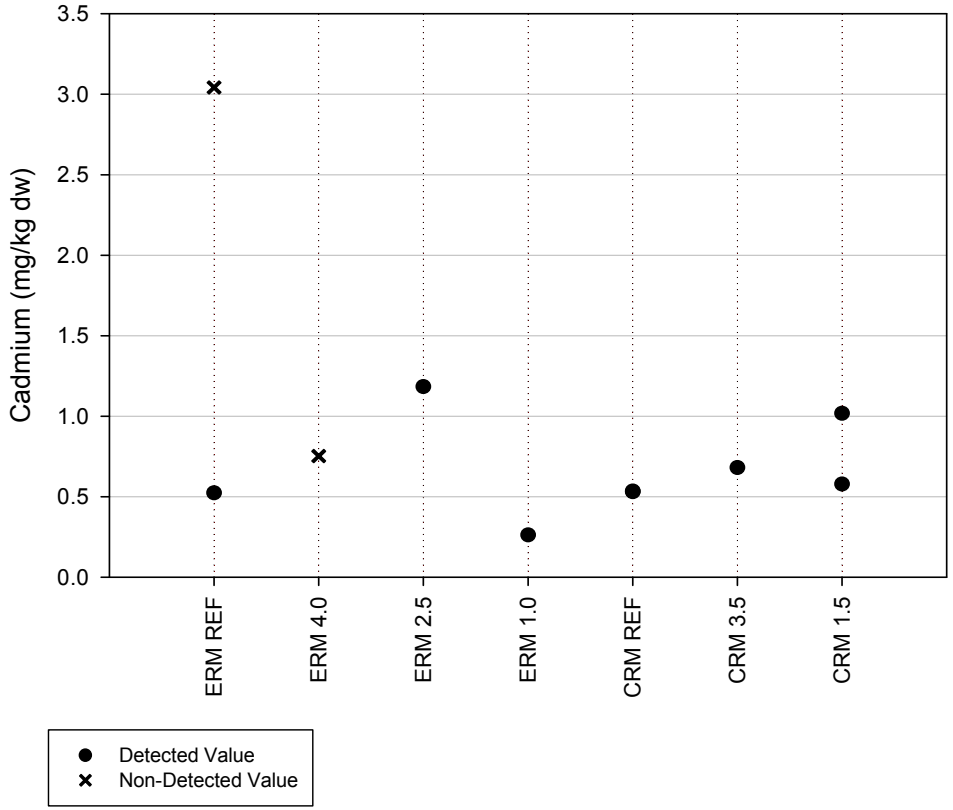
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

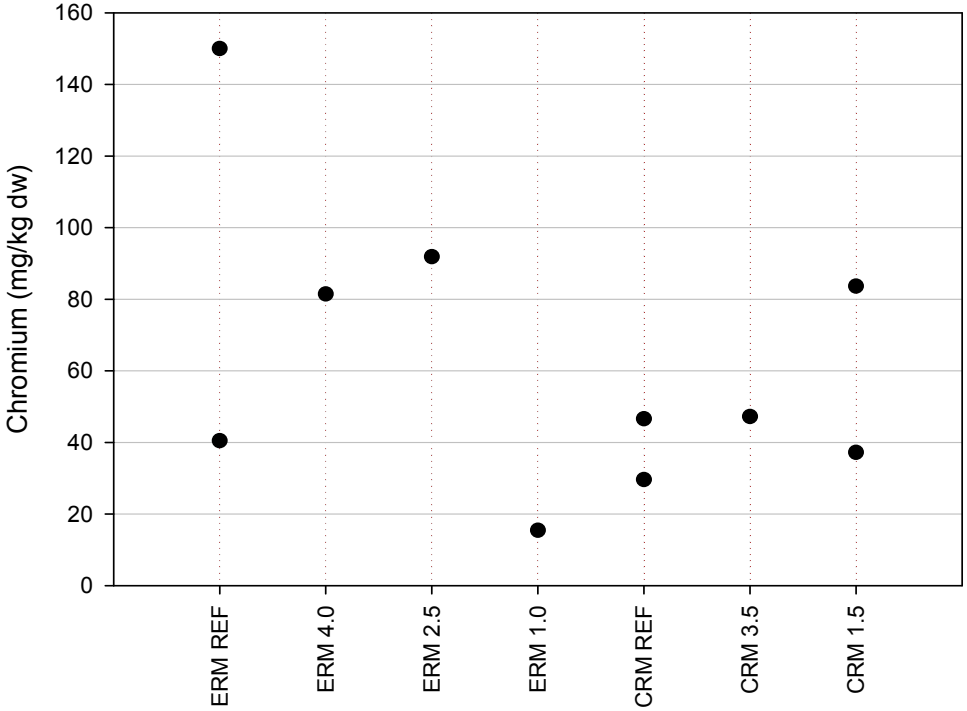
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

BERYLLIUM AND BORON CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
41





Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

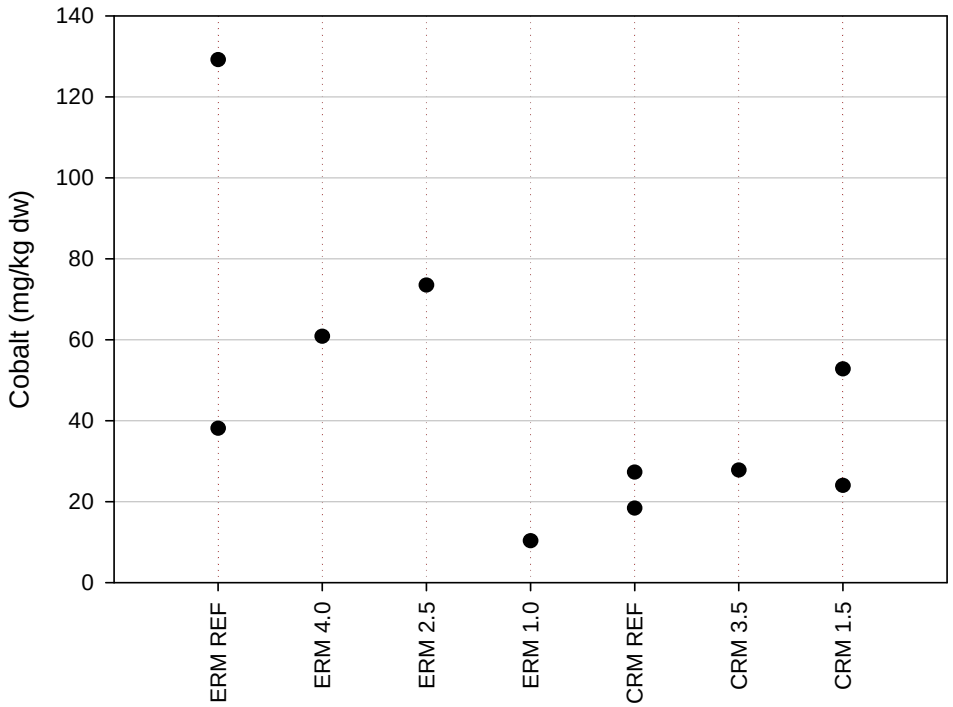
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

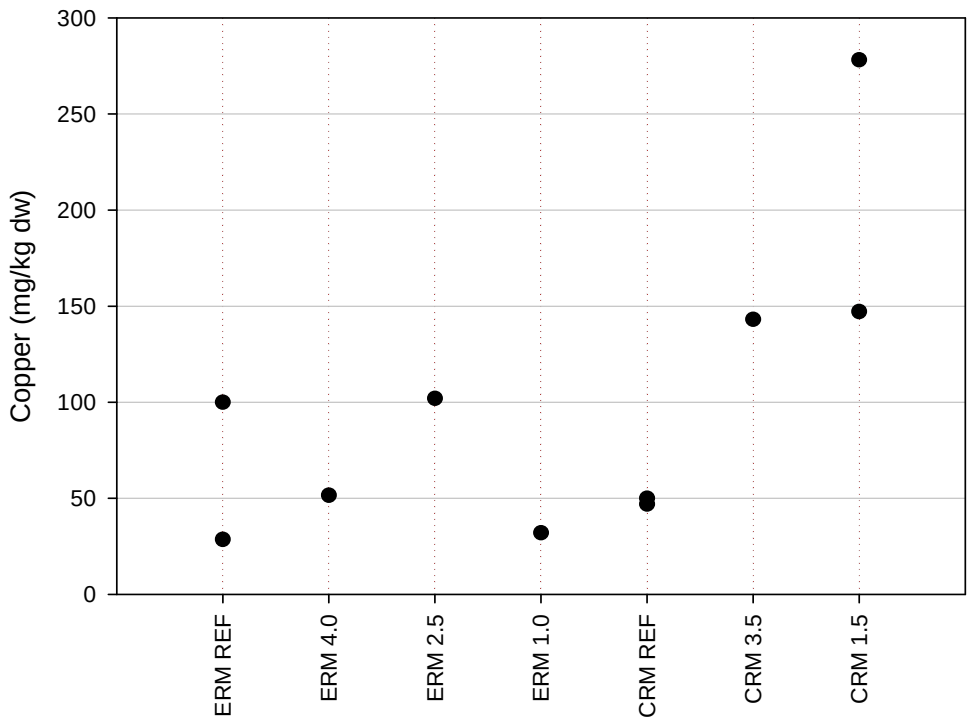
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

CADMIUM AND CHROMIUM CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
42





Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

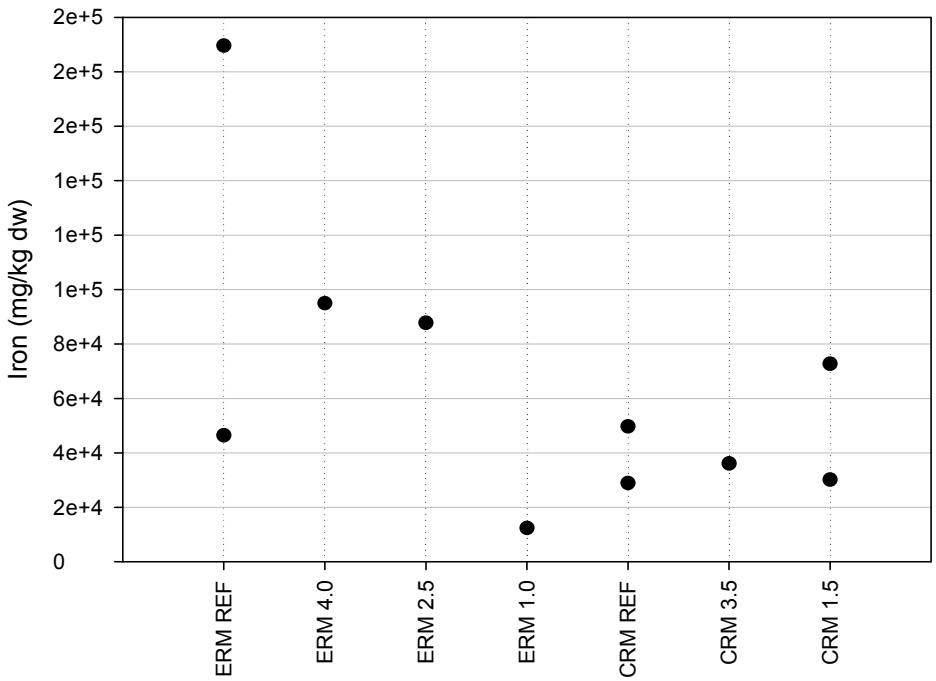
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

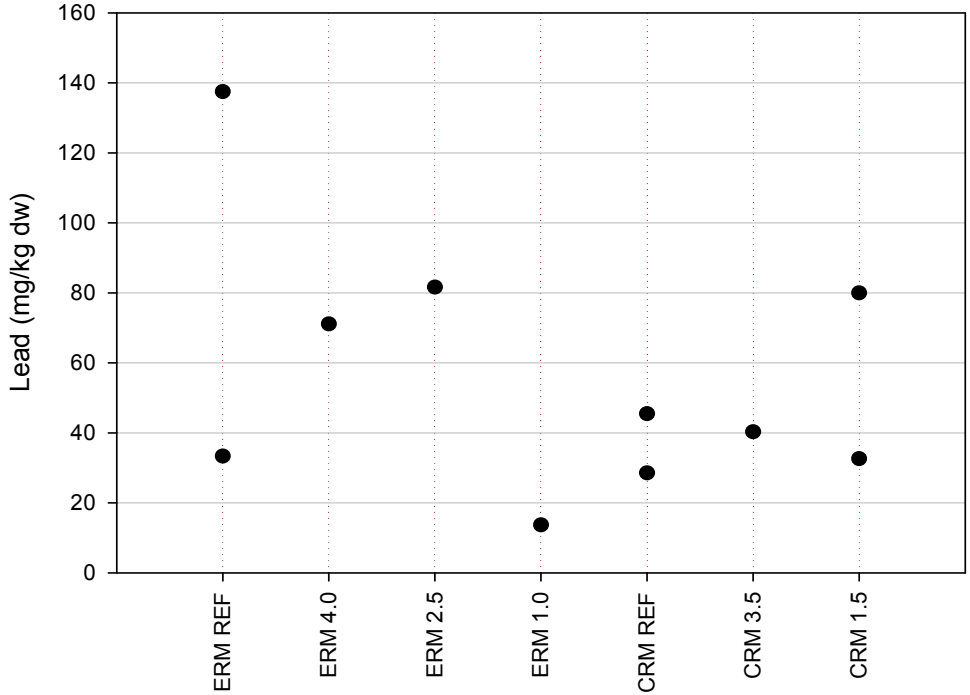
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

COBALT AND COPPER CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
43





● Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

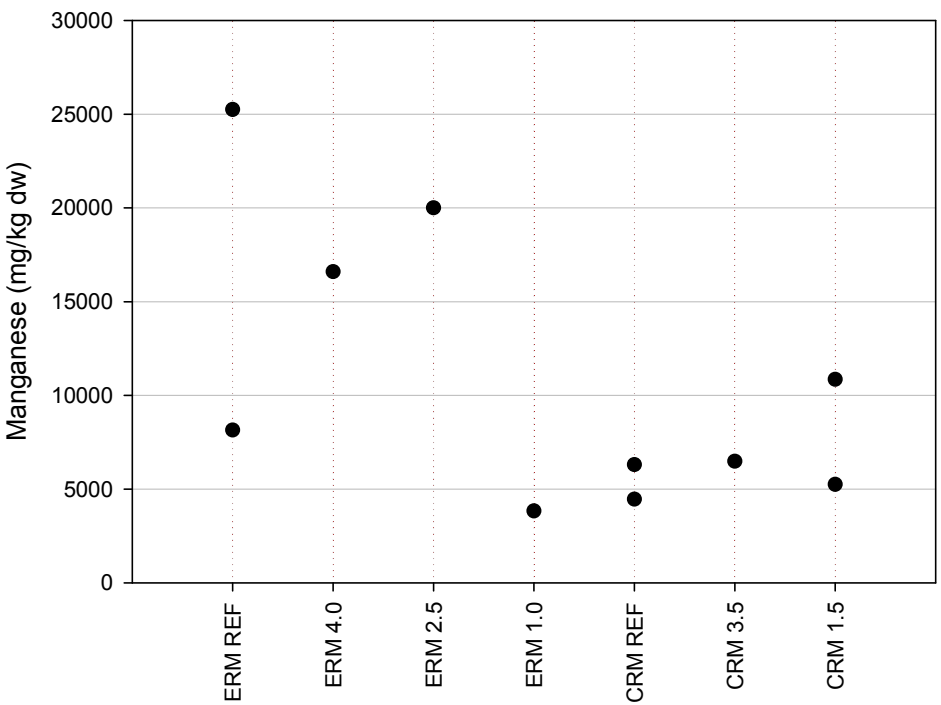
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

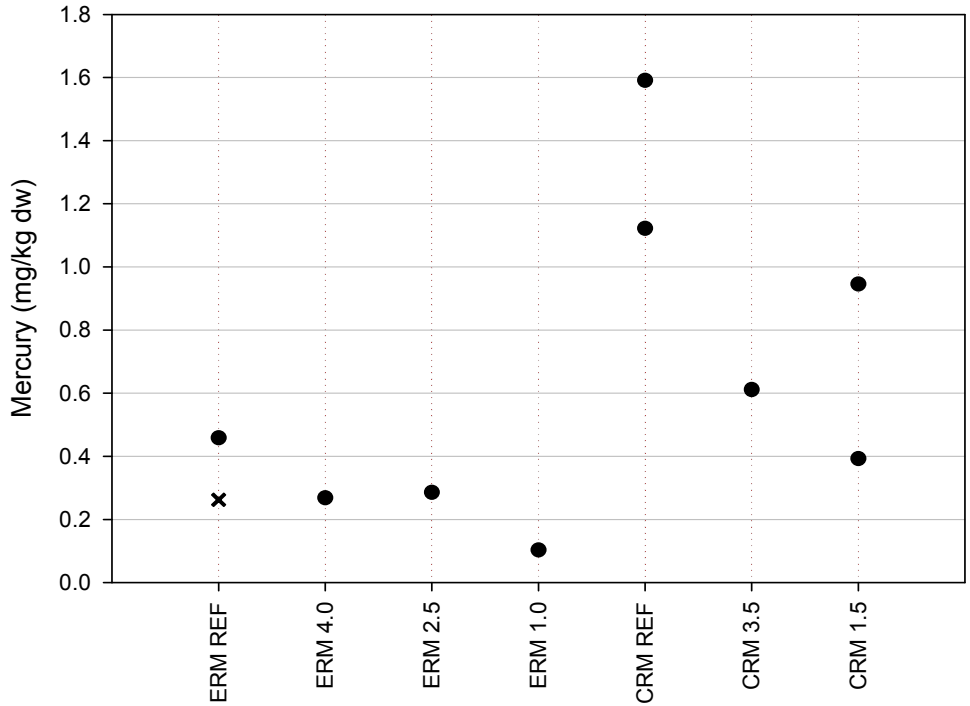
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

IRON AND LEAD CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
44





● Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

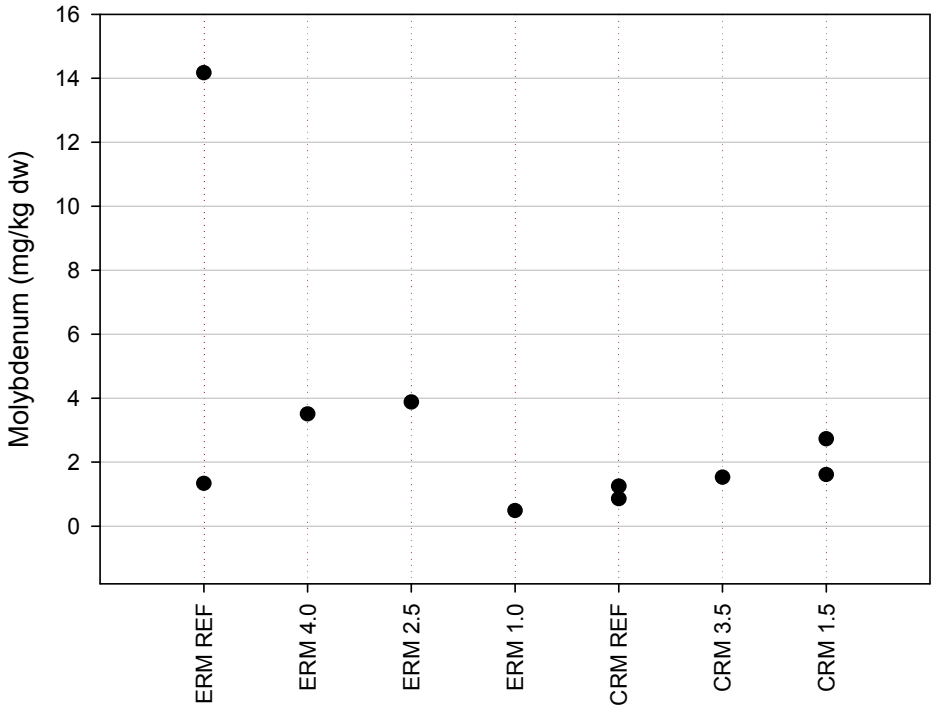
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

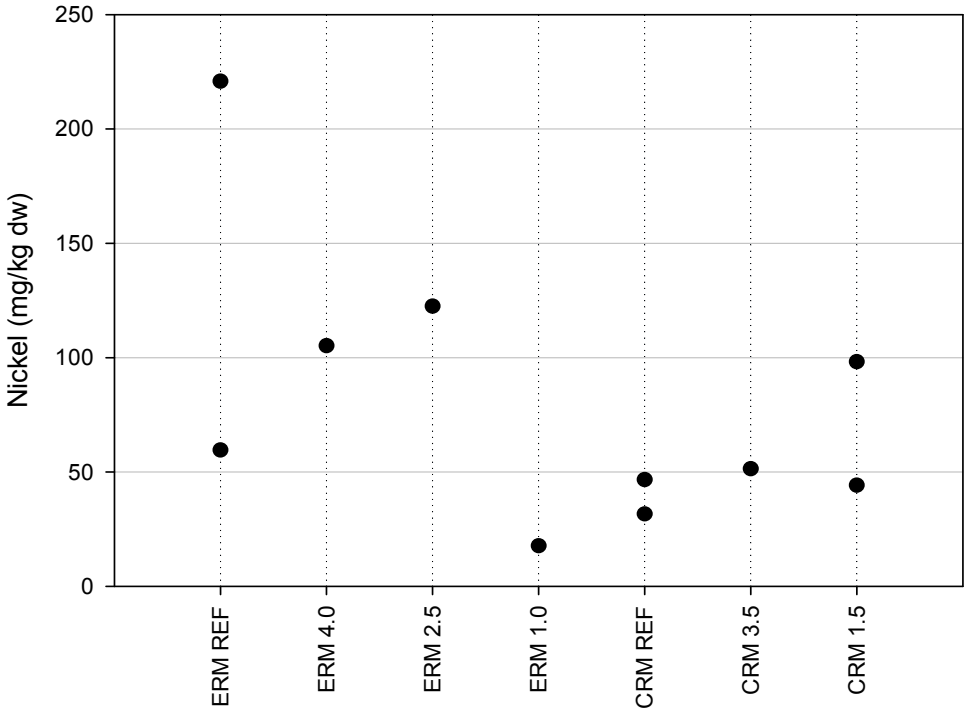
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MANGANESE AND MERCURY CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
45





● Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

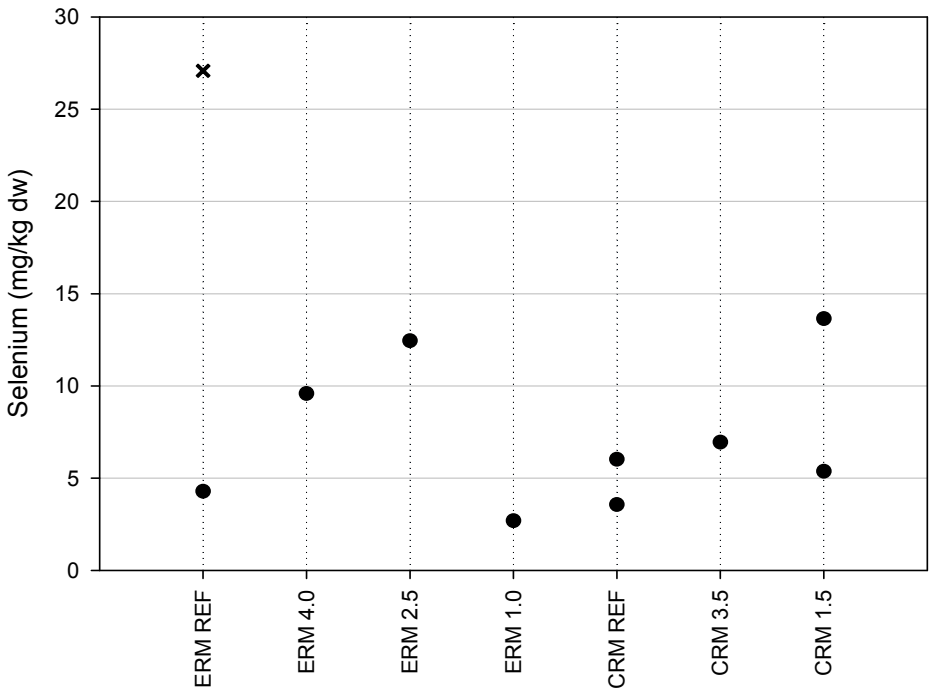
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

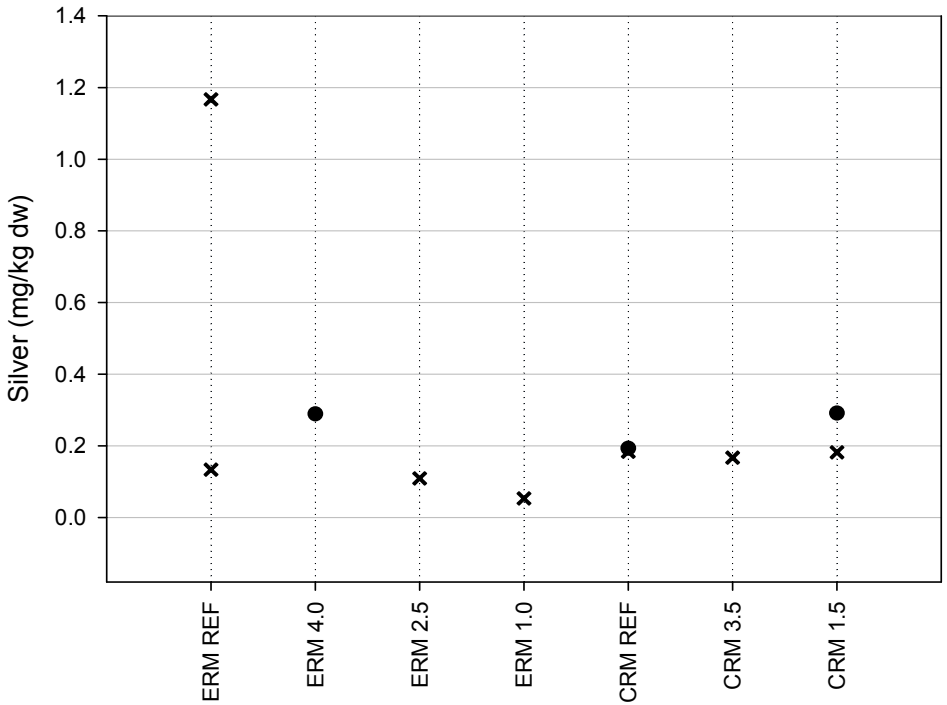
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

MOLYBDENUM AND NICKEL CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
46





● Detected Value
× Non-Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

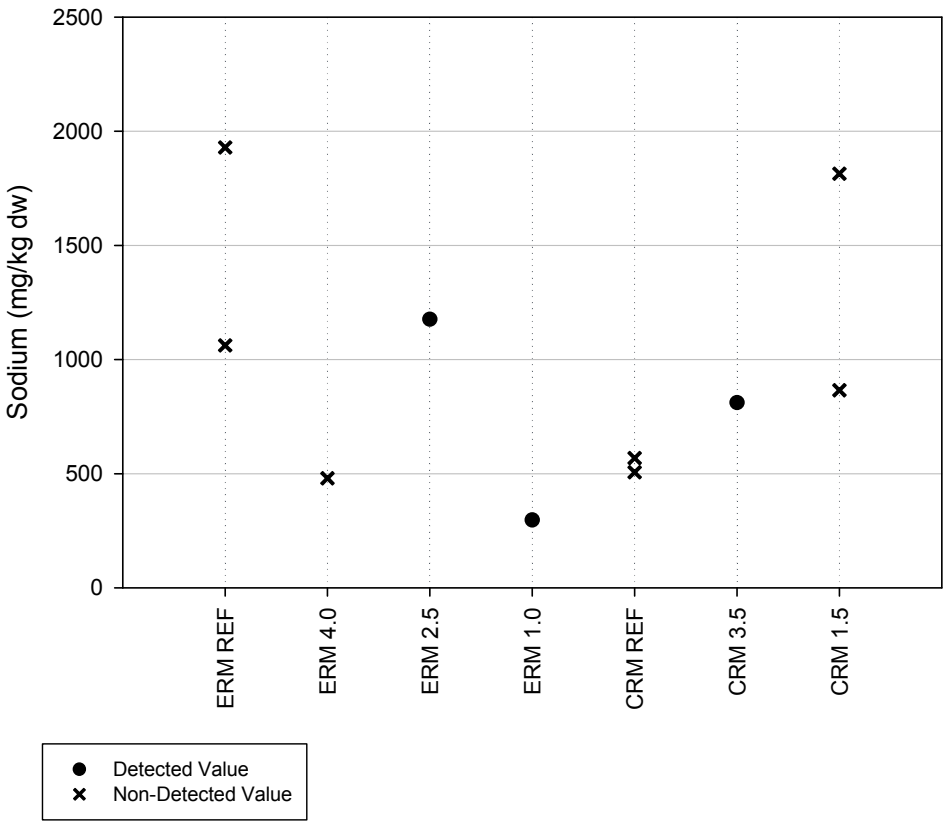
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

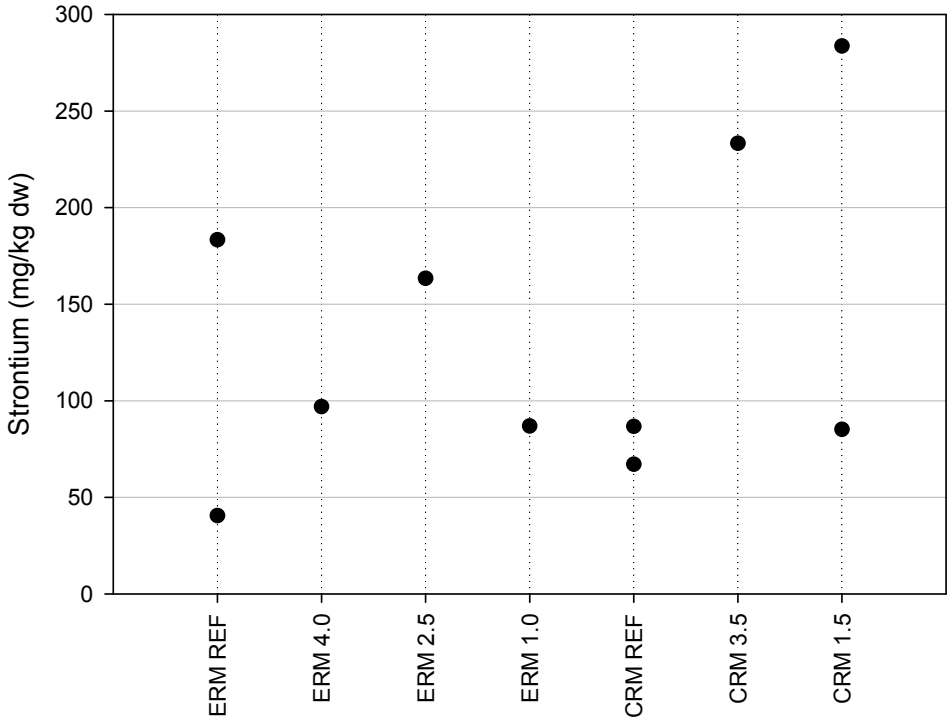
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

SELENIUM AND SILVER CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
47





Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

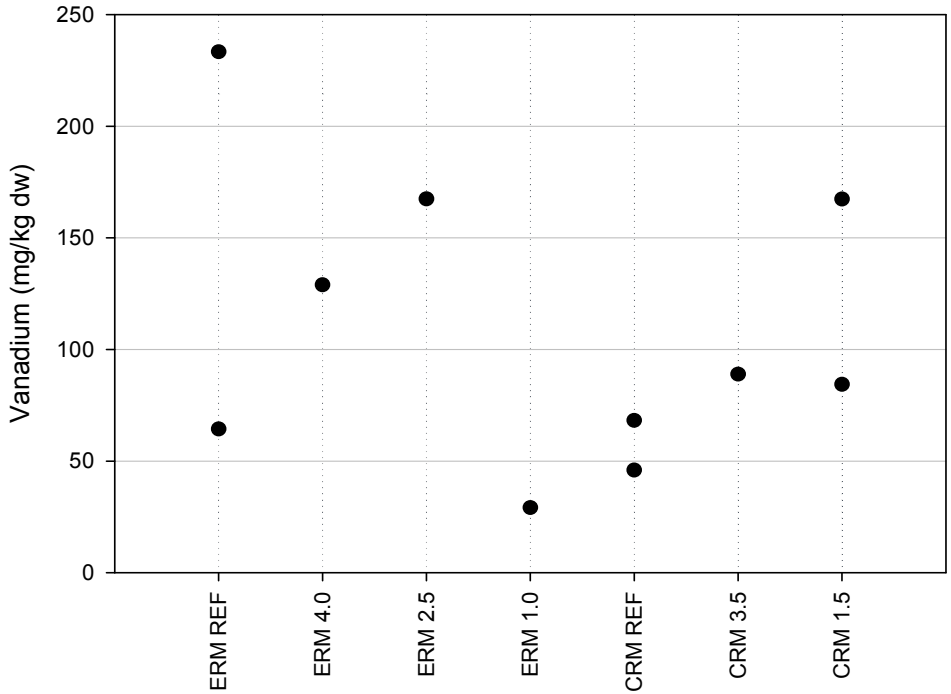
TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

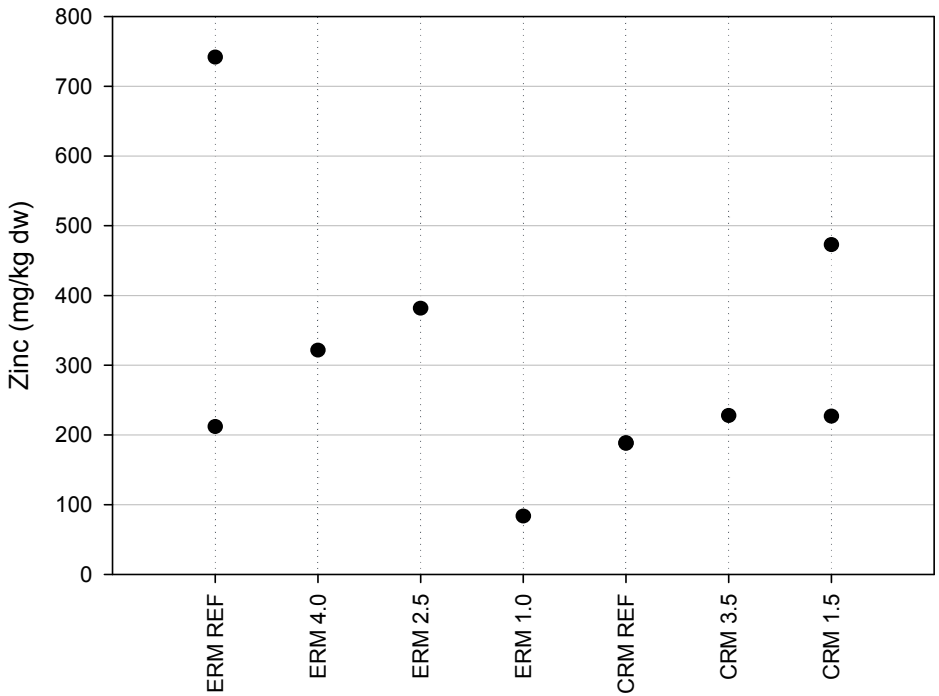
TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

SODIUM AND STRONTIUM CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
48





● Detected Value

Note: Plant tissue concentrations in mg/kg (dw) = milligrams per kilogram (dry weight).

CRM = Clinch River Mile.
ERM = Emory River Mile.
REF = Reference Location.

TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE

TRACE ELEMENT CONCENTRATIONS IN AQUATIC VEGETATION AND PERIPHYTON

VANADIUM AND ZINC CONCENTRATIONS IN PERIPHYTON

ARCADIS

FIGURE
49

ARCADIS

Appendix A

Emergent Vegetation
Occurrence Tables

Table A-1
Emergent Vegetation Dataset
Clinch River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	202.8	-	506.8	–	-	–
Antimony	0	-	3	0	–	-	–	0.09859	-	0.122
Arsenic	2	-	3	66.7	0.2314	-	0.5285	0.1972	-	0.1972
Barium	3	-	3	100	33.06	-	35.59	–	-	–
Beryllium	0	-	3	0	–	-	–	0.2042	-	0.252
Boron	3	-	3	100	46.48	-	55.93	–	-	–
Cadmium	1	-	3	33.3	0.1382	-	0.1382	0.05282	-	0.06198
Calcium	3	-	3	100	23732	-	28099	–	-	–
Chromium	0	-	3	0	–	-	–	0.8451	-	1.074
Cobalt	3	-	3	100	0.1972	-	0.6342	–	-	–
Copper	3	-	3	100	8.451	-	11.86	–	-	–
Iron	3	-	3	100	214.8	-	478	–	-	–
Lead	3	-	3	100	0.2606	-	0.7881	–	-	–
Magnesium	3	-	3	100	7348	-	8239	–	-	–
Manganese	3	-	3	100	97.18	-	400.9	–	-	–
Mercury	0	-	3	0	–	-	–	0.07746	-	0.09756
Molybdenum	3	-	3	100	0.5282	-	0.9917	–	-	–
Nickel	3	-	3	100	1.24	-	5.07	–	-	–
Potassium	3	-	3	100	20986	-	33388	–	-	–
Selenium	0	-	3	0	–	-	–	0.4648	-	0.5691
Silver	0	-	3	0	–	-	–	0.01972	-	0.02439
Sodium	0	-	3	0	–	-	–	333.1	-	406.5
Strontium	3	-	3	100	26.76	-	58.68	–	-	–
Thallium	0	-	3	0	–	-	–	0.09859	-	0.1157
Vanadium	3	-	3	100	0.3873	-	1.017	–	-	–
Zinc	3	-	3	100	43.8	-	80.49	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-2
Emergent Vegetation Dataset
Clinch River (2.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	26.21	-	98.25	–	-	–
Antimony	0	-	3	0	–	-	–	0.05645	-	0.07487
Arsenic	3	-	3	100	0.1979	-	0.7661	–	-	–
Barium	3	-	3	100	26.21	-	44.92	–	-	–
Beryllium	0	-	3	0	–	-	–	0.1129	-	0.1551
Boron	3	-	3	100	27.82	-	67.01	–	-	–
Cadmium	0	-	3	0	–	-	–	0.02944	-	0.04011
Calcium	3	-	3	100	10242	-	26316	–	-	–
Chromium	0	-	3	0	–	-	–	0.4839	-	0.6701
Cobalt	3	-	3	100	0.06048	-	0.2781	–	-	–
Copper	3	-	3	100	6.452	-	11.11	–	-	–
Iron	3	-	3	100	82.26	-	121.1	–	-	–
Lead	3	-	3	100	0.125	-	0.1872	–	-	–
Magnesium	3	-	3	100	3710	-	8342	–	-	–
Manganese	3	-	3	100	326.3	-	386.6	–	-	–
Mercury	0	-	3	0	–	-	–	0.04435	-	0.05882
Molybdenum	3	-	3	100	1.25	-	1.711	–	-	–
Nickel	3	-	3	100	0.5242	-	1.551	–	-	–
Potassium	3	-	3	100	19798	-	29485	–	-	–
Selenium	3	-	3	100	0.4032	-	0.7487	–	-	–
Silver	0	-	3	0	–	-	–	0.01129	-	0.01497
Sodium	0	-	3	0	–	-	–	186.7	-	253.5
Strontium	3	-	3	100	24.6	-	55.61	–	-	–
Thallium	0	-	3	0	–	-	–	0.05242	-	0.07487
Vanadium	0	-	3	0	–	-	–	0.1774	-	0.2406
Zinc	3	-	3	100	34.27	-	53.8	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-3
Emergent Vegetation Dataset
Clinch River (4.0)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	88.44	-	154.1	–	-	–
Antimony	0	-	3	0	–	-	–	0.04281	-	0.09524
Arsenic	1	-	3	33.3	0.2523	-	0.2523	0.08563	-	0.1837
Barium	3	-	3	100	16.97	-	42.81	–	-	–
Beryllium	0	-	3	0	–	-	–	0.09174	-	0.1973
Boron	3	-	3	100	14.07	-	50.34	–	-	–
Cadmium	2	-	3	66.7	0.05714	-	0.06881	0.02324	-	0.02324
Calcium	3	-	3	100	7248	-	17687	–	-	–
Chromium	1	-	3	33.3	0.7798	-	0.7798	0.367	-	0.8163
Cobalt	3	-	3	100	0.1973	-	0.4037	–	-	–
Copper	3	-	3	100	6.422	-	10.2	–	-	–
Iron	3	-	3	100	108.3	-	168.3	–	-	–
Lead	2	-	3	66.7	0.1835	-	0.3394	0.1837	-	0.1837
Magnesium	3	-	3	100	1936	-	5551	–	-	–
Manganese	3	-	3	100	98.17	-	600.7	–	-	–
Mercury	0	-	3	0	–	-	–	0.0367	-	0.07483
Molybdenum	3	-	3	100	0.4587	-	1.468	–	-	–
Nickel	3	-	3	100	1.239	-	2.783	–	-	–
Potassium	3	-	3	100	11651	-	28776	–	-	–
Selenium	1	-	3	33.3	0.3899	-	0.3899	0.208	-	0.4422
Silver	0	-	3	0	–	-	–	0.008869	-	0.01905
Sodium	0	-	3	0	–	-	–	147.7	-	317
Strontium	3	-	3	100	25.08	-	37.41	–	-	–
Thallium	0	-	3	0	–	-	–	0.04281	-	0.08844
Vanadium	1	-	3	33.3	0.3257	-	0.3257	0.1407	-	0.2993
Zinc	3	-	3	100	18.35	-	41.5	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-4
Emergent Vegetation Dataset
Emory River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations		Detection Limits	
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	3	-	3	100	293.2	955	–	–
Antimony	0	-	3	0	–	–	0.03509	0.1172
Arsenic	3	-	3	100	0.1429	0.5	–	–
Barium	3	-	3	100	17.29	60.16	–	–
Beryllium	0	-	3	0	–	–	0.07268	0.2344
Boron	3	-	3	100	6.516	57.81	–	–
Cadmium	2	-	3	66.7	0.1328	0.16	0.06016	0.06016
Calcium	3	-	3	100	2632	24141	–	–
Chromium	3	-	3	100	0.5013	1.4	–	–
Cobalt	3	-	3	100	0.4261	1.4	–	–
Copper	3	-	3	100	2.757	8.594	–	–
Iron	3	-	3	100	325.8	1080	–	–
Lead	3	-	3	100	0.3509	1.016	–	–
Magnesium	3	-	3	100	1068	7055	–	–
Manganese	3	-	3	100	443.6	535	–	–
Mercury	0	-	3	0	–	–	0.02757	0.09375
Molybdenum	3	-	3	100	0.5514	0.9375	–	–
Nickel	3	-	3	100	1.003	3.828	–	–
Potassium	3	-	3	100	11579	29531	–	–
Selenium	0	-	3	0	–	–	0.1654	0.5391
Silver	0	-	3	0	–	–	0.007018	0.02266
Sodium	0	-	3	0	–	–	117.8	382
Strontium	3	-	3	100	7.769	57.81	–	–
Thallium	0	-	3	0	–	–	0.03258	0.1094
Vanadium	3	-	3	100	0.401	1.6	–	–
Zinc	3	-	3	100	32.83	53.13	–	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-5
Emergent Vegetation Dataset
Emory River (1.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	49.66	-	96.79	–	-	–
Antimony	0	-	3	0	–	-	–	0.08929	-	0.1034
Arsenic	0	-	3	0	–	-	–	0.1731	-	0.3452
Barium	3	-	3	100	25.6	-	39.74	–	-	–
Beryllium	0	-	3	0	–	-	–	0.1795	-	0.2069
Boron	3	-	3	100	37.5	-	60	–	-	–
Cadmium	0	-	3	0	–	-	–	0.04679	-	0.0531
Calcium	3	-	3	100	16250	-	29359	–	-	–
Chromium	0	-	3	0	–	-	–	0.7692	-	0.8276
Cobalt	3	-	3	100	0.08929	-	0.3205	–	-	–
Copper	3	-	3	100	8.333	-	8.966	–	-	–
Iron	3	-	3	100	99.31	-	117.9	–	-	–
Lead	0	-	3	0	–	-	–	0.1726	-	0.1931
Magnesium	3	-	3	100	5202	-	8414	–	-	–
Manganese	3	-	3	100	135.1	-	333.8	–	-	–
Mercury	0	-	3	0	–	-	–	0.07051	-	0.08276
Molybdenum	3	-	3	100	0.5833	-	1.282	–	-	–
Nickel	3	-	3	100	0.8333	-	1.724	–	-	–
Potassium	3	-	3	100	24167	-	31724	–	-	–
Selenium	1	-	3	33.3	0.531	-	0.531	0.4167	-	0.8333
Silver	0	-	3	0	–	-	–	0.01786	-	0.02
Sodium	0	-	3	0	–	-	–	297.6	-	336.6
Strontium	3	-	3	100	36.9	-	69.23	–	-	–
Thallium	0	-	3	0	–	-	–	0.08333	-	0.09655
Vanadium	0	-	3	0	–	-	–	0.2798	-	0.3172
Zinc	3	-	3	100	30.34	-	39.1	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-6
Emergent Vegetation Dataset
Emory River (3.0)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	70.51	-	167.3	–	-	–
Antimony	0	-	3	0	–	-	–	0.04714	-	0.06452
Arsenic	3	-	3	100	0.1016	-	1.077	–	-	–
Barium	3	-	3	100	22.86	-	43.32	–	-	–
Beryllium	0	-	3	0	–	-	–	0.09524	-	0.129
Boron	3	-	3	100	13.8	-	28.57	–	-	–
Cadmium	3	-	3	100	0.05387	-	0.2889	–	-	–
Calcium	3	-	3	100	3460	-	11336	–	-	–
Chromium	1	-	3	33.3	0.4377	-	0.4377	0.4127	-	0.553
Cobalt	3	-	3	100	0.1556	-	0.553	–	-	–
Copper	3	-	3	100	3.704	-	5.714	–	-	–
Iron	3	-	3	100	109.8	-	235.7	–	-	–
Lead	2	-	3	66.7	0.1429	-	0.2222	0.1198	-	0.1198
Magnesium	3	-	3	100	1502	-	3074	–	-	–
Manganese	3	-	3	100	310.8	-	866.4	–	-	–
Mercury	0	-	3	0	–	-	–	0.0381	-	0.05069
Molybdenum	3	-	3	100	0.8889	-	1.429	–	-	–
Nickel	3	-	3	100	0.7071	-	1.429	–	-	–
Potassium	3	-	3	100	14343	-	22765	–	-	–
Selenium	0	-	3	0	–	-	–	0.4381	-	0.5899
Silver	0	-	3	0	–	-	–	0.009206	-	0.01244
Sodium	0	-	3	0	–	-	–	155.9	-	211.1
Strontium	3	-	3	100	11.75	-	35.94	–	-	–
Thallium	0	-	3	0	–	-	–	0.04444	-	0.05991
Vanadium	1	-	3	33.3	0.3064	-	0.3064	0.1492	-	0.1982
Zinc	3	-	3	100	28.28	-	47.62	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-7
Emergent Vegetation Dataset
Emory River (4.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	141.9	-	440.1	–	-	–
Antimony	0	-	3	0	–	-	–	0.0436	-	0.07558
Arsenic	1	-	3	33.3	0.2442	-	0.2442	0.1628	-	0.1846
Barium	3	-	3	100	19.19	-	76.17	–	-	–
Beryllium	0	-	3	0	–	-	–	0.08721	-	0.1512
Boron	3	-	3	100	13.08	-	50.58	–	-	–
Cadmium	2	-	3	66.7	0.2791	-	0.3691	0.03953	-	0.03953
Calcium	3	-	3	100	3895	-	21047	–	-	–
Chromium	0	-	3	0	–	-	–	0.3779	-	0.6395
Cobalt	3	-	3	100	0.2587	-	1.208	–	-	–
Copper	3	-	3	100	4.07	-	7.558	–	-	–
Iron	3	-	3	100	220.1	-	645.3	–	-	–
Lead	3	-	3	100	0.198	-	0.5756	–	-	–
Magnesium	3	-	3	100	1485	-	5360	–	-	–
Manganese	3	-	3	100	392.4	-	1591	–	-	–
Mercury	0	-	3	0	–	-	–	0.03488	-	0.05814
Molybdenum	3	-	3	100	0.5705	-	0.9884	–	-	–
Nickel	3	-	3	100	0.8721	-	2.093	–	-	–
Potassium	3	-	3	100	15101	-	26919	–	-	–
Selenium	0	-	3	0	–	-	–	0.3924	-	0.6977
Silver	0	-	3	0	–	-	–	0.00843	-	0.01512
Sodium	1	-	3	33.3	231.7	-	231.7	159.7	-	248.8
Strontium	3	-	3	100	12.21	-	50.58	–	-	–
Thallium	1	-	3	33.3	0.05705	-	0.05705	0.0407	-	0.06977
Vanadium	3	-	3	100	0.1711	-	0.7558	–	-	–
Zinc	3	-	3	100	36.34	-	57.05	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-8
Emergent Vegetation Dataset
Tennessee River (567)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations		Detection Limits	
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	3	-	3	100	92.77	362.2	–	–
Antimony	0	-	3	0	–	–	0.06383	0.1102
Arsenic	2	-	3	66.7	0.2468	0.2677	0.3253	0.3253
Barium	3	-	3	100	25.53	210.8	–	–
Beryllium	0	-	3	0	–	–	0.1277	0.2205
Boron	3	-	3	100	11.91	51.97	–	–
Cadmium	0	-	3	0	–	–	0.03362	0.05591
Calcium	3	-	3	100	8426	25591	–	–
Chromium	0	-	3	0	–	–	0.5532	0.9449
Cobalt	3	-	3	100	0.315	0.6024	–	–
Copper	3	-	3	100	5.106	7.874	–	–
Iron	3	-	3	100	122.9	419.7	–	–
Lead	2	-	3	66.7	0.1702	0.4094	0.1627	0.1627
Magnesium	3	-	3	100	2574	8189	–	–
Manganese	3	-	3	100	192.8	395.3	–	–
Mercury	0	-	3	0	–	–	0.05106	0.08661
Molybdenum	3	-	3	100	0.5482	1.102	–	–
Nickel	3	-	3	100	0.4681	2.047	–	–
Potassium	3	-	3	100	14936	31205	–	–
Selenium	0	-	3	0	–	–	0.5915	1
Silver	0	-	3	0	–	–	0.01277	0.02126
Sodium	0	-	3	0	–	–	211.9	355.9
Strontium	3	-	3	100	23.83	58.27	–	–
Thallium	0	-	3	0	–	–	0.05957	0.1024
Vanadium	2	-	3	66.7	0.3106	0.6535	0.2651	0.2651
Zinc	3	-	3	100	32.53	43.31	–	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table A-9
Emergent Vegetation Dataset
Tennessee River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations		Detection Limits	
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	3	-	3	100	18.58	102	–	–
Antimony	0	-	3	0	–	–	0.05242	0.06829
Arsenic	1	-	3	33.3	0.1344	0.1344	0.2097	0.2634
Barium	3	-	3	100	3.557	43.41	–	–
Beryllium	0	-	3	0	–	–	0.1089	0.1366
Boron	3	-	3	100	4.743	16.94	–	–
Cadmium	2	-	3	66.7	0.06829	0.125	0.02846	0.02846
Calcium	3	-	3	100	1980	13171	–	–
Chromium	1	-	3	33.3	1.317	1.317	0.4743	0.4839
Cobalt	3	-	3	100	0.06855	1.22	–	–
Copper	3	-	3	100	4.878	8.871	–	–
Iron	3	-	3	100	55.65	243.4	–	–
Lead	1	-	3	33.3	0.1129	0.1129	0.1028	0.1317
Magnesium	3	-	3	100	1289	4435	–	–
Manganese	3	-	3	100	242.7	887.8	–	–
Mercury	0	-	3	0	–	–	0.04348	0.05366
Molybdenum	3	-	3	100	0.2621	1.512	–	–
Nickel	2	-	3	66.7	0.4585	0.6855	0.3676	0.3676
Potassium	3	-	3	100	12661	22439	–	–
Selenium	0	-	3	0	–	–	0.504	0.6293
Silver	1	-	3	33.3	0.01532	0.01532	0.01067	0.01366
Sodium	1	-	3	33.3	1798	1798	179.8	225.4
Strontium	3	-	3	100	4.348	37.56	–	–
Thallium	0	-	3	0	–	–	0.05138	0.06341
Vanadium	1	-	3	33.3	0.2585	0.2585	0.1694	0.17
Zinc	3	-	3	100	30.73	47.18	–	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

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Appendix B

Shoreline Vegetation
Occurrence Tables

Table B-1
Shoreline Vegetation Dataset
Clinch River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	26.35	-	32.55	–	-	–
Antimony	0	-	3	0	–	-	–	0.0473	-	0.06604
Arsenic	0	-	3	0	–	-	–	0.08784	-	0.1274
Barium	3	-	3	100	10.54	-	44.59	–	-	–
Beryllium	0	-	3	0	–	-	–	0.09459	-	0.1368
Boron	3	-	3	100	12.59	-	19.81	–	-	–
Cadmium	1	-	3	33.3	0.03176	-	0.03176	0.02687	-	0.03491
Calcium	3	-	3	100	6803	-	10330	–	-	–
Chromium	0	-	3	0	–	-	–	0.4054	-	0.566
Cobalt	2	-	3	66.7	0.06757	-	0.119	0.06604	-	0.06604
Copper	3	-	3	100	5.782	-	10.85	–	-	–
Iron	3	-	3	100	49.66	-	77.83	–	-	–
Lead	1	-	3	33.3	0.1081	-	0.1081	0.09864	-	0.1274
Magnesium	3	-	3	100	2297	-	4505	–	-	–
Manganese	3	-	3	100	67.92	-	112.5	–	-	–
Mercury	0	-	3	0	–	-	–	0.03716	-	0.05189
Molybdenum	3	-	3	100	0.277	-	1.429	–	-	–
Nickel	3	-	3	100	0.5782	-	1.419	–	-	–
Potassium	3	-	3	100	13367	-	20566	–	-	–
Selenium	0	-	3	0	–	-	–	0.2162	-	0.3113
Silver	0	-	3	0	–	-	–	0.009122	-	0.01321
Sodium	0	-	3	0	–	-	–	153	-	221.7
Strontium	3	-	3	100	11.32	-	19.93	–	-	–
Thallium	0	-	3	0	–	-	–	0.04392	-	0.06132
Vanadium	0	-	3	0	–	-	–	0.1453	-	0.2123
Zinc	3	-	3	100	30.66	-	42.57	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-2
Shoreline Vegetation Dataset
Clinch River (2.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	38.04	-	450.8	–	-	–
Antimony	0	-	3	0	–	-	–	0.03627	-	0.053
Arsenic	1	-	3	33.3	0.3109	-	0.3109	0.08282	-	0.09894
Barium	3	-	3	100	7.669	-	30.04	–	-	–
Beryllium	0	-	3	0	–	-	–	0.07513	-	0.106
Boron	3	-	3	100	8.834	-	22.7	–	-	–
Cadmium	2	-	3	66.7	0.03067	-	0.05181	0.02721	-	0.02721
Calcium	3	-	3	100	5890	-	9378	–	-	–
Chromium	1	-	3	33.3	0.7254	-	0.7254	0.3681	-	0.4594
Cobalt	2	-	3	66.7	0.05215	-	0.4404	0.04947	-	0.04947
Copper	3	-	3	100	5.3	-	7.669	–	-	–
Iron	3	-	3	100	53.99	-	435.2	–	-	–
Lead	3	-	3	100	0.1012	-	1.244	–	-	–
Magnesium	3	-	3	100	1463	-	3057	–	-	–
Manganese	3	-	3	100	19.43	-	57.25	–	-	–
Mercury	0	-	3	0	–	-	–	0.0285	-	0.0424
Molybdenum	3	-	3	100	0.9509	-	1.554	–	-	–
Nickel	2	-	3	66.7	0.424	-	0.8808	0.2914	-	0.2914
Potassium	3	-	3	100	8342	-	22546	–	-	–
Selenium	0	-	3	0	–	-	–	0.1736	-	0.2403
Silver	0	-	3	0	–	-	–	0.007513	-	0.01025
Sodium	0	-	3	0	–	-	–	124.1	-	171.4
Strontium	3	-	3	100	12.27	-	18.02	–	-	–
Thallium	0	-	3	0	–	-	–	0.03627	-	0.04947
Vanadium	1	-	3	33.3	0.829	-	0.829	0.135	-	0.1625
Zinc	3	-	3	100	29.33	-	36.5	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-3
Shoreline Vegetation Dataset
Clinch River (4.0)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	25.91	-	94.03	–	-	–
Antimony	0	-	3	0	–	-	–	0.04179	-	0.06073
Arsenic	0	-	3	0	–	-	–	0.0806	-	0.1134
Barium	3	-	3	100	11.96	-	45.97	–	-	–
Beryllium	0	-	3	0	–	-	–	0.08657	-	0.1215
Boron	3	-	3	100	11.34	-	18.21	–	-	–
Cadmium	3	-	3	100	0.03279	-	0.05075	–	-	–
Calcium	3	-	3	100	7015	-	9190	–	-	–
Chromium	1	-	3	33.3	0.6073	-	0.6073	0.3582	-	0.3987
Cobalt	3	-	3	100	0.08638	-	0.3881	–	-	–
Copper	3	-	3	100	7.164	-	12.55	–	-	–
Iron	3	-	3	100	55.15	-	76.72	–	-	–
Lead	3	-	3	100	0.09302	-	0.1612	–	-	–
Magnesium	3	-	3	100	2254	-	2968	–	-	–
Manganese	3	-	3	100	118.6	-	267.2	–	-	–
Mercury	0	-	3	0	–	-	–	0.03284	-	0.04858
Molybdenum	3	-	3	100	0.2567	-	4.319	–	-	–
Nickel	3	-	3	100	0.598	-	2.836	–	-	–
Potassium	3	-	3	100	14534	-	16716	–	-	–
Selenium	0	-	3	0	–	-	–	0.194	-	0.2753
Silver	1	-	3	33.3	0.01741	-	0.01741	0.008358	-	0.009302
Sodium	0	-	3	0	–	-	–	139.1	-	197.2
Strontium	3	-	3	100	15.95	-	23.58	–	-	–
Thallium	0	-	3	0	–	-	–	0.03881	-	0.05668
Vanadium	0	-	3	0	–	-	–	0.1313	-	0.1862
Zinc	3	-	3	100	28.36	-	38.46	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-4
Shoreline Vegetation Dataset
Emory River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	37.25	-	206	–	-	–
Antimony	0	-	3	0	–	-	–	0.0549	-	0.07609
Arsenic	0	-	3	0	–	-	–	0.1059	-	0.1522
Barium	3	-	3	100	47.06	-	120.9	–	-	–
Beryllium	0	-	3	0	–	-	–	0.1137	-	0.1576
Boron	3	-	3	100	12.16	-	30.77	–	-	–
Cadmium	3	-	3	100	0.1581	-	0.3859	–	-	–
Calcium	3	-	3	100	6667	-	15128	–	-	–
Chromium	1	-	3	33.3	0.902	-	0.902	0.5556	-	0.7065
Cobalt	3	-	3	100	0.1961	-	0.5435	–	-	–
Copper	3	-	3	100	5.128	-	11.96	–	-	–
Iron	3	-	3	100	71.76	-	262	–	-	–
Lead	2	-	3	66.7	0.2337	-	0.2436	0.1059	-	0.1059
Magnesium	3	-	3	100	3027	-	4829	–	-	–
Manganese	3	-	3	100	206.7	-	348.9	–	-	–
Mercury	0	-	3	0	–	-	–	0.04314	-	0.05978
Molybdenum	3	-	3	100	0.1923	-	0.5098	–	-	–
Nickel	3	-	3	100	2.337	-	3.59	–	-	–
Potassium	3	-	3	100	12094	-	24783	–	-	–
Selenium	0	-	3	0	–	-	–	0.2588	-	0.3641
Silver	1	-	3	33.3	0.07609	-	0.07609	0.01098	-	0.01282
Sodium	0	-	3	0	–	-	–	184.3	-	259.2
Strontium	3	-	3	100	22.75	-	50.85	–	-	–
Thallium	0	-	3	0	–	-	–	0.05098	-	0.07609
Vanadium	1	-	3	33.3	0.2949	-	0.2949	0.1765	-	0.2446
Zinc	3	-	3	100	45.1	-	76.63	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-5
Shoreline Vegetation Dataset
Emory River (1.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	35.34	-	200.8	–	-	–
Antimony	0	-	3	0	–	-	–	0.03769	-	0.05639
Arsenic	0	-	3	0	–	-	–	0.07143	-	0.109
Barium	3	-	3	100	26.69	-	32.24	–	-	–
Beryllium	0	-	3	0	–	-	–	0.07538	-	0.1128
Boron	3	-	3	100	9.694	-	20.72	–	-	–
Cadmium	0	-	3	0	–	-	–	0.01964	-	0.1165
Calcium	3	-	3	100	7270	-	11805	–	-	–
Chromium	1	-	3	33.3	0.4592	-	0.4592	0.4276	-	0.4887
Cobalt	3	-	3	100	0.09398	-	0.5528	–	-	–
Copper	3	-	3	100	5.357	-	9.398	–	-	–
Iron	3	-	3	100	66.92	-	265.3	–	-	–
Lead	2	-	3	66.7	0.09211	-	0.1225	0.109	-	0.109
Magnesium	3	-	3	100	1510	-	2434	–	-	–
Manganese	3	-	3	100	48.5	-	152	–	-	–
Mercury	0	-	3	0	–	-	–	0.03015	-	0.04511
Molybdenum	2	-	3	66.7	0.5921	-	0.7895	0.09045	-	0.09045
Nickel	3	-	3	100	0.8271	-	2.161	–	-	–
Potassium	3	-	3	100	9924	-	17895	–	-	–
Selenium	0	-	3	0	–	-	–	0.1735	-	0.2632
Silver	0	-	3	0	–	-	–	0.007398	-	0.02594
Sodium	0	-	3	0	–	-	–	124.2	-	186.5
Strontium	3	-	3	100	27.07	-	34.21	–	-	–
Thallium	0	-	3	0	–	-	–	0.03518	-	0.05263
Vanadium	1	-	3	33.3	0.2806	-	0.2806	0.148	-	0.1767
Zinc	2	-	3	66.7	19.9	-	32.24	38.35	-	38.35

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-6
Shoreline Vegetation Dataset
Emory River (3.0)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	18.99	-	27.76	–	-	–
Antimony	0	-	3	0	–	-	–	0.04982	-	0.05426
Arsenic	3	-	3	100	0.1317	-	0.3424	–	-	–
Barium	3	-	3	100	31.13	-	54.09	–	-	–
Beryllium	0	-	3	0	–	-	–	0.1032	-	0.1124
Boron	3	-	3	100	8.915	-	9.609	–	-	–
Cadmium	0	-	3	0	–	-	–	0.04626	-	0.0969
Calcium	3	-	3	100	4708	-	6318	–	-	–
Chromium	0	-	3	0	–	-	–	0.4626	-	0.5039
Cobalt	3	-	3	100	0.1362	-	0.3333	–	-	–
Copper	3	-	3	100	5.426	-	6.05	–	-	–
Iron	3	-	3	100	59.53	-	74.81	–	-	–
Lead	2	-	3	66.7	0.1068	-	0.1089	0.1085	-	0.1085
Magnesium	3	-	3	100	2062	-	2412	–	-	–
Manganese	3	-	3	100	268.1	-	883.7	–	-	–
Mercury	0	-	3	0	–	-	–	0.04264	-	0.0428
Molybdenum	3	-	3	100	0.605	-	1.051	–	-	–
Nickel	3	-	3	100	1.24	-	1.779	–	-	–
Potassium	3	-	3	100	15552	-	19961	–	-	–
Selenium	0	-	3	0	–	-	–	0.2384	-	0.2597
Silver	0	-	3	0	–	-	–	0.01032	-	0.0144
Sodium	0	-	3	0	–	-	–	170.8	-	185.7
Strontium	3	-	3	100	18.29	-	23.64	–	-	–
Thallium	0	-	3	0	–	-	–	0.04982	-	0.05426
Vanadium	0	-	3	0	–	-	–	0.1601	-	0.1744
Zinc	2	-	3	66.7	50.97	-	55.16	35.27	-	35.27

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-7
Shoreline Vegetation Dataset
Emory River (4.5)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	31.82	-	138.1	–	-	–
Antimony	0	-	3	0	–	-	–	0.03423	-	0.04762
Arsenic	1	-	3	33.3	0.2687	-	0.2687	0.06846	-	0.08766
Barium	3	-	3	100	24.69	-	66.67	–	-	–
Beryllium	0	-	3	0	–	-	–	0.0709	-	0.09524
Boron	3	-	3	100	10.02	-	12.59	–	-	–
Cadmium	1	-	3	33.3	0.1491	-	0.1491	0.0487	-	0.119
Calcium	3	-	3	100	4903	-	5952	–	-	–
Chromium	0	-	3	0	–	-	–	0.3178	-	0.4082
Cobalt	3	-	3	100	0.07143	-	0.3741	–	-	–
Copper	3	-	3	100	4.89	-	6.169	–	-	–
Iron	3	-	3	100	57.14	-	180.3	–	-	–
Lead	3	-	3	100	0.1006	-	0.1905	–	-	–
Magnesium	3	-	3	100	1511	-	2675	–	-	–
Manganese	3	-	3	100	247.1	-	642.9	–	-	–
Mercury	0	-	3	0	–	-	–	0.02934	-	0.03741
Molybdenum	3	-	3	100	0.2825	-	1.687	–	-	–
Nickel	3	-	3	100	1.701	-	2.175	–	-	–
Potassium	3	-	3	100	9578	-	15102	–	-	–
Selenium	0	-	3	0	–	-	–	0.1638	-	0.2211
Silver	0	-	3	0	–	-	–	0.00709	-	0.009524
Sodium	0	-	3	0	–	-	–	117.4	-	156.5
Strontium	3	-	3	100	16.87	-	22.45	–	-	–
Thallium	0	-	3	0	–	-	–	0.03423	-	0.04422
Vanadium	2	-	3	66.7	0.132	-	0.2109	0.1396	-	0.1396
Zinc	2	-	3	66.7	37.9	-	47.28	37.01	-	37.01

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-8
Shoreline Vegetation Dataset
Tennessee River (567)
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations			Detection Limits		
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	-	Max (mg/kg)	Min (mg/kg)	-	Max (mg/kg)
Aluminum	3	-	3	100	14.49	-	36.26	–	-	–
Antimony	0	-	3	0	–	-	–	0.04058	-	0.05344
Arsenic	2	-	3	66.7	0.1101	-	0.1637	0.1069	-	0.1069
Barium	3	-	3	100	27.48	-	34.88	–	-	–
Beryllium	0	-	3	0	–	-	–	0.08406	-	0.1107
Boron	3	-	3	100	4.982	-	6.957	–	-	–
Cadmium	0	-	3	0	–	-	–	0.02174	-	0.02901
Calcium	3	-	3	100	4493	-	4626	–	-	–
Chromium	0	-	3	0	–	-	–	0.3768	-	0.4962
Cobalt	3	-	3	100	0.07117	-	0.1374	–	-	–
Copper	3	-	3	100	6.406	-	8.397	–	-	–
Iron	3	-	3	100	56.52	-	72.52	–	-	–
Lead	2	-	3	66.7	0.1459	-	0.3397	0.08116	-	0.08116
Magnesium	3	-	3	100	1859	-	2779	–	-	–
Manganese	3	-	3	100	167.5	-	366.5	–	-	–
Mercury	0	-	3	0	–	-	–	0.03188	-	0.04198
Molybdenum	3	-	3	100	0.1679	-	2.899	–	-	–
Nickel	3	-	3	100	0.6087	-	1.489	–	-	–
Potassium	3	-	3	100	12870	-	16031	–	-	–
Selenium	0	-	3	0	–	-	–	0.1942	-	0.2557
Silver	0	-	3	0	–	-	–	0.008406	-	0.01107
Sodium	0	-	3	0	–	-	–	138.3	-	182.8
Strontium	3	-	3	100	11.39	-	12.75	–	-	–
Thallium	0	-	3	0	–	-	–	0.04058	-	0.05344
Vanadium	0	-	3	0	–	-	–	0.1304	-	0.1718
Zinc	3	-	3	100	61.83	-	76.87	–	-	–

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

Table B-9
Shoreline Vegetation Dataset
Tennessee River - Reference Site
Tennessee Valley Authority (TVA)
Kingston Ash Recovery Project

Constituent	Frequency of Detection (FOD) [a]				Detected Concentrations		Detection Limits	
	Number of Detects / Number of Samples			FOD %	Min (mg/kg)	Max (mg/kg)	Min (mg/kg)	Max (mg/kg)
Aluminum	3	-	3	100	175.8	223.4	–	–
Antimony	0	-	3	0	–	–	0.04545	0.05814
Arsenic	0	-	3	0	–	–	0.09091	0.1124
Barium	3	-	3	100	6.169	49.19	–	–
Beryllium	0	-	3	0	–	–	0.0974	0.1163
Boron	3	-	3	100	4.221	12.5	–	–
Cadmium	0	-	3	0	–	–	0.02468	0.1331
Calcium	3	-	3	100	3042	12339	–	–
Chromium	2	-	3	66.7	0.5242	0.5519	0.5039	0.5039
Cobalt	3	-	3	100	0.1163	0.375	–	–
Copper	3	-	3	100	9.416	26.36	–	–
Iron	3	-	3	100	206.5	228.9	–	–
Lead	3	-	3	100	0.246	0.7364	–	–
Magnesium	3	-	3	100	1750	4556	–	–
Manganese	3	-	3	100	418.8	758.1	–	–
Mercury	0	-	3	0	–	–	0.03896	0.04651
Molybdenum	3	-	3	100	0.1948	1.976	–	–
Nickel	3	-	3	100	0.8065	5.039	–	–
Potassium	3	-	3	100	14838	21357	–	–
Selenium	0	-	3	0	–	–	0.2208	0.2713
Silver	0	-	3	0	–	–	0.009416	0.02558
Sodium	0	-	3	0	–	–	156.8	192.6
Strontium	3	-	3	100	6.494	34.27	–	–
Thallium	0	-	3	0	–	–	0.04545	0.05426
Vanadium	3	-	3	100	0.2752	0.3117	–	–
Zinc	1	-	3	33.3	60.48	60.48	30.84	42.64

– - Not detected/ not analyzed/ not applicable.
mg/kg dw - Milligram per kilogram dry weight.

[a] - Frequency of detection (FOD) = number of detects / total number of samples analyzed.

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Appendix C

Emergent Vegetation 2011
Sample Results

Table C-1. Emergent Vegetation 2011 Sample Results, Emory River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	ERM_REF 06/21/2011	ERM_REF 06/21/2011	ERM_REF 06/21/2011	ERM1.5 06/21/2011	ERM1.5 06/21/2011	ERM1.5 06/21/2011	ERM3.0 6/21/2011	ERM3.0 6/21/2011	ERM3.0 6/21/2011	ERM4.5 6/21/2011	ERM4.5 6/21/2011	ERM4.5 6/21/2011
Aluminum	955	293.2	882.8	49.66 J	96.79 J	63.1 J	80.32	70.51 J	167.3	440.1	160.8	141.9
Antimony	<0.065	<0.03509	<0.1172	<0.1034	<0.08974	<0.08929	<0.04762	<0.06452	<0.04714	<0.07558	<0.0436	<0.04698
Arsenic	0.5	0.1429 J	0.375 J	<0.1931	<0.1731	<0.3452	0.1016 J	0.235 J	1.077	0.2442 J	<0.1628	<0.1846
Barium	30.5	17.29	60.16	36.55	39.74	25.6	22.86	43.32	37.04	52.33	19.19	76.17
Beryllium	<0.135	<0.07268	<0.2344	<0.2069	<0.1795	<0.1845	<0.09524	<0.129	<0.09764	<0.1512	<0.08721	<0.09732
Boron	11	6.516	57.81	60	48.72	37.5	14.92	28.57	13.8	50.58	13.08	16.11
Cadmium	0.16 J	0.1328 J	<0.06016	<0.0531	<0.04679	<0.04702	0.2889 J	0.06452 J	0.05387 J	<0.03953	0.2791 J	0.3691
Calcium	6650	2632	24141	25379	29359	16250	3460	11336	6195	21047	3895	6342
Chromium	1.4 J	0.5013 J	1.328 J	<0.8276 J	<0.7692 J	<0.7738 J	<0.4127 J	<0.553 J	0.4377 J	<0.6395 J	<0.3779 J	<0.4362 J
Cobalt	1.4 J	0.4261 J	1.172 J	0.1448 J	0.3205 J	0.08929 J	0.1556 J	0.553 J	0.2593 J	0.5814 J	0.2587 J	1.208 J
Copper	6	2.757	8.594	8.966	8.333	8.333	5.714	5.069	3.704	7.558	4.07	5.369
Iron	1080	325.8	1023	99.31 J	117.9 J	111.3 J	109.8	132.7	235.7	645.3	220.1	228.9
Lead	0.9 J	0.3509 J	1.016 J	<0.1931	<0.1731	<0.1726	0.1429 J	<0.1198	0.2222 J	0.5756 J	0.2151 J	0.198 J
Magnesium	2270	1068	7055	8414	7436	5202	1502	3074	1970	5360	1485	2842
Manganese	535	443.6	525	333.8	201.3	135.1	310.8	866.4	552.2	610.5	392.4	1591
Mercury	<0.05	<0.02757	<0.09375	<0.08276	<0.07051	<0.07143	<0.0381	<0.05069	<0.0404	<0.05814	<0.03488	<0.03691
Molybdenum	0.8 J	0.5514 J	0.9375 J	1.172 J	1.282 J	0.5833 J	0.8889 J	1.429 J	1.313 J	0.8721 J	0.9884 J	0.5705 J
Nickel	2.85	1.003 J	3.828	1.724 J	1.218 J	0.8333 J	0.8254 J	1.429 J	0.7071 J	2.093 J	0.8721 J	1.342 J
Potassium	13300	11579	29531	31724	28077	24167	14571	22765	14343	26919	15465	15101
Selenium	<0.305	<0.1654	<0.5391 J	0.531 J	<0.4167	<0.8333	<0.4381	<0.5899	<0.4545	<0.6977	<0.3924	<0.4463
Silver	<0.013	<0.007018	<0.02266	<0.02	<0.01795	<0.01786	<0.009206	<0.01244	<0.009764	<0.01512	<0.00843	<0.009732
Sodium	<217.5	<117.8	<382	<336.6	<298.1	<297.6	<155.9	<211.1	<162.3	<248.8	231.7 J	<159.7
Strontium	18.5	7.769	57.81	60	69.23	36.9	11.75	35.94	19.53	50.58	12.21	32.89
Thallium	<0.06	<0.03258	<0.1094	<0.09655	<0.08333	<0.08333	<0.04444	<0.05991	<0.04714	<0.06977	<0.0407	0.05705 J
Vanadium	1.6	0.401 J	1.328 J	<0.3172	<0.2821	<0.2798	<0.1492	<0.1982	0.3064 J	0.7558 J	0.2267 J	0.1711 J
Zinc	52.5	32.83	53.13	30.34 J	39.1	36.31	47.62	35.48	28.28	38.95	36.34	57.05

< - Not detected at sample quantitation limit indicated.

J - Estimated value.

ERM - Emory River Mile.

mg/kg dw - Milligrams per kilogram dry weight.

Table C-2. Emergent Vegetation 2011 Sample Results, Clinch River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	CRM_REF 06/21/2011	CRM_REF 06/21/2011	CRM_REF 06/21/2011	CRM2.5 06/21/2011	CRM2.5 06/21/2011	CRM2.5 06/21/2011	CRM4.0 06/21/2011	CRM4.0 06/21/2011	CRM4.0 06/21/2011
Aluminum	506.8	357	202.8	98.25 J	26.21 J	68.98 J	88.44 J	154.1	103.1
Antimony	<0.122	<0.1157	<0.09859	<0.06701	<0.05645	<0.07487	<0.09524	<0.06881	<0.04281
Arsenic	0.5285 J	0.2314 J	<0.1972	0.2784 J	0.7661	0.1979 J	<0.1837	0.2523 J	<0.08563
Barium	35.59	33.06	33.8	37.43	26.21	44.92	25.85	16.97	42.81
Beryllium	<0.252	<0.2397	<0.2042	<0.134	<0.1129	<0.1551	<0.1973	<0.1376	<0.09174
Boron	55.93	50.41	46.48	67.01	27.82	49.73	50.34	33.94	14.07
Cadmium	0.1382 J	<0.06198	<0.05282	<0.03454	<0.02944	<0.04011	0.05714 J	0.06881 J	<0.02324
Calcium	24715	28099	23732	26316	10242	22193	17687	13578	7248
Chromium	<1.017 J	<1.074 J	<0.8451 J	<0.6701 J	<0.4839 J	<0.6417 J	<0.8163 J	0.7798 J	<0.367 J
Cobalt	0.6342 J	0.4959 J	0.1972 J	0.1579 J	0.06048 J	0.2781 J	0.1973 J	0.4037 J	0.1988 J
Copper	11.86	9.091	8.451	11.11	6.452	10.7	10.2	7.339	6.422
Iron	478	339.7	214.8	121.1 J	82.26 J	110.7 J	122.4 J	168.3	108.3
Lead	0.7881 J	0.4876 J	0.2606 J	0.1813 J	0.125 J	0.1872 J	<0.1837	0.3394 J	0.1835 J
Magnesium	7348	7818	8239	7076	3710	8342	5551	4532	1936
Manganese	400.9	309.1	97.18	326.3 J	356.9	386.6	600.7	458.7	98.17
Mercury	<0.09756	<0.09091	<0.07746	<0.05155	<0.04435	<0.05882	<0.07483	<0.05505	<0.0367
Molybdenum	0.9322 J	0.9917 J	0.5282 J	1.443 J	1.25 J	1.711 J	1.088 J	1.468 J	0.4587 J
Nickel	2.119 J	1.24 J	5.07	0.9278 J	0.5242 J	1.551 J	1.769 J	1.239 J	2.783
Potassium	32797	33388	20986	29485	19798	27861	28776	18349	11651
Selenium	<0.5691	<0.5537	<0.4648	0.5146 J	0.4032 J	0.7487 J	<0.4422	0.3899 J	<0.208
Silver	<0.02439	<0.02314	<0.01972	<0.01289	<0.01129	<0.01497	<0.01905	<0.01376	<0.008869
Sodium	<406.5	<391.7	<333.1	<217.5	<186.7	<253.5	<317	<228.4	<147.7
Strontium	54.24	58.68	26.76	53.8	24.6	55.61	37.41	25.69	25.08
Thallium	<0.1138	<0.1157	<0.09859	<0.06186	<0.05242	<0.07487	<0.08844	<0.06422	<0.04281
Vanadium	1.017 J	0.5868 J	0.3873 J	<0.2062	<0.1774	<0.2406	<0.2993	0.3257 J	<0.1407
Zinc	80.49	43.8	62.68	53.8	34.27	42.78	41.5	38.99	18.35

< - Not detected at sample quantitation limit indicated.

CRM - Clinch River Mile.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

Table C-3. Emergent Vegetation 2011 Sample Results, Tennessee River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte	Location: Sample Date:	TRM567 06/21/2011	TRM567 06/21/2011	TRM567 06/21/2011	TRM570.0 06/21/2011	TRM570.0 06/21/2011	TRM570.0 06/21/2011
Aluminum		362.2	189.8	92.77 J	102 J	18.58 J	20.16 J
Antimony		<0.1102	<0.06383	<0.08434	<0.06829	<0.05534	<0.05242
Arsenic		0.2677 J	0.2468 J	<0.3253	<0.2634	0.1344 J	<0.2097
Barium		34.65	25.53	210.8	43.41	3.557	27.82
Beryllium		<0.2205	<0.1277	<0.1687	<0.1366	<0.1107	<0.1089
Boron		51.97	11.91	31.93	15.12	4.743 J	16.94
Cadmium		<0.05591	<0.03362	<0.04398	0.06829 J	<0.02846	0.125 J
Calcium		25591	8426	14096	13171	1980	12581
Chromium		<0.9449 J	<0.5532 J	<0.7229 J	1.317 J	<0.4743 J	<0.4839 J
Cobalt		0.315 J	0.3957 J	0.6024 J	1.22 J	0.1423 J	0.06855 J
Copper		7.874	5.106	7.831	4.878	6.324	8.871
Iron		419.7	155.3	122.9 J	243.4	72.73 J	55.65 J
Lead		0.4094 J	0.1702 J	<0.1627	<0.1317	<0.1028	0.1129 J
Magnesium		8189	2574	5970	3132	1289	4435
Manganese		395.3	192.8	354.2	887.8	289.7	242.7
Mercury		<0.08661	<0.05106	<0.06627	<0.05366	<0.04348	<0.04435
Molybdenum		1.102 J	0.8936 J	0.5482 J	1.512 J	0.6324 J	0.2621 J
Nickel		2.047 J	0.4681 J	1.205 J	0.4585 J	<0.3676	0.6855 J
Potassium		24882	14936	31205	22439	15731	12661
Selenium		<1	<0.5915	<0.7771	<0.6293	<0.5059	<0.504
Silver		<0.02126	<0.01277	<0.01687	<0.01366	<0.01067	0.01532 J
Sodium		<355.9	<211.9	<277.7	<225.4	1798	<179.8
Strontium		58.27	23.83	40.36	37.56	4.348	31.05
Thallium		<0.1024	<0.05957	<0.07831	<0.06341	<0.05138	<0.05242
Vanadium		0.6535 J	0.3106 J	<0.2651	0.2585 J	<0.17	<0.1694
Zinc		43.31	34.04	32.53	30.73	39.53	47.18

< - Not detected at sample quantitation limit indicated.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

TRM - Tennessee River Mile.

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Appendix D

Shoreline Vegetation 2011
Sample Results

Table D-1. Shoreline Vegetation 2011 Sample Results, Emory River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	ERM_REF 06/21/2011	ERM_REF 06/21/2011	ERM_REF 06/21/2011	ERM1.5 06/21/2011	ERM1.5 06/21/2011	ERM1.5 06/21/2011	ERM3.0 6/21/2011	ERM3.0 6/21/2011	ERM3.0 6/21/2011	ERM4.5 6/21/2011	ERM4.5 6/21/2011	ERM4.5 6/21/2011
Aluminum	169	206	37.25 J	200.8	47.37 J	35.34 J	23.35 J	18.99 J	27.76 J	85.09	31.82 J	138.1
Antimony	<0.07609	<0.0641	<0.0549	<0.03769	<0.04605	<0.05639	<0.05058	<0.05426	<0.04982	<0.03423	<0.04545	<0.04762
Arsenic	<0.1522	<0.1239	<0.1059	<0.07143	<0.09211	<0.109	0.3424 J	0.1589 J	0.1317 J	<0.06846	<0.08766	0.2687 J
Barium	64.67 J	120.9	47.06	27.81	32.24	26.69	31.13	43.8	54.09	24.69	37.01	66.67
Beryllium	<0.1576	<0.1282	<0.1137	<0.07538	<0.09539	<0.1128	<0.1051	<0.1124	<0.1032	<0.0709	<0.09091	<0.09524
Boron	21.74	30.77	12.16	9.694	20.72	18.8	9.339 J	8.915 J	9.609 J	10.02	10.06 J	12.59
Cadmium	0.3859 J	0.1581 J	0.349 J	<0.01964	<0.025	<0.1165	<0.05837	<0.0969	<0.04626	0.1491 J	<0.0487	<0.119
Calcium	9674	15128	6667	7270	10461	11805	4708	6318	5160	5183	4903	5952
Chromium	<0.7065 J	<0.5556 J	0.902 J	0.4592 J	<0.4276 J	<0.4887 J	<0.4669 J	<0.5039 J	<0.4626 J	<0.3178 J	<0.3896 J	<0.4082 J
Cobalt	0.5435 J	0.2949 J	0.1961 J	0.5528 J	0.1875 J	0.09398 J	0.1362 J	0.3333 J	0.1673 J	0.1589 J	0.07143 J	0.3741 J
Copper	11.96	5.128	8.235	5.357	9.211	9.398	5.447	5.426	6.05	4.89	6.169	5.782
Iron	262	250.4	71.76 J	265.3	75.99 J	66.92 J	59.53 J	74.81 J	65.48 J	121	57.14 J	180.3
Lead	0.2337 J	0.2436 J	<0.1059	0.1225 J	0.09211 J	<0.109	<0.1089	<0.1085	0.1068 J	0.1247 J	0.1006 J	0.1905 J
Magnesium	3962	4829	3027	1510	2434	2038	2412	2062	2320	1511	2675	2133
Manganese	348.9	238	206.7	152	134.5	48.5 J	268.1 J	883.7 J	322.1 J	342.3 J	247.1 J	642.9 J
Mercury	<0.05978	<0.05128 J	<0.04314 J	<0.03015 J	<0.03618 J	<0.04511	<0.0428	<0.04264	<0.0427	<0.02934	<0.03571	<0.03741
Molybdenum	0.3207 J	0.1923 J	0.5098 J	<0.09045	0.5921 J	0.7895 J	1.051 J	0.969 J	0.605 J	1.687 J	0.2825 J	0.4082 J
Nickel	2.337 J	3.59 J	3.569 J	2.161 J	1.711 J	0.8271 J	1.245 J	1.24 J	1.779	2.152	2.175	1.701
Potassium	24783	12094	15098	9924	17171	17895	16148	19961	15552	11663	9578	15102
Selenium	<0.3641	<0.2991	<0.2588	<0.1735	<0.2204	<0.2632	<0.2412	<0.2597	<0.2384	<0.1638	<0.2078	<0.2211
Silver	0.07609 J	<0.01282	<0.01098	<0.007398	<0.009539	<0.02594	<0.0144	<0.01124	<0.01032	<0.00709	<0.009091	<0.009524
Sodium	<259.2	<212	<184.3	<124.2	<157.2	<186.5	<173.2	<185.7	<170.8	<117.4	<149	<156.5
Strontium	32.07	50.85	22.75	28.57	34.21	27.07	18.29	23.64	23.49	16.87	17.53	22.45
Thallium	<0.07609	<0.05983	<0.05098	<0.03518	<0.04605	<0.05263	<0.05058	<0.05426	<0.04982	<0.03423	<0.04221	<0.04422
Vanadium	<0.2446	0.2949 J	<0.1765	0.2806 J	<0.148	<0.1767	<0.1634	<0.1744	<0.1601	0.132 J	<0.1396	0.2109 J
Zinc	76.63	59.83	45.1	19.9	32.24	<38.35	50.97	<35.27	55.16	37.9	<37.01	47.28

< - Not detected at sample quantitation limit indicated.

ERM - Emory River Mile.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

Table D-2. Shoreline Vegetation 2011 Sample Results, Clinch River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	CRM_REF 06/21/2011	CRM_REF 06/21/2011	CRM_REF 06/21/2011	CRM2.5 06/21/2011	CRM2.5 06/21/2011	CRM2.5 06/21/2011	CRM4.0 06/21/2011	CRM4.0 06/21/2011	CRM4.0 06/21/2011
Aluminum	26.35 J	30.27 J	32.55 J	46.64 J	38.04 J	450.8	40.89 J	25.91 J	94.03
Antimony	<0.0473	<0.05102	<0.06604	<0.053	<0.04294	<0.03627	<0.06073	<0.04651	<0.04179
Arsenic	<0.08784	<0.09864	<0.1274	<0.09894	<0.08282	0.3109	<0.1134	<0.0897	<0.0806
Barium	44.59	10.54	27.83	30.04	7.669	28.76	17	11.96	45.97
Beryllium	<0.09459	<0.1054	<0.1368	<0.106	<0.08896	<0.07513	<0.1215	<0.09302	<0.08657
Boron	18.24	12.59	19.81	8.834	22.7	14.51	11.34	15.28	18.21
Cadmium	0.03176 J	<0.02687	<0.03491	<0.02721	0.03067 J	0.05181 J	0.03279 J	0.04983 J	0.05075 J
Calcium	8311	6803	10330	7739	5890	9378	9190	7508	7015
Chromium	<0.4054 J	<0.4422 J	<0.566 J	<0.4594 J	<0.3681 J	0.7254 J	0.6073 J	<0.3987 J	<0.3582 J
Cobalt	0.06757 J	0.119 J	<0.06604	<0.04947	0.05215 J	0.4404 J	0.1053 J	0.08638 J	0.3881 J
Copper	8.108	5.782	10.85	5.3	7.669	7.513	12.55	10.96	7.164
Iron	49.66 J	54.76 J	77.83 J	72.08 J	53.99 J	435.2	76.11 J	55.15 J	76.72
Lead	0.1081 J	<0.09864	<0.1274	0.1025 J	0.1012 J	1.244 J	0.1417 J	0.09302 J	0.1612 J
Magnesium	2297	2769	4505	2258	1463	3057	2968	2296	2254
Manganese	112.5	83.33	67.92	19.43	42.02	57.25	267.2	118.6	213.7
Mercury	<0.03716 J	<0.04082 J	<0.05189 J	<0.0424 J	<0.03374 J	<0.0285 J	<0.04858 J	<0.03654 J	<0.03284 J
Molybdenum	0.277 J	1.429 J	1.226 J	1.519 J	0.9509 J	1.554 J	2.186 J	4.319	0.2567 J
Nickel	1.419 J	0.5782 J	0.6604 J	0.424 J	<0.2914	0.8808 J	0.9717 J	0.598 J	2.836 J
Potassium	13885	13367	20566	16325	22546	8342	14534	15515	16716
Selenium	<0.2162	<0.2381	<0.3113	<0.2403	<0.2025	<0.1736	<0.2753	<0.2159	<0.194
Silver	<0.009122	<0.0102	<0.01321	<0.01025	<0.008589	<0.007513	0.01741 J	<0.009302	<0.008358
Sodium	<153	<169.7	<221.7	<171.4	<143.9	<124.1	<197.2	<153.5	<139.1
Strontium	19.93	14.63	11.32	18.02	12.27	15.28	22.67	15.95	23.58
Thallium	<0.04392	<0.04762	<0.06132	<0.04947	<0.03988	<0.03627	<0.05668	<0.04319	<0.03881
Vanadium	<0.1453	<0.1599	<0.2123	<0.1625	<0.135	0.829	<0.1862	<0.1462	<0.1313
Zinc	42.57	30.95	30.66	29.33	36.5	32.9	38.46	36.54	28.36

< - Not detected at sample quantitation limit indicated.

CRM - Clinch River Mile.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

Table D-3. Shoreline Vegetation 2011 Sample Results, Tennesee River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	TRM567 06/21/2011	TRM567 06/21/2011	TRM567 06/21/2011	TRM570.0 06/21/2011	TRM570.0 06/21/2011	TRM570.0 06/21/2011
Aluminum	22.42 J	14.49 J	36.26 J	175.8	223.4	188.4
Antimony	<0.04626	<0.04058	<0.05344	<0.05242	<0.04545	<0.05814
Arsenic	0.1637 J	0.1101 J	<0.1069	<0.1048	<0.09091	<0.1124
Barium	34.88	28.99	27.48	49.19	6.169	18.6
Beryllium	<0.09609	<0.08406	<0.1107	<0.1089	<0.0974	<0.1163
Boron	4.982 J	6.957 J	6.489 J	12.5 J	4.221 J	5.426 J
Cadmium	<0.02456	<0.02174	<0.02901	<0.1331	<0.02468	<0.04651
Calcium	4626	4493	4618	12339	3042	5930
Chromium	<0.427 J	<0.3768 J	<0.4962 J	0.5242 J	0.5519 J	<0.5039 J
Cobalt	0.07117 J	0.08406 J	0.1374 J	0.375 J	0.1266 J	0.1163 J
Copper	6.406	6.957	8.397	16.53	9.416	26.36
Iron	62.99 J	56.52 J	72.52 J	206.5	228.9	208.1
Lead	0.1459 J	<0.08116	0.3397 J	0.246 J	0.3019 J	0.7364 J
Magnesium	2779	2655	1859	4556	1750	2814
Manganese	366.5 J	167.5 J	334.7 J	758.1 J	418.8 J	492.2 J
Mercury	<0.03915	<0.03188	<0.04198	<0.04435	<0.03896	<0.04651
Molybdenum	0.9609 J	2.899	0.1679 J	1.976 J	0.1948 J	1.357 J
Nickel	1.103 J	0.6087 J	1.489 J	0.8065 J	1.169 J	5.039
Potassium	14769	12870	16031	16573	14838	21357
Selenium	<0.2206	<0.1942	<0.2557	<0.254	<0.2208	<0.2713
Silver	<0.009253	<0.008406	<0.01107	<0.01089	<0.009416	<0.02558
Sodium	<156.2	<138.3	<182.8	<180.6	<156.8	<192.6
Strontium	11.39	12.75	12.21	34.27	6.494	15.5
Thallium	<0.04626	<0.04058	<0.05344	<0.05242	<0.04545	<0.05426
Vanadium	<0.1495	<0.1304	<0.1718	0.2782 J	0.3117 J	0.2752 J
Zinc	76.87	76.23	61.83	60.48	<30.84	<42.64

< - Not detected at sample quantitation limit indicated.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

TRM - Tennessee River Mile.

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Appendix E

Periphyton 2011 Sample Results

Table E-1. Periphyton 2011 Sample Results, Emory River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	ERM_REF 6/22/2011	ERM_REF 8/5/2011	ERM1.0 6/22/2011	ERM2.5 6/22/2011	ERM4.0 8/5/2011
Aluminum	38333	151667	12400	82449	80928
Antimony	0.4048 J	1.25 J	0.28 J	1.204 J	0.6495 J
Arsenic	21.9	62.5	19.43	116.3	50.52
Barium	485.7	1863	232.6	963.3	1072
Beryllium	2.119	9.167	0.9714	6.122	4.536
Boron	15.48 J	50 J	12.57	51.02	23.71
Cadmium	0.5238 J	<3.042	0.2629 J	1.184 J	<0.7526
Calcium	9405	28125	78857	18939	11856
Chromium	40.48 J	150 J	15.43 J	91.84 J	81.44 J
Cobalt	38.1	129.2	10.29	73.47	60.82
Copper	28.57 J	100	32 J	102 J	51.55
Iron	46429	189583	12343	87755 J	94948
Lead	33.33	137.5	13.71	81.63	71.13
Magnesium	4190	15125	2549	9020	7423
Manganese	8143	25250	3834	20000	16598
Mercury	<0.2619 J	0.4583 J	0.1029 J	0.2857 J	0.268
Molybdenum	1.333 J	<14.17	0.4857 J	3.878 J	<3.505
Nickel	59.52	220.8	17.71	122.5	105.2
Potassium	<15952	<28917	<3989	14959 J	9330 J
Selenium	4.286	<27.08	2.686	12.45 J	9.588 J
Silver	<0.1333	<1.167	<0.05314	<0.1091	0.2887 J
Sodium	<1062	<1929	296.6 J	1176 J	<479.4
Strontium	40.48 J	183.3 J	86.86 J	163.3 J	96.91 J
Thallium	<0.4286	<1.542	<0.2629	<0.45	<0.9897
Vanadium	64.29	233.3	29.14	167.4 J	128.9
Zinc	211.9	741.7	83.43	381.6	321.6

< - Not detected at sample quantitation limit indicated.

ERM - Emory River Mile.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.

Table E-2. Periphyton 2011 Sample Results, Clinch River (mg/kg dw)

Tennessee Valley Authority **Kingston, Tennessee**

Analyte / Location: / Sample Date:	CRM_REF 6/22/2011	CRM_REF 8/5/2011	CRM1.5 6/22/2011	CRM1.5 8/5/2011	CRM3.5 6/22/2011
Aluminum	26122	43636	30868	69091	37222
Antimony	0.2857 J	0.375 J	0.4959 J	1.436 J	0.7917 J
Arsenic	19.39	23.86	39.67	74.55	44.44
Barium	239.8	342	307	770.9	462.5
Beryllium	1.327	1.932	2.603 J	5.455	2.778
Boron	19.39 J	35.23	23.55 J	78.18	40.28
Cadmium	0.5306 J	0.5341 J	0.5785 J	1.018 J	0.6806 J
Calcium	78367	40909	12603	137273	187500
Chromium	29.59 J	46.59 J	37.19 J	83.64 J	47.22 J
Cobalt	18.37	27.27	23.97	52.73	27.78
Copper	46.94 J	50	147.1 J	278.2	143.1 J
Iron	28878	49659	30165	72727	36111
Lead	28.57	45.45	32.64	80	40.28
Magnesium	4755	6409	3802	10818	6889
Manganese	4459	6307	5248	10855	6486
Mercury	1.122	1.591	0.3926	0.9455	0.6111 J
Molybdenum	0.8571 J	1.25 J	1.612 J	2.727 J	1.528 J
Nickel	31.63	46.59	44.21	98.18	51.39
Potassium	<7592	<8523	<27231	<12982	<9139
Selenium	3.571	6.023	5.372 J	13.64	6.944
Silver	<0.1837	0.1932 J	<0.1818	0.2909 J	<0.1667
Sodium	<506.1	<568.2	<1814	<865.5	811.1 J
Strontium	86.73 J	67.05 J	85.12 J	283.6 J	233.3 J
Thallium	<0.3776	<0.5	<0.6612	<1.545	<0.8194
Vanadium	45.92	68.18	84.3	167.3	88.89
Zinc	187.8	188.6	226.9	472.7	227.8

< - Not detected at sample quantitation limit indicated.

CRM - Clinch River Mile.

J - Estimated value.

mg/kg dw - Milligrams per kilogram dry weight.