Kingston Ash Incident
Evaluation of Potential Legacy Contamination in Local Sediments
March 20, 2009

Conclusion – Based on recent data collected by DOE and TVA, there is no evidence that past contamination of sediments would have any impact on TVA's dredging of ash from the Emory River. The remainder of this report summarizes our investigation related to legacy contamination of sediments in the vicinity of the KIF ash incident.

Summary

The Emory and Clinch River arms of Watts Bar Reservoir are on the state 303(d) list (TDEC 2008) because of sediments contaminated from industrial point sources and atmospheric deposition. Because of potential concerns about dredging being impacted by pre-incident contamination, TVA worked with other agencies to collect data to evaluate this risk. TVA has used Consensus-Based Sediment Quality Guidelines to perform a screening analysis of sediment and ash sample data. In general the sediment and ash data show that the materials removed during dredging should present a low to moderate ecological risk. No chlordane concentrations were above the laboratory's Reportable Limits (RLs) and most polychlorinated biphenyls (PCB) concentrations were less than RLs. All mercury concentrations were less than 0.71 mg/kg dry weight in the ash and sediment samples collected from the Emory River.

Higher concentrations of mercury and PCBs were found by U.S. Department of Energy (DOE) in the deeper sediments in the Clinch River samples. However, in the current phases of dredging, TVA will not be dredging in the Clinch River. TVA also plans to avoid those sediments during dredging in the Emory. However, even in those deeper sediments (6 inches to bottom of core) all the samples had less than RL concentrations of chlordane and half had less than RLs of PCBs. The other samples had less than 0.243 mg/kg of PCBs.

Toxicological monitoring will also be conducted as part of the KIF Monitoring Plan for Phase 1 dredging to evaluate whole sediment, dredge plume, and ash elutriate toxicity to representative aquatic species.

Introduction

The Emory River arm of Watts Bar Reservoir is on the state 303(d) list (TDEC 2008) because of sediments contaminated with PCBs and chlordane from industrial point sources. The section of the Emory above the influence of the Watts Bar impoundment is listed because of mercury from atmospheric deposition. The Emory River may have elevated metal levels because several upstream tributaries are listed for manganese, iron, and pH from historic coal mining activities.

The Clinch River arm of Watts Bar Reservoir is also on the state 303(d) list of impaired waters. The Clinch River is on the list due to PCB, chlordane, and mercury contamination of sediment from industrial point source discharges and atmospheric deposition. Nearby tributaries to the Clinch that are also listed for PCBs, chlordane, and mercury and one nearby tributary listed for arsenic may be sources of contamination to the Clinch. Some of this contamination occurs as a result of former DOE operations on the Oak Ridge Reservation (TDEC 2008). Past DOE actions at Oak Ridge resulted in the contamination of sediments by radioactivity and other wastes. The

primary concern is PCB contamination in fish. Other contaminants include radioactive materials and metals.

In 1991, TVA entered an interagency agreement with DOE, USEPA, TDEC, and USACE to establish a procedure for interagency coordination and review of permitting and other use authorizations that could result in the disturbance, resuspension, removal, and/or disposal of contaminated or potentially contaminated sediment in Watts Bar Reservoir. The Watts Bar Interagency Working Group (WBIWG) interagency group reviews and screens all activities that may impact previously contaminated sediments and provides appropriate remediation. Based on information gathered during the implementation of this agreement, the contaminants of interest have been narrowed to CS-137 and mercury. Projects are reviewed to determine whether the sediment contains CS-137 or mercury at levels that when disturbed or removed constitute environmental risk or require special handling techniques or equipment to protect human health and the environment from injury or harm.

Because of these potential concerns about pre-incident legacy contamination, TVA has been working with TDEC, US EPA, US FWS, and the WBIWG about the potential issues that could be raised if TVA disturbs pre-existing sediments during dredging operations to recover ash.

Sediment Quality Guidelines

TVA used Consensus-Based Sediment Quality Guidelines (CBSQGs) for 12 metals (MacDonald et al. 2000, Wisconsin DNR 2003, Table 1 below) to perform a screening analysis of sediment and ash sample data. Total metals maximum and average values were compared to the Threshold Effect Concentration, or TEC, the concentration below which adverse effects on sediment-dwelling organisms are not expected to occur; and the Probable Effect Concentration, or PEC, the concentration above which adverse effects on sediment dwelling organisms could be expected to frequently occur (McDonald et al. 2000).

Table 1. Consensus-Based Sediment Quality Guidelines (MacDonald et al. 2000, Wisconsin DNR 2003)

	Threshold Effect Concentration (TEC) for Sediment (mg/kg dry wt.)	Probable Effect Concentration (PEC) for Sediment (mg/kg dry wt.)
Antimony	2.0	25
Arsenic	9.8	33
Cadmium	1.0	5.0
Chromium	43.4	111
Copper	31.6	149
Iron	20000	40000
Lead	35.8	128
Manganese	460	1100
Mercury	0.18	1.06
Nickel	22.7	48.6
Silver	1.6	2.2
Zinc	121	459

Preliminary screening of ash samples utilizing CBSQG methodology should be interpreted with caution because of the limited scope of the sampling, the preliminary nature of the data (i.e., the ash data has not yet undergone a thorough QA review) and because these sediment quality guidelines were developed from studies using sediments collected from natural water bodies. Fly ash may behave differently than the natural sediments for which these sediment quality guideline numbers were developed, but this approach does provide a general point of reference for assessing potential risks from materials that may end up in aquatic systems.

Upstream (Background) Samples
Upstream sediment from the Emory River was sampled in early February, 2009. Locations included Emory River Miles (ERM) 9.0 -9.9 and ERM 6.3-7.7. The ERM 9 samples locations had a rocky stream bottom and did not provide much sediment. Suitable bottom sediment was located upstream at ERM 6 and a subsequent re-sampling effort took place at points from Miles 6.3 to 7.7. Samples were composites of material from the surface to 6 inch depths, or less if bedrock were encountered at shallower depths.

Emory River Mile 9.0 through 9.9 – Sediments Summary (9 Samples Taken)
TCLP metals were all less than the RLs except for barium (maximum 0.95 mg/L, minimum 0.47, average 0.58). Chlordane and PCBs were all less than RLs (<0.28 mg/kg and <0.024) at this location. All the samples analyzed for mercury, antimony and silver were also less than their RLs. The maximum concentrations for arsenic, chromium, copper, and zinc were less than their respective TECs in Table 1. The maximum concentrations of cadmium, iron, and nickel exceeded their TEC value, but were less than the PEC value. The average concentrations of these metals were less than the TEC values. The maximum concentration of manganese exceeded both the TEC and the PEC, but the average concentration was less than the TEC. Selenium doesn't have TEC or PEC values, but the maximum concentration of selenium in these samples was 4 mg/kg with an average value of 2.5 mg/kg.

The elevated iron and manganese values are probably due to impacts from mining or industries upstream. No dredging is planned at this location. However, none of the sediment concentrations would have presented a significant concern if dredging were to be done.

Emory River Mile 6.3 through 7.7 – Sediments Summary (8 Samples Taken)
TCLP metals were all less than RLs except for barium (maximum 0.87 mg/L, minimum 0.29, average 0.58). Chlordane and PCBs were all less than RLs (<0.28 mg/kg and <0.024) at this location. Mercury, cadmium, selenium, and silver were all less than RLs in these 8 samples. The maximum concentrations of antimony, arsenic, chromium, copper, and lead were all less than their respective TECs in Table 1. The maximum concentrations of iron, nickel, and zinc exceeded their TEC value, but were less than the PEC value. The average concentrations of these metals were less than the TEC values. The maximum concentration of manganese exceeded both the TEC and the PEC. The average concentration also exceeded the TEC, but was less than the PEC.

Two samples, ERMs 6.3 and 6.9, were split between two separate laboratories as part of TVA's quality process. One sample had a trace detection of gamma-chlordane (0.00017 and

0.00022mg/kg), slightly higher than the highest value reported from the other laboratory. However, these detections were below the reported analytical sensitivity of the second laboratory. PCB results were less than RL (<0.033 mg/kg). Trace levels of mercury were observed at 0.021 and 0.095 mg/kg. Arsenic was observed at 8.1 mg/kg on one of the samples. Cadmium was detected at 0.13 and 0.75 mg/kg. Selenium was less than RL. Zinc was reported at 169 mg/kg which was over the TEC but below the PEC. TCLP extraction was performed on these two samples with less than RLs for all elements.

None of these sediment concentrations would present a significant concern if dredging were to be done in this area.

Emory River Mile 2.1 – Sediments Summary (22 Samples Taken)
TCLP metals were all less than RLs except for Arsenic (maximum 0.16 mg/L, minimum 0.06, average 0.09) and barium (maximum 1.9 mg/L, minimum 0.22, average 0.66). Chlordane and PCBs were all less than RLs (<0.28 mg/kg and <0.024) at this location.

Upstream sediment values were observed to be lower for many elements than at ERM 2.1 where the ash slide deposited ash on the river bottom. Furthermore, sediment samples from the sampling grid used at ERM 2.1 would be expected to contain more ash on the side of the river toward the ash pile. Analyses were, generally speaking, higher in metals concentrations the closer the sample locations were to the ash. A graphical presentation of the sample locations with the arsenic data for the ERM 2.1 grid is shown below in Figure 1.

The maximum concentrations of mercury, chromium, iron, lead, manganese, silver, and zinc were all less than their respective TECs in Table 1. The maximum concentrations of cadmium, copper, and nickel exceeded their TEC values, but were less than the PEC value. The average concentrations of these metals were less than their TEC values. The maximum and average concentrations of antimony and arsenic exceeded their TECs, but the average concentrations of antimony and arsenic were less than the PECs.

Figure 1 – ERM 2.1 Sample Locations with arsenic levels

DOE Deep Sediment Sampling - Emory River and Clinch River

In conjunction with routine interagency efforts regarding sampling of the Clinch and Tennessee Rivers to examine the historical problems from White Oak Lake mercury and Cs-137, TVA requested that additional samples be taken in the mouth of the Emory River. At ERM 1.0 the mercury concentration was 0.44 mg/kg and chlordane and PCBs were both below RLs. At ERM 0.5 the mercury concentration was 0.525 mg/kg, chlordane was less than RL, and low levels of PCB (maximum 0.165 mg/kg) were detected in deep sediment. It should be noted that the TVA sampling focused on surface (0-6 inches) sediments pertaining to ash and recent downflow deposits while DOE sampling focused on deeper sediments (6 inches – bottom of cores) pertaining to their historic issues.

In the DOE Clinch River deeper samples (6 inches – bottom of cores) mercury ranged from 0.031 to 6.17 mg/kg, the chlordane isomers were all less than RL and in 5 of the 10 locations PCBs were less than RLs. Results from the other 5 locations in the Clinch River revealed PCBs. While Aroclor 1016, Aroclor 1221, and Aroclor 1232 were all less than the RLs, Aroclor 1248, Aroclor 1254, and Aroclor 1260 had low level concentrations between 0.020 and 0.243 mg/kg.

Sampling for metals in prior DOE work has focused on mercury below mile 20 of the Clinch where a well-documented plume enters the White Oak Lake. TVA requested a full suite of metals for this sampling event to compare to ash data. Metals results are tabulated in the Appendix for five metals of interest from this sampling event. Arsenic is slightly higher at ERM 0.5 and 1.0 compared to the Clinch. Mercury follows its historic pattern with little indicated in the mouth of the Emory and above Mile 20 of the Clinch. Differences between the underlying geologies of the Clinch and Emory watersheds may be also involved in data differences. Known differences in water hardness (Ca and Mg) and pH have been documented historically as ready indicators of the differences in the two watersheds.

The maximum concentrations for cadmium and lead were less than their respective TECs. The maximum concentration for arsenic was greater than its TEC but was less than its PEC. The average and maximum concentrations for mercury were greater than its PEC.

TVA Surface Deposit Sampling at Emory River Mile 0.5

TVA only plans to remove the released ash and not to disturb the deeper historic sediments. Furthermore, TVA's initial dredging efforts will focus on removing ash in areas upstream of ERM 1.0. Therefore, the concentrations discussed above from deeper sediments should not be representative of what will be involved in the dredging. Following receipt of results from the DOE sediment at ERM 0.5 and the detection of PCBs in deeper sediment there, TVA sampled surface sediment at eleven points on a grid located about ERM 0.5. TCLP metals were not run on this data set. PCBs were all below the reportable level of 0.033 mg/kg but PCB Aroclor 1254 and Aroclor 1260 showed ten separate detects at low levels of 0.010 or less. Electronic data are not yet available for this data set.

The concentrations of silver were all less than RL. The maximum concentrations for antimony, cadmium, chromium, copper, iron, lead, and zinc were all less than their respective TECs. The maximum concentrations for arsenic, manganese, mercury, and nickel were greater than their TECs but were less than their PECs. These lower concentrations reinforce the importance of only removing the ash and avoiding the deeper sediments.

APPENDIX A

Sediment Sampling Data Tables

Emory River Mile 9.0 through 9.9 – Sediments Summary (9 Samples Taken)

Non-Detects	Max	Min	Average	Parameter	Units
0	72	11.1	44.1	Total Solids	%
9	N/A	N/A	N/A	Mercury	mg/kg
0	15000	1600	6060	Aluminum	mg/kg
9	N/A	N/A	N/A	Antimony	mg/kg
2	4	1.9	2.9	Arsenic	mg/kg
0	150	19	81	Barium	mg/kg
0	1.8	0.32	0.91	Beryllium	mg/kg
9	N/A	N/A	N/A	Boron	mg/kg
1	1.7	0.41	0.98	Cadmium	mg/kg
1	19	5.5	10.7	Chromium	mg/kg
0	23	3.4	12.2	Cobalt	mg/kg
1	12	1.9	6.2	Copper	mg/kg
0	24000	7100	13800	Iron	mg/kg
0	84	3.3	20.3	Lead	mg/kg
0	1900	290	960	Magnesium	mg/kg
0	1400	84	450	Manganese	mg/kg
8	0.46	0.46	0.46	Molybdenum	mg/kg
0	32	4.9	16.2	Nickel	mg/kg
3	4	1.4	2.5	Selenium	mg/kg
9	N/A	N/A	N/A	Silver	mg/kg
9	N/A	N/A	N/A	Thallium	mg/kg
9	N/A	N/A	N/A	Tin	mg/kg
0	94	28	52	Titanium	mg/kg
0	120	16	56	Zinc	mg/kg

Emory River Mile 6.3 through 7.7 – Sediments Summary (8 Samples Taken)

Non-Detects	Max	Min	Average	Parameter	Units
0	69.8	24.9	52.7	Total Solids	%
8	N/A	N/A	N/A	Mercury	mg/kg
0	15000	2300	5800	Aluminum	mg/kg
7	1.8	1.8	1.8	Antimony	mg/kg
3	6.8	1.8	3.58	Arsenic	mg/kg
0	180	28	65.6	Barium	mg/kg
0	1.7	0.34	0.69	Beryllium	mg/kg
8	N/A	N/A	N/A	Boron	mg/kg
8	N/A	N/A	N/A	Cadmium	mg/kg
0	19	4	8.2	Chromium	mg/kg
0	27	4.6	10.4	Cobalt	mg/kg
0	15	2.6	5.9	Copper	mg/kg
0	24000	5100	10600	Iron	mg/kg
0	22	3.9	8.6	Lead	mg/kg
0	1700	240	690	Magnesium	mg/kg
0	1800	170	580	Manganese	mg/kg
8	N/A	N/A	N/A	Molybdenum	mg/kg
0	34	5.1	12.9	Nickel	mg/kg
8	N/A	N/A	N/A	Selenium	mg/kg
8	N/A	N/A	N/A	Silver	mg/kg
8	N/A	N/A	N/A	Thallium	mg/kg
0	15	5	7.7	Tin	mg/kg
0	82	18	35	Titanium	mg/kg
0	130	18	47	Zinc	mg/kg

Emory River Mile2.1 – Sediments Summary (22 Samples Taken)

Non-Detects	Max	Min	Average	Parameter	Units
0	76.1	47.5	66.6	Total Solids	%
7	0.12	0.028	0.064	Mercury	mg/kg
0	20000	1700	6760	Aluminum	mg/kg
9	8.4	2.6	4.5	Antimony	mg/kg
0	110	1.7	23	Arsenic	mg/kg
0	350	16	105	Barium	mg/kg
0	4.4	0.21	1.2	Beryllium	mg/kg
17	63	26	45	Boron	mg/kg
4	2.8	0.34	1.4	Cadmium	mg/kg
0	30	3.2	10.3	Chromium	mg/kg
0	15	2.6	7.4	Cobalt	mg/kg
0	62	1.4	15.3	Copper	mg/kg
0	14000	3800	7340	Iron	mg/kg
0	29	3.1	11.5	Lead	mg/kg
0	1400	210	640	Magnesium	mg/kg
0	370	41	122	Manganese	mg/kg
8	3.5	0.41	1.6	Molybdenum	mg/kg
0	30	3.7	12	Nickel	mg/kg
15	2.6	1.7	2.0	Selenium	mg/kg
21	0.76	0.76	0.76	Silver	mg/kg
16	4.1	1.6	3.25	Thallium	mg/kg
22	N/A	N/A	N/A!	Tin	mg/kg
0	720	12	183	Titanium	mg/kg
0	66	12	30	Zinc	mg/kg

DOE Deep Sediment Sampling - Emory River Mile 0.5 and Clinch River

PCB in Deep Sediments - Emory River Mile 0.5 and Clinch River

River and Mile	PCB 1016	PCB-1221	PBC-1232	PCB-1248	PCB-1254	PCB-1260
ER0.5	<0.03	<0.03	<0.03	0.243 P	0.165	0.0849
ER1.0	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
CLINCH06	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
CLINCH09	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
CLINCH13	<0.04	<0.04	<0.04	0.0274	0.0279	0.0224
CLINCH14	<0.03	<0.03	<0.03	0.106	0.105	0.0584
CLINCH14	<0.03	<0.03	<0.03	0.0879	0.0885	0.0503
CLINCH17	<0.03	<0.03	<0.03	0.0559	0.0564	0.0347
CLINCH21	<0.04	<0.04	<0.04	0.0297	0.0341	0.0266
CLINCH21	<0.03	<0.03	<0.03	0.026	0.027	0.0249
CLINCH23	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
CLINCH29	<0.03	<0.03	<0.03	0.0238	0.0255	0.02
TVA samples @ ERM2.1	<0.024	<0.024	<0.024	<0.024	<0.024	<0.024

Metals Sampling in Deep Sediments - Emory River Mile 0.5 and Clinch River

Location	Arsenic (mg/kg)	Selenium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Cadmium (mg/kg)
ER0.5	17.4	4.76	22.4	0.525	0.552
ER1.0	15.7	4.64	19.4	0.44	0.493
CLINCH06	7.37	5.17	23.6	0.541	0.646
CLINCH09	5.41	6.14	11.9	0.13	0.592
CLINCH13	9.44	5.52	25.8	1.61	0.543
CLINCH14	9.7	4.62	29.2	5.98	0.969
CLINCH14	6.26	4.68	19.9	3.67	0.511
CLINCH16	14			1.77	
CLINCH17	8.92	4.21	24.6	6.17	0.497
CLINCH18	8.2			1.66	
CLINCH19	20			1.65	
CLINCH20	7.59			6.54	
CLINCH21	6.89	4.69	22.7	0.941	0.499
CLINCH21	7.25	5.29	19.2	1.03	0.563
CLINCH23	3.61	3.15	11.1	0.031	0.131
CLINCH29	7.37	3.86	21.4	4.43	0.539
Maximum	**20**	**6.14**	**29.2**	**6.54**	**0.969**
Average	**9.7**	**4.7**	**21**	**2.32**	**0.545**

TVA Surface Deposit Sampling at Emory River Mile 0.5

Limited metal results from 11 samples are summarized below:

Non-Detects	Maximum	Minimum	Average	Parameter	Units
10	0.76	ND	0.76	Antimony	mg/kg
0	39.6	9.9	24.2	Arsenic	mg/kg
0	315	126	240	Barium	mg/kg
0	2.5	1.3	2.0	Beryllium	mg/kg
0	0.40	0.19	0.28	Cadmium	mg/kg
0	34	23	27.2	Chromium	mg/kg
0	36.9	22.3	31.2	Copper	mg/kg
0	22400	15900	19590	Iron	mg/kg
0	20	12	16	Lead	mg/kg
0	770	292	482	Manganese	mg/kg
0	0.71	0.16	0.35	Mercury	mg/kg
0	32	23	28	Nickel	mg/kg
0	3.7	1.4	2.4	Selenium	mg/kg
11	ND	ND		Silver	mg/kg
11	ND	ND		Thallium	mg/kg
0	93	52	72	Zinc	mg/kg