Integrated Ecotoxicological Research Program—TVA Kingston Ash Recovery Project

Neil Carriker, Dennis Yankee, Anda Ray – Tennessee Valley Authority, Kingston Ash Recovery Project, Kingston, TN

Problem Statement

Removal or remediation of the approximately 300,000 cubic yards of ash from the Kingston ash spill remaining in the Emory, Clinch, and Tennessee Rivers after completion of hydraulic dredging will be difficult and costly, and might cause more harm than good. However, the potential ecological consequences of leaving ash in the river are poorly defined.

Objectives

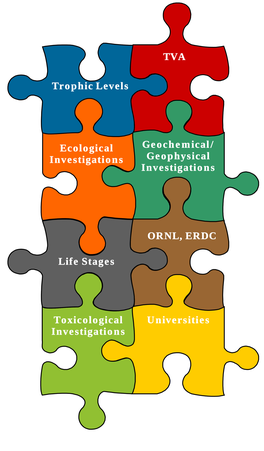
1) accurately assess immediate and intermediate-term effects of the spill on the aquatic ecology of the system
2) develop information necessary to predict long-term ecosystem responses

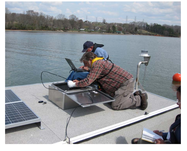
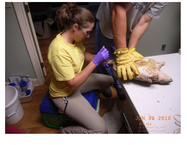
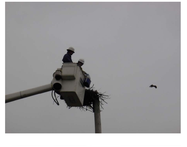
Approach

An integrated research program drawing on TVA's own technical expertise, as well as that of researchers at independent, nationally-recognized Federal research institutions and universities. The charge to these researchers is to assess potential effects using multiple scientific disciplines, multiple potential ecological receptors representing different trophic levels and life stages, and examining potential effects at cellular, organ, organism, and population levels.

Questions:

- Is the remaining ash subject to further movement by storm flows, and to what extent is it mixing with or being covered by fresh native sediments?
- How much of the potentially toxic contaminants in the ash are available for biological uptake, and are transformations occurring that either reduce or increase bioavailability?
- How significant is the potential for adverse ecological effects?



TVA-Funded Ecotoxicological and Supporting Investigations

	TVA-based	USACE-ERDC or ORNL-based	University-based
ECOLOGICAL INVESTIGATIONS	• Fish population assessments	• Fish population effects (ORNL)	
	• Benthic macroinvertebrates community structure effects		
	• Field fish health assessments	• Laboratory-based fish health assessments (ORNL)	
	• Bioaccumulation: • Fish, benthic macroinvertebrates • amphibians (frogs & toads) • piscivorous birds (heron & osprey) • herbivorous birds (geese) • vegetation (grass, periphyton, & emergent macrophytes)	• Bioaccumulation: • Fish, adults & juvenile (ORNL) • Invertebrates - mayfly nymphs and adults, snails (ORNL)	• Bioaccumulation: • Pure algae culture (NC State) • Periphyton (NC State) • Invertebrates - mayfly nymphs (NC State) • Insectivorous birds - tree swallows (VA Tech) • Reptiles - turtles (VA Tech) • Mammals - raccoons (University of Tennessee)
	• In-vivo larval fish studies	• In-vitro larval fish studies (ORNL)	
	• Fish spawning surveys	• Fish reproductive competence (ORNL)	• Clutch size & hatchling survival - tree swallows & turtles (VA Tech)
	• Physical Anomalies - fish	• Physical Anomalies • mayfly nymphs & adults (ORNL) • Fish (ORNL)	• Physical Anomalies - tree swallows & turtles (VA Tech)
		• Biochemical/cellular/organism stress markers in fish (ORNL)	• Biochemical stress markers in raccoons (University of Tennessee)
GEOCHEMICAL/ GEOPHYSICAL INVESTIGATIONS	• Chemical & geochemical speciation in water, porewater, ash, & sediments	• Arsenic & selenium speciation in ash and water (ERDC)	• Chemical speciation (focused on As & Se) in water, porewater, ash, sediments (Duke/ Kentucky/ Illinois; NC State; Colorado & USGS)
		• Photo-oxidation of selenite (ERDC)	• Leaching/uptake of bioactive contaminants by fly ash in freshwater systems (Old Dominion)
		• Dissolution kinetics and rate determinations (ERDC)	• Dissolution kinetics and rate determinations (Old Dominion; NC State; Colorado & USGS)
			• Numerical modeling of contaminant dissolution from ash (Duke/Kentucky/ Illinois)
		• Geochemical speciation of metals/metalloids in ash (ERDC)	• Geochemical speciation of metals/metalloids in ash & sediments (Appalachian State)
		• Heterogeneity of contaminants in ash solids (EXAFS & XANES, micro-XAFS methodology) (ERDC)	• Mineralogy of ash solids (XANES, microscopy, X-ray diffraction) (NC State; Colorado & USGS)
			• Geochemical and isotopic characterization of fly ash (Duke/Kentucky/ Illinois)
		• Extended elution of fly ash (aerobic and anaerobic) followed by toxicity bioassays using elutriates (ERDC)	• Effects of mixing energy on contaminant dissolution (Colorado & USGS)
TOXICOLOGICAL INVESTIGATIONS	• Core sampling for ash deposit depths	• Numerical modeling of ash transport & deposition (ERDC)	• Numerical modeling of ash transport & deposition (BYU)
	• Mapping of ash depths	• Mapping predicted scour & deposition areas (ERDC)	• Ash & sediment stratigraphy (Appalachian State)
	• Ash elutriates • *Ceriodaphnia dubia* – 96 hour • *Pimephales promelas* – 96 hour • *Lampsilis siliquoidea* - 10 day • *Lampsilis cardium* - 10 day	• 10-day ash elutriates (ERDC) • *Pimephales promelas* – 10 day; juvenile & adult life stages	
	• Whole ash • *Lampsilis siliquoidea* - 5 day; 10 day • *Lampsilis cardium* - 5 day; 10 day • *Hyalella azteca* - 10 day • *Lumbriculus variegatus* – 4 day • *Corbicula fluminea – 28 day bioaccumulation*		
	• Dredge plumes • *Ceriodaphnia dubia* – 3 brood; 96 hr • *Pimephales promelas* - 7 day; 96 hr		
	• Wastewater discharges • *Ceriodaphnia dubia* – 3 brood; 96 hr • *Pimephales promelas* - 7 day; 96 hr		
	• Submerged Sediments • *Hyalella azteca* - 10 day; 28 day • *Ceriodaphnia dubia* - 7 day • *Chironomus tentans* – 10 day; 28 day		
	• Surface water • *C. dubia* - 7 day • *Pimephales promelas* - 7 day