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Nonradioactive Metals Concentrations in Asparagus, Rabbitbrush, and Sandberg's Bluegrass

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**Westinghouse
Hanford Company**

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NONRADIOACTIVE METALS CONCENTRATIONS IN ASPARAGUS,
RABBITBRUSH, AND SANDBERG'S BLUGRASS

W. H. Rickard
C. A. Brandt

Pacific Northwest Labotatory

Draft letter report
Task 5: Biota Investigations at 300-FF-1 Operable Unit

Prepared for Westinghouse Hanford Company
Richland, WA 99352

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WHC-MR- 0255



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April 29, 1991

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Mr. M. R. Adams, Manager
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Environmental Division
Westinghouse Hanford Company
P.O. Box 1970/H4-55
Richland, WA 99352

Dear Mr. Adams:

SUBJECT: DRAFT LETTER REPORT FOR TASK 5 "TERRESTRIAL BIOLOGICAL INVESTIGATIONS" OF THE 300-FF-1 REMEDIAL INVESTIGATION

Reference: Letter, M. R. Adams (WHC) to D. A. Kane (EMO), "Supplemental Funding for Fiscal Year 1991 300-FF-1 Remedial Investigation/ Feasibility Studies Support", dated December 13, 1990.

Enclosed is a copy of the draft letter report entitled "Nonradioactive Metals Concentrations in Asparagus, Rabbitbrush, and Sandberg's Bluegrass". This letter report was not included in the Statement of Work (reference) but was verbally requested by Mr. L. C. Hulstrom on February 25, 1991.

Please call me if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Donald A. Kane".

Donald A. Kane, PhD, PE
Manager, Hanford RI/FS Program
Environmental Management Operations

DAK/GVL/dla

Enclosure

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Introduction

Metals have been released to ponds and trenches from wastewater streams in the 300 Area since 1943 (Dennison et al. 1989). The purpose of this field survey was to determine if contaminating metals have become associated with the shoots of terrestrial plants growing outside the fenced exclusion zones of the 300 FF-1 Operable Unit.

Metals are ubiquitously distributed in soils and plants worldwide (Bowen 1979). Uptake of metals from soil is determined by the solubility, ionic form, and organic complexations of the metal ions and the pH of the rooting medium. Different plant species also accumulate metals differently. The shoots of plants also adsorb metals externally deposited from the air or as resuspended dust. Metal concentrations in plants also vary according to the kind of tissue and the physiological age of tissue.

In this survey, particular attention is paid to asparagus (*Asparagus officinalis*) because it grows wild around the Operable Unit and is harvested and eaten by people. Samples of rabbitbrush (*Chrysothamnus nauseosus*) and Sandberg's bluegrass (*Poa sandbergii*) were also collected because these plants provide forage for mule deer (*Odocoileus hemionus*), cottontails (*Sylvilagus nutalli*), Canada geese (*Branta canadensis*), and other wildlife.

The toxic metals that have been discharged to the ground in the greatest amounts are chromium, copper, lead, nickel, uranium, and zinc (Table 1). Silver, beryllium, cadmium, and mercury have also been discharged in the wastewater streams in smaller quantities. However, only uranium appears in enhanced levels in the groundwater beneath the Operable Unit (Dennison et al. 1989).

Table 1. Metal Inventory of the North and South Process Ponds and Process Trenches in the 300 F-1 Operable Unit (Metric Tons)^a.

<u>Metal</u>	<u>South Pond</u>	<u>North Pond</u>	<u>Trenches</u>	<u>Total</u>
Chromium	5	3	1	9
Copper	60	50	20	130
Lead	4	2	0.6	6.6
Nickel	10	8	3	21
Uranium	40	30	10	80
Zinc		5	3	19
Silver	1	0.9	0.3	2.2
Beryllium	0.04	0.03	0.01	0.08
Cadmium	0.08	0.06	0.02	0.16
Mercury	0.06	0.40	0.01	0.47

^a(DOE 1990).

Methods

Collection sites for asparagus (Figure 1) were identified to provide local background estimates (sites West, Upstream, Far downstream, and South Old Field), Hanford background (Hanford Townsite), and regional background (commercially-grown plants from Toppenish, Sunnyside, Benton City, and Taylor Flats), as well as potentially contaminated areas (Operable Unit and Near Downstream). Wild asparagus plants were harvested by clipping new growth above ground as practiced by people seeking wild

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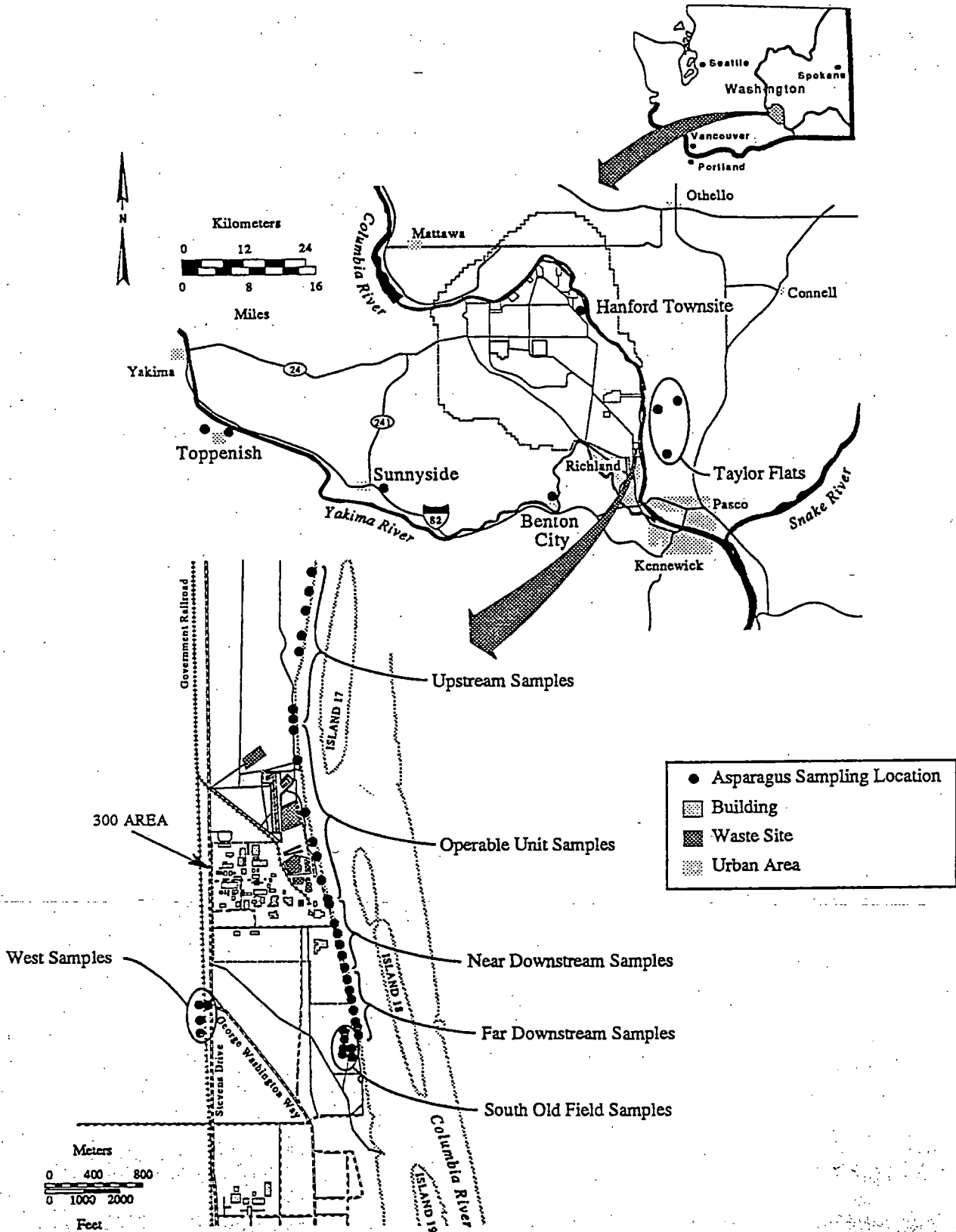


FIGURE 1. Asparagus Sampling Locations

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plants. At least six samples were taken from different groups of plants at each of the sites. All asparagus plants occurring within the Operable Unit and Near Downstream areas were sampled. Sampling locations within the Operable Unit, Near Downstream, local background, and Hanford background were marked with numbered stakes. Commercial plants were purchased in the field at harvest or from a nearby retail outlet for a specific field or fields. Commercial plants were washed before drying to remove mud and other debris. Wild plants were not washed, but were not obviously contaminated with soil.

Twigs and leaves of rabbitbrush were collected by clipping the terminal few inches of branches of new growth. Sandberg's bluegrass was also collected by clipping. Plants were collected outside the exclusion-zone fencing east of waste ponds and trenches within the Operable Unit, and at a location in the same habitat type north of the Operable Unit (Figure 2).

Samples were divided into three fractions for mercury, radionuclide, and other heavy metals analyses. Samples for mercury analysis were vacuum-dried; the remaining samples were oven-dried to constant weight. All were then ground with a Wiley Mill and packaged for delivery to an analytical laboratory.

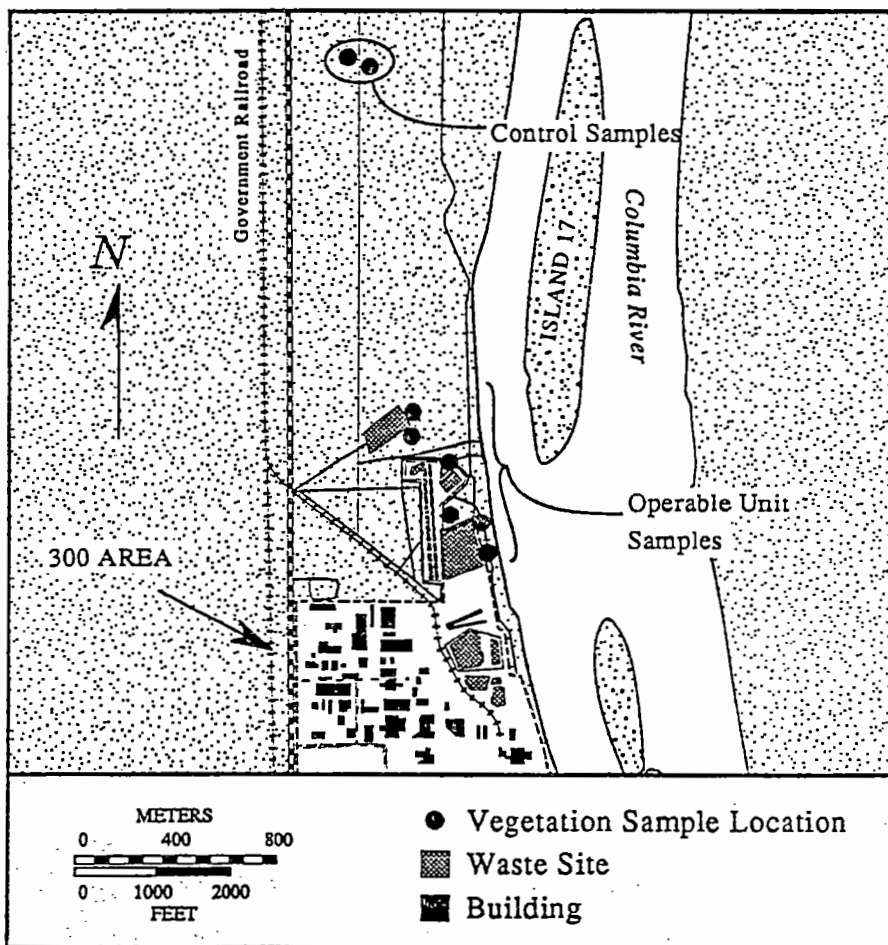


FIGURE 2. Rabbitbrush and Sandberg's Bluegrass Sampling Locations

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Results

The results of metals analyses, except uranium, are tabulated in Appendix A. Values are presented as ppm dry wt. ($\mu\text{g/g}$). Values are presented for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, titanium, vanadium, and zinc.

The nonradioactive metals of most environmental concern to the 300-FF-1 Operable Unit are chromium, copper, lead, nickel, and zinc (Table 1). Metals released in smaller amounts were silver, beryllium, cadmium and mercury. The mean, standard deviation, coefficient of variation, and minimum and maximum values are summarized in Tables 2, 3, and 4 for asparagus and in Table 5 for rabbitbrush and Sandberg's bluegrass.

Asparagus

Metal concentrations in asparagus were compared between commercial fields (Table 2), abandoned fields (Table 3), and wild plants growing along the shoreline of the Columbia River (Table 4).

Table 2. Concentrations of metals ($\mu\text{g/g}$ dry wt.) in asparagus shoots harvested from commercial fields, 1990.

<u>Location</u>		<u>Cr</u>	<u>Cu</u>	<u>Pb</u>	<u>Ni</u>	<u>Zn</u>	<u>Ag</u>	<u>Be</u>	<u>Cd</u>	<u>Hg</u>
<u>Benton, Co.</u> Benton City (n=5)	\bar{x}	0.85	17.3	0.29	3.38	67.3	0.51	0.17	0.85	0.10
	SD	0.094	2.07	0.086	0.38	5.77	0.054	0.02	0.094	0.00
	CV	0.11	0.12	0.30	0.11	0.086	0.11	0.12	0.11	0.00
	Max	0.93	19.4	0.39	3.7	71.5	0.56	0.19	0.93	0.10
	Min	0.71	13.9	0.21	2.8	57.1	0.43	0.14	0.71	0.10
<u>Yakima, Co.</u> Sunnyside (n=7)	\bar{x}	0.97	24.2	0.18	4.27	80.2	0.58	0.19	0.97	0.097
	SD	0.044	5.13	0.029	0.68	13.1	0.024	0.010	0.044	0.005
	CV	0.045	0.21	0.16	0.16	0.16	0.042	0.050	0.045	0.050
	Max	1.0	31.1	0.23	5.6	100	0.60	0.20	1.0	0.10
	Min	0.91	18.3	0.14	3.6	63.5	0.55	0.18	0.91	0.09
Toppenish (n=8)	\bar{x}	0.89	16.0	0.25	5.32	53.3	0.54	0.18	0.89	0.098
	SD	0.10	2.35	0.24	1.52	8.0	0.064	0.022	0.10	0.005
	CV	0.12	0.15	0.99	0.29	0.15	0.12	0.12	0.12	0.047
	Max	1.0	19.5	0.85	8.4	67.7	0.60	0.20	1.0	0.10
	Min	0.74	13	0.14	3.5	43.7	0.44	0.15	0.74	0.09
<u>Franklin, Co.</u> Taylor Flats (n=18)	\bar{x}	0.83	17.7	2.02	3.83	61.0	0.50	0.17	0.83	0.095
	SD	0.084	2.4	3.37	0.71	6.4	0.052	0.017	0.084	0.007
	CV	0.10	0.14	1.7	0.18	0.11	0.10	0.10	0.10	0.074
	Max	0.95	24	14.1	5.2	75.9	0.57	0.19	0.95	0.10
	Min	0.70	13.6	0.16	2.9	50.5	0.42	0.14	0.70	0.08

Table 3. Concentrations of metals (µg/g dry wt.) in asparagus shoots harvested from abandoned cultivated fields on the Hanford Site, 1990.

Location		Cr	Cu	Pb	Ni	Zn	Ag	Be	Cd	Hg
<u>South Old Field</u> (N=6)	\bar{x}	0.88	15.6	2.04	3.53	41.4	0.53	0.18	0.88	0.097
	SD	0.12	6.17	1.52	0.48	8.33	0.072	0.026	0.118	0.005
	CV	0.13	0.40	0.74	0.14	0.20	0.14	0.15	0.13	0.053
	Max	1.0	27.7	3.8	4.0	52.9	0.60	0.20	1.0	0.10
	Min	0.67	10.1	0.19	2.7	27.8	0.40	0.13	0.67	0.09
<u>West</u> (n=4)	\bar{x}	0.92	16.7	0.21	3.77	24.0	0.55	0.18	0.92	0.095
	SD	0.098	4.03	0.033	0.54	4.85	0.057	0.017	0.098	0.010
	CV	0.11	0.24	0.16	0.14	0.20	0.10	0.094	0.11	0.105
	Max	1.0	20.7	0.25	4.4	31.1	0.60	0.20	1.0	0.10
	Min	0.78	11.2	0.18	3.1	20.3	0.47	0.16	0.78	0.08
<u>Hanford Townsite</u> (n=6)	\bar{x}	0.81	16.7	2.93	3.40	67.6	0.50	0.16	0.81	0.095
	SD	0.10	1.11	2.54	0.46	4.51	0.083	0.019	0.10	0.005
	CV	0.12	0.07	0.87	0.13	0.07	0.17	0.12	0.12	0.053
	Max	0.97	17.9	6.3	4.0	72.3	0.62	0.19	0.97	0.10
	Min	0.69	15.5	0.47	2.9	61.9	0.41	0.14	0.69	0.09

Table 4. Concentrations of metals (µg/g dry wt.) in asparagus shoots harvested from the shoreline of the Columbia River, upstream and downstream from the 300 FF-1 Operable Unit, 1990.

Location		Cr	Cu	Pb	Ni	Zn	Ag	Be	Cd	Hg
<u>Upstream</u> (n=7)	\bar{x}	0.93	7.49	0.29	3.96	33.2	0.56	0.19	0.95	0.096
	SD	0.055	1.18	0.16	0.50	3.28	0.032	0.010	0.082	0.005
	CV	0.059	0.16	0.56	0.13	0.099	0.058	0.051	0.087	0.056
	Max	1.0	9.2	0.59	4.8	36.2	0.60	0.20	1.1	0.10
	Min	0.83	5.8	0.17	3.3	27.2	0.54	0.17	0.83	0.09
<u>Operable Unit</u> (n=7)	\bar{x}	0.86	8.69	0.20	3.44	21.0	0.52	0.17	0.86	0.097
	SD	0.097	3.3	0.054	0.39	2.85	0.060	0.020	0.097	0.005
	CV	0.11	0.38	0.27	0.11	0.14	0.115	0.11	0.113	0.050
	Max	1.0	15.4	0.32	4.0	24.1	0.60	0.20	1.0	0.10
	Min	0.76	6.2	0.17	3.0	16.9	0.45	0.15	0.76	0.09
<u>Near Downstream</u> (n=6)	\bar{x}	1.03	7.10	0.18	3.62	46.4	0.54	0.18	1.04	0.090
	SD	0.24	1.85	0.010	0.30	47.9	0.043	0.014	0.231	0.009
	CV	0.23	0.26	0.056	0.083	1.03	0.079	0.077	0.22	0.10
	Max	1.5	9.7	0.19	4.0	142	0.60	0.20	1.50	0.10
	Min	0.88	4.4	0.16	3.1	13.1	0.47	0.16	0.88	0.08
<u>Far Downstream</u> (n=7)	\bar{x}	0.88	8.63	0.35	3.5	29.0	0.53	0.17	0.88	0.096
	SD	0.063	2.14	0.18	0.26	7.08	0.039	0.013	0.063	0.005
	CV	0.072	0.25	0.52	0.076	0.24	0.074	0.076	0.072	0.052
	Max	1.0	11.6	0.71	4.0	40.7	0.60	0.20	1.0	0.10
	Min	0.81	5.8	0.18	3.2	20.3	0.48	0.16	0.81	0.09

Chromium. The highest mean concentration of chromium (0.97 ppm) was measured in commercial asparagus collected at Sunnyside (Table 2) and from wild plants (1.03 ppm) collected downstream from the Operable Unit (Table 4). The highest concentration of any sample was from a plant in the downstream sample (1.5 ppm); no other samples were above 1 ppm. There was little variation among sampling locations.

Copper. The highest mean concentration of copper was found in samples taken from a commercial field in Sunnyside (24.2 ppm) (Table 2). Average concentrations in the Operable Unit and vicinity were 7.1 to 8.7 ppm. In general, the concentrations of copper were slightly higher in commercial asparagus than in samples from abandoned fields (Table 3). Wild plants had lower concentrations of copper than did the plants from commercial or abandoned fields (Table 4).

Lead. The highest mean concentration of lead was measured in samples collected from an abandoned field at the Hanford townsite (2.93 ppm) and a field south of the 300 Area (2.04 ppm) (Table 3). However, samples from a commercial field in Taylor Flats had a mean value of 2.02 ppm (Table 2). Lead concentrations in all other samples were below 0.35 ppm. The distribution of lead suggests contamination by airborne particulates (arising from leaded gas combustion on roadways) that became adsorbed on shoot surfaces rather than as root uptake from soil. Lead levels in plant tissues are commonly higher near roadways than elsewhere (Davies 1990).

Nickel. The highest mean concentration of nickel was measured in commercial asparagus collected at Toppenish (5.32 ppm) (Table 2). However, mean values at all other locations were greater than 3 ppm (Tables 2, 3, 4).

Zinc. The highest mean concentration of zinc was measured in commercial asparagus from Sunnyside (80 ppm) (Table 2). The lowest mean zinc concentrations were measured in wild plants collected from the shoreline of the Columbia River (Table 4).

Silver, Beryllium, Cadmium, and Mercury. The concentrations of silver, beryllium, cadmium and mercury were generally less than 1 ppm, with little difference between sampling locations (Tables 2, 3, and 4).

Rabbitbrush

Rabbitbrush is a common desert shrub in and around the 300-FF-1 Operable Unit. Rabbitbrush plants sampled along the exclusion-zone fence had higher mean concentrations of chromium, copper, lead, nickel, and zinc than did shrubs collected at locations remote from the Operable Unit (Table 5). There was little difference in silver, beryllium, cadmium, and mercury between samples (Table 5).

Sandberg's Bluegrass

Sandberg's bluegrass is a common, perennial bunchgrass that grows in and adjacent to the Operable Unit. The only metal found in concentrations above background was zinc (Table 5).

Table 5. Concentrations of metals ($\mu\text{g/g}$ dry wt.) in foliage of rabbitbrush and Sandberg's bluegrass, 1990.

Location		Cr	Cu	Pb	Ni	Zn	Ag	Be	Cd	Hg
Operable Unit Rabbitbrush (n=6)	\bar{x}	2.89	5.72	2.78	4.42	23.8	0.55	0.18	0.92	0.092
	SD	4.85	2.72	1.36	1.97	5.6	0.042	0.012	0.072	0.004
	CV	1.7	0.48	0.49	0.45	0.24	0.076	0.066	0.078	0.045
	Max	12.8	9.5	4.9	8.4	29.3	0.58	0.19	0.97	0.10
	Min	0.78	2.6	1.2	3.1	14.3	0.47	0.16	0.78	0.09
Sandberg's bluegrass (n=6)	\bar{x}	1.01	3.38	3.23	3.63	42.0	0.55	0.18	0.92	0.093
	SD	0.17	2.23	1.14	0.28	34.9	0.042	0.014	0.067	0.005
	CV	0.17	0.66	0.35	0.077	0.83	0.077	0.075	0.073	0.055
	Max	1.3	6.9	4.8	3.9	103	0.59	0.20	0.98	0.10
	Min	0.81	1.4	1.9	3.1	15.9	0.47	0.16	0.79	0.09
Control Area Rabbitbrush (n=2)	\bar{x}	0.88	3.2	1.85	3.55	12.0	0.53	0.18	0.88	0.09
	SD	0.13	1.8	0.21	0.50	2.15	0.071	0.021	0.13	0.00
	CV	0.14	0.54	0.12	0.14	0.17	0.13	0.12	0.14	0.00
	Max	0.97	4.5	2.0	3.9	13.0	0.58	0.19	0.97	0.09
	Min	0.79	2.0	1.7	3.2	10.5	0.48	0.16	0.79	0.09
Sandberg's bluegrass (n=2)	\bar{x}	1.02	3.6	4.35	3.55	17.9	0.53	0.18	0.88	0.09
	SD	0.25	3.11	0.21	0.21	3.68	0.028	0.007	0.049	0.00
	CV	0.24	0.86	0.049	0.060	0.20	0.053	0.040	0.056	0.00
	Max	1.2	5.8	4.5	3.7	20.5	0.55	0.18	0.92	0.09
	Min	0.85	1.4	4.2	3.4	15.3	0.51	0.17	0.85	0.09

Toxicity Evaluation

Normal ranges and toxic ranges of metal concentrations in plants are shown in Table 6. The concentrations found in asparagus from the 300-FF-1 Operable Unit and its environs were well below the levels regarded as toxic to plants. Furthermore, all metal levels for asparagus were well below levels that could produce toxic effects in small mammals (Table 7) or humans (Table 8) consuming a normal amount of asparagus from the area.

Average concentrations of chromium in rabbitbrush tissue from near exclusion-zone fences were 50% of levels toxic to many plants (Table 6). Some rabbitbrush plants had concentrations above levels producing toxic effects in some plants. A small mammal, such as a sagebrush vole (*Lagurus curtatus* - 30-g body wt.) that forages in such habitat, would need to consume 39 g/d of the most contaminated rabbitbrush to reach toxic intake levels. However, average daily intake from all rabbitbrush sampled within the Operable Unit would need to be nearly six times body weight for toxic effects from chromium to be evident. Average copper concentrations in rabbitbrush within the Operable Unit were such that daily consumption of from half to six times body weight would be necessary for toxic effects from copper to be evident.

In summary, ecological risk and human health risk from metals in vegetation outside exclusion fences in the 300-FF-1 Operable Unit are minimal. The potential for toxic effects on wild animals as a result of intake of rabbitbrush with combined elevated levels of chromium and copper warrants further investigation.

Table 6. Concentrations of metals in plants (µg/g dry wt.) showing normal and toxic ranges.^a

		<u>Cr</u>	<u>Cu</u>	<u>Pb</u>	<u>Ni</u>	<u>Zn</u>	<u>Ag</u>	<u>Be</u>	<u>Cd</u>	<u>Hg</u>
Normal range	Min	0.1	5	5	0.1	27	0.5	<1	0.05	
	Max	0.5	30	10	5	150	-	7	0.20	
Toxic range	Min	5	20	30	10	100	5	10	5	1
	Max	30	100	300	100	400	10	50	30	3

^aKabata-Pendias and Pendias (1984). Values are not given for very sensitive or highly tolerant plant species.

Table 7. Concentrations of metals in small mammal diets (µg/g body wt./day) showing normal and toxic ranges.^a

		<u>Cr</u>	<u>Cu</u>	<u>Pb</u>	<u>Ni</u>	<u>Zn</u>	<u>Ag</u>	<u>Be</u>	<u>Cd</u>	<u>Hg</u>
Normal range	Min	0.067	0.167		0.10	0.067			0.0002	
	Max	0.167	0.667			0.134			0.04	
Toxic range	Min	16.7	3.3		167	167	200 ^b		1.6	0.17
	Max		16.7							
Lethal range	Min	147	67	150	267	500		11	53	27
	Max		433	900					183	30

^aBowen (1979)

^bFowler and Nordbert (1979).

Table 8. Concentrations of metals in human diets (µg/kg body wt./day) showing normal and toxic ranges.^a

		<u>Cr</u>	<u>Cu</u>	<u>Pb</u>	<u>Ni</u>	<u>Zn</u>	<u>Ag</u>	<u>Be</u>	<u>Cd</u>	<u>Hg</u>
Normal range	Min	.14	7	.86	4.3	71	0.02	.14	.1	.057
	Max	17	86	7.1	7.1	571	1.1	2.8 ^b		.286
Toxic range	Min	2.8k		14.3	unk	2.1k	857		43	5.7
	Max					8.6k			4.7k	
Lethal range	Min	42.8k	2.5k	143k		85.7k	18.6k		21.4k	2.1k
	Max		3.5k				88.6k		128.6k	4.3k

^aBowen (1979)

^bReeves (1979).

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APPENDIX A

ANALYTICAL VALUES FOR NONRADIOACTIVE METALS IN VEGETATION SAMPLES

91129113792

Sample ID	Location	Al (ppm)	Sb (ppm)	As (ppm)	Ba (ppm)	Be (ppm)	Cd (ppm)	Ca (ppm)	Cr (ppm)	Co (ppm)	Cu (ppm)	Fe (ppm)	Pb (ppm)	Mg (ppm)	Mn (ppm)	Hg (ppm)	Ni (ppm)	K (ppm)	Se (ppm)	Ag (ppm)	Na (ppm)	Tl (ppm)	V (ppm)	Zn (ppm)
B009B4	Benton City	110	3.5	0.31	3.9	0.18	0.88	2750	0.88	0.35	18	251	0.39	1830	22.5	0.1	3.5	38000	0.47	0.53	183	0.16	0.35	69.4
B009B5	Benton City	118	3.2	0.38	3.6	0.14	0.71	2580	0.71	0.36	19.4	232	0.38	1930	22.6	0.1	2.8	37400	0.57	0.43	203	0.38	0.28	71.5
B009B6	Benton City	106	3.7	0.37	3.8	0.19	0.93	2500	0.93	0.38	18.1	222	0.24	1880	21.8	0.1	3.7	36200	0.56	0.58	210	0.37	0.37	69.4
B009B7	Benton City	121	3.7	0.35	3.9	0.18	0.92	2150	0.92	0.37	13.9	217	0.21	1580	19.2	0.1	3.7	29400	0.53	0.55	200	0.35	0.37	57.1
B009B8	Benton City	78.3	3.2	0.37	3.2	0.18	0.79	2420	0.79	0.32	17.2	162	0.24	1860	20.7	0.1	3.2	35300	0.55	0.48	198	0.37	0.32	69
B00979	Far Downstream	45.8	3.2	0.38	10.2	0.18	0.81	4390	0.81	0.32	9.4	124	0.46	1830	22.8	9e-2	3.2	20400	0.57	0.48	44.5	0.19	0.32	21.4
B00980	Far Downstream	41.8	3.4	0.36	7	0.17	0.85	4030	0.85	0.34	8.7	104	0.32	1530	21.8	0.1	3.4	17700	0.63	0.51	52.7	0.38	0.34	20.3
B00981	Far Downstream	30.8	3.4	0.34	5.8	0.17	0.88	3270	0.86	0.34	10.8	85.6	0.71	1320	15.3	9e-2	3.4	20200	0.51	0.52	64.6	0.38	0.34	40.7
B00982	Far Downstream	27.8	3.4	0.4	6.2	0.17	0.85	3220	0.85	0.34	5.8	70	0.22	1250	9.3	0.1	3.4	17700	0.69	0.51	121	0.2	0.34	27.7
B00983	Far Downstream	15.5	3.4	0.33	4.6	0.17	0.85	2710	0.85	0.34	11.6	52.7	0.23	1080	10.8	0.1	3.4	18500	0.5	0.51	74.3	0.17	0.34	34.4
B00984	Far Downstream	37.8	3.7	0.31	13	0.18	0.92	5290	0.92	0.37	7.4	89.5	0.36	1770	18.4	0.1	3.7	18900	0.49	0.55	50.8	0.25	0.37	29.1
B009C4	Far Downstream	85	4	0.31	10.8	0.2	1	3650	1	0.4	8.7	118	0.18	1500	13.9	9e-2	4	19700	0.48	0.6	180	0.31	0.4	29.1
ASPG023	Hanford Townsite	10.4	3.4	1.4	0.9	0.17	0.84	1310	0.84	0.34	15.5	66.5	0.47	1690	14.7	9e-2	3.4	31700	0.95	0.5	109	0.24	0.34	61.9
ASPG024	Hanford Townsite	6.6	2.9	0.32	1.1	0.14	0.72	1360	0.72	0.29	15.7	62	0.52	1500	12.5	0.1	2.9	30000	1.1	0.43	100	0.16	0.29	63
ASPG025	Hanford Townsite	9	2.8	0.29	0.83	0.14	0.69	1280	0.69	0.28	16	63.3	4.5	1630	15.1	0.1	3.1	32500	0.5	0.41	103	0.35	0.28	70.9
ASPG026	Hanford Townsite	8.2	3.9	0.39	1.6	0.19	0.97	1850	0.97	0.39	17.9	70.1	1.1	1530	13.8	9e-2	3.9	32300	2.6	0.58	118	0.37	0.39	72.3
ASPG027	Hanford Townsite	8.4	3.4	0.33	1.2	0.17	0.84	1520	0.84	0.34	17.9	67.9	4.7	1810	13.9	0.1	4	32600	4.4	0.62	103	0.21	0.34	66.1
ASPG028	Hanford Townsite	7.5	3.1	0.31	0.84	0.16	0.79	1470	0.79	0.31	17.3	63.7	6.3	1520	13.1	9e-2	3.1	33200	0.47	0.47	109	0.28	0.31	71.2
B009C5	Near Downstream	47.5	3.7	0.36	9.9	0.18	0.92	3580	0.92	0.37	7.5	87.6	0.18	1410	14.5	8e-2	3.7	15800	0.55	0.55	134	1.8	0.37	25.4
B009C6	Near Downstream	46.4	3.7	0.36	10.1	0.19	0.93	3650	0.93	0.37	7.8	98.4	0.18	1580	32.8	0.1	3.7	20100	0.54	0.56	311	0.41	0.37	44.8
B009C7	Near Downstream	41.3	3.7	0.38	9	0.19	1	3710	0.93	0.37	7.8	50.6	0.19	1430	13.2	9e-2	3.7	18000	0.57	0.56	199	0.38	0.37	29.8
B009C8	Near Downstream	52.5	4	0.31	10.8	0.2	1	3220	1	0.4	4.4	66.8	0.18	1310	11.9	8e-2	4	19800	0.47	0.6	104	0.31	0.4	13.1
B009C9	Near Downstream	59.1	3.1	0.34	21.9	0.18	1.5	5790	1.5	0.38	9.7	184	0.17	1780	17.4	0.1	3.1	18700	0.52	0.47	110	1.7	0.31	142
B009D0	Near Downstream	50.4	3.5	0.36	12.7	0.18	0.88	6960	0.88	0.35	5.6	78.6	0.18	1920	21.8	9e-2	3.5	21000	0.55	0.53	202	0.36	0.35	23.5
B009C2	Operable Unit	33.2	3.1	0.38	8.1	0.15	0.76	3620	0.76	0.31	8.7	58.2	0.19	1210	15.3	0.1	3.1	19700	0.57	0.46	112	0.38	0.31	24.1
B009C3	Operable Unit	99.5	3.3	0.33	10.7	0.17	0.83	6420	0.83	0.33	10.6	157	0.18	1630	41.3	0.1	3.3	18800	0.55	0.5	123	0.33	0.33	19.4
B009D1	Operable Unit	57.8	4.7	0.38	11	0.2	1	8210	1	0.4	7.2	72.1	0.18	1540	20.4	0.1	4	18400	1.4	0.8	111	0.38	0.4	18.9
B009D2	Operable Unit	50	3.8	0.33	17.7	0.19	0.96	6150	0.96	0.38	6.7	70	0.17	1900	16.7	0.1	3.8	16800	0.5	0.58	164	0.33	0.38	22.2
B009D3	Operable Unit	57.3	3	0.33	13.5	0.15	0.76	7520	0.76	0.3	6.2	91.8	0.32	2040	27	0.1	3	16700	0.5	0.45	99.5	0.33	0.3	18.1
B009D4	Operable Unit	45.6	3.2	0.35	14	0.16	0.81	5880	0.81	0.32	8	68.9	0.17	1600	14.4	9e-2	3.2	20500	0.52	0.48	126	0.35	0.32	22.8
B009D5	Operable Unit	35.6	3.7	0.38	13.1	0.18	0.92	6080	0.92	0.37	15.4	78.7	0.19	1880	22.6	9e-2	3.7	14900	0.8	0.55	134	0.38	0.37	23.8
ASPG019	South Plateau	15.9	4	0.31	2.8	0.2	1	2590	1	0.4	27.7	84.9	2.5	1900	19.4	0.1	4	29400	0.47	0.6	87.4	0.16	0.4	52.9
ASPG020	South Plateau	12.9	3.5	0.38	2	0.18	0.88	1620	0.88	0.35	13.7	58.1	2.2	1340	11.9	0.1	3.5	21900	0.58	0.53	63.7	0.19	0.35	38.9
ASPG021	South Plateau	15	3.4	0.37	3.6	0.17	0.88	1700	0.86	0.54	14.8	88.8	3.3	1630	17.5	9e-2	3.4	24500	0.78	0.52	95.1	0.47	0.34	46
ASPG022	South Plateau	6.1	2.7	0.36	1.4	0.13	0.67	1110	0.67	0.27	14.5	52.9	3.8	1360	11.8	0.1	2.7	26700	0.54	0.4	60.5	0.34	0.27	42.4
ASPG047	South Plateau	70.6	3.6	0.4	4.2	0.18	0.91	3110	0.91	0.36	10.1	146	0.26	1730	21.5	9e-2	3.6	19700	0.6	0.55	66.9	0.72	0.38	27.8
ASPG048	South Plateau	55.8	3.9	0.37	5.2	0.2	0.98	2360	0.98	0.39	12.7	130	0.19	1730	18.4	0.1	4	24600	0.77	0.59	83.2	0.19	0.39	40.4
B00989	Sunnyside	346	4	0.29	11.2	0.2	1	5790	1	0.53	31.1	874	0.14	2280	47.2	0.1	5.6	38200	0.43	0.6	300	0.14	0.4	91.5
B00990	Sunnyside	103	4	0.36	7.7	0.2	1	5510	1	0.48	30	380	0.18	2420	40.6	0.1	4	46900	0.55	0.6	309	0.18	0.4	100
B00993	Sunnyside	56.9	4	0.35	4.1	0.2	1	3450	1	0.53	21.1	170	0.18	2040	28.4	0.1	4.4	36300	0.53	0.8	172	0.18	0.4	71
B00994	Sunnyside	36.2	4	0.34	3.5	0.2	1	3330	1	0.4	25.6	158	0.2	2300	28.5	0.1	4.2	41600	0.52	0.6	197	0.17	0.4	84
B00995	Sunnyside	51.2	4	0.3	3.8	0.2	1	3280	1	0.4	24.4	165	0.16	2190	26.8	9e-2	4.5	39800	0.45	0.6	186	0.15	0.4	82.4
B00996	Sunnyside	50.4	3.6	0.33	3.6	0.18	0.91	2950	0.91	0.36	18.3	153	0.2	1880	22.9	0.1	3.6	33600	0.5	0.55	157	0.17	0.36	69
B00997	Sunnyside	56.9	3.6	0.46	3.2	0.18	0.91	2700	0.91	0.36	18.7	163	0.23	1710	23	9e-2	3.6	31800	0.57	0.55	150	0.25	0.36	63.5

A.1

Draft Letter Report: Metals

WHC-MR- 0255

Task 5: Biota

Sample ID	Location	Al (ppm)	Sb (ppm)	As (ppm)	Ba (ppm)	Be (ppm)	Cd (ppm)	Ca (ppm)	Cr (ppm)	Co (ppm)	Cu (ppm)	Fe (ppm)	Pb (ppm)	Mg (ppm)	Mn (ppm)	Hg (ppm)	Ni (ppm)	K (ppm)	Se (ppm)	Ag (ppm)	Na (ppm)	Tl (ppm)	V (ppm)	Zn (ppm)
ASPG029	Taylor Flats	27.5	3.3	0.39	4.2	0.17	0.83	3180	0.83	0.33	15.3	83.9	2.6	1740	19.8	0.1	3.9	24600	0.58	0.54	152	0.19	0.33	59.5
ASPG030	Taylor Flats	20.3	3.7	1.4	4	0.19	0.93	2930	0.93	0.37	17.1	70.9	1.3	1660	19.8	9e-2	3.7	24600	0.41	0.58	158	0.14	0.37	57.9
ASPG031	Taylor Flats	15.5	3.3	1.7	3.5	0.16	0.81	3100	0.81	0.33	14.9	68.1	0.5	1620	20.1	0.1	3.3	35000	0.5	0.49	150	0.17	0.33	61.8
ASPG032	Taylor Flats	16.6	3.8	0.32	4.1	0.19	0.94	3120	0.94	0.38	15.6	68.3	14.1	1620	19.3	0.1	3.8	35400	0.48	0.57	152	0.18	0.38	58.1
ASPG033	Taylor Flats	17.8	2.8	1.5	3	0.14	0.7	2750	0.7	0.29	15.3	70.4	1.3	1830	19.3	0.1	2.9	34400	0.48	0.42	146	0.15	0.28	57.8
ASPG034	Taylor Flats	18.2	3	0.37	3.2	0.15	0.75	2470	0.75	0.3	13.6	66.9	0.59	1400	16.2	0.1	3.3	30400	0.55	0.45	146	0.18	0.3	50.5
ASPG035	Taylor Flats	75.9	3.2	0.31	4.7	0.16	0.79	2230	0.79	0.59	16.8	183	3.9	1440	18.9	0.1	3.3	30300	0.47	0.48	163	0.16	0.32	52.8
ASPG036	Taylor Flats	69.3	3.1	0.39	5.5	0.16	0.78	2350	0.78	0.57	17.8	189	0.59	1530	19	8e-2	3.1	30500	0.59	0.47	158	0.2	0.31	56.1
ASPG037	Taylor Flats	49.3	3	1.4	4.6	0.15	0.75	2350	0.75	0.66	18.4	146	3.9	1690	18.7	0.1	3	30700	0.43	0.45	163	0.14	0.3	58.8
ASPG038	Taylor Flats	57.8	3	0.35	5	0.15	0.74	2350	0.74	0.45	18	153	0.63	1540	18.6	0.1	3.6	30000	0.52	0.44	160	0.17	0.3	59.4
ASPG039	Taylor Flats	47.7	2.8	0.33	4.6	0.14	0.7	2400	0.7	0.28	24	147	0.18	1530	18.4	9e-2	5	30000	0.5	0.42	148	0.25	0.28	63
ASPG040	Taylor Flats	58.3	3.3	0.32	4.7	0.17	0.83	2280	0.83	0.33	17.5	159	0.16	1510	18.3	9e-2	3.4	30300	0.48	0.5	154	0.22	0.33	55.3
ASPG041	Taylor Flats	54.6	3.8	0.34	4.4	0.19	0.95	2690	0.95	0.38	19.8	142	0.19	1520	20.2	9e-2	5.2	32700	0.51	0.57	154	0.17	0.38	75.9
ASPG042	Taylor Flats	51.1	3.4	0.33	5.2	0.17	0.88	2750	0.86	0.34	18.8	131	0.28	1480	18.3	0.1	4	30500	0.49	0.52	144	0.16	0.34	62.6
ASPG043	Taylor Flats	40.1	3.6	0.34	3.8	0.18	0.91	2670	0.91	0.36	20	117	0.48	1580	18.6	8e-2	6.1	31900	2.6	0.55	153	0.17	0.36	72.3
ASPG044	Taylor Flats	54	3.3	0.35	4.5	0.17	0.83	2790	0.83	0.33	19.7	144	5	1550	19.7	0.1	4.2	31800	0.53	0.5	155	0.28	0.33	68.7
ASPG045	Taylor Flats	40.3	3.8	0.37	4.3	0.19	0.95	2710	0.95	0.38	17.5	117	0.5	1530	18.6	9e-2	3.8	31400	0.56	0.57	147	0.19	0.38	63.4
ASPG046	Taylor Flats	44.9	3.5	0.37	4.7	0.16	0.88	2700	0.88	0.35	18.9	132	0.19	1500	18.8	0.1	4.4	32000	0.56	0.53	146	0.49	0.35	63.4
B00991	Toppenish	54.3	4	0.32	2.6	0.2	1	3940	1	0.4	19.5	125	0.16	1860	26.6	0.1	4.3	35300	0.47	0.6	212	0.18	0.4	58.4
B00992	Toppenish	53.3	4	0.37	2.4	0.2	1	3940	1	0.4	19.1	123	0.19	1930	27.6	0.1	8.4	37200	0.58	0.6	215	0.19	0.4	57.9
B00996	Toppenish	64.4	2.9	0.31	1.7	0.15	0.74	3060	0.74	0.29	14.7	109	0.15	1510	17.9	9e-2	4.8	33900	0.42	0.44	142	0.2	0.29	48.6
B00999	Toppenish	39.9	3	0.33	2.1	0.15	0.75	3170	0.75	0.3	14.2	85.5	0.14	1620	17.4	0.1	5.6	36000	0.42	0.45	144	0.14	0.3	55.2
B009B0	Toppenish	38.1	3.5	0.33	2.6	0.17	0.87	3190	0.87	0.35	16.3	94.5	0.17	1910	19.7	0.1	3.5	39200	0.5	0.52	160	1.7	0.35	67.7
B009B1	Toppenish	29.5	3.7	0.4	2	0.19	0.93	3710	0.93	0.37	16.8	66.4	0.14	1670	22.6	0.1	5.2	36000	0.43	0.56	142	0.14	0.37	50.8
B009B2	Toppenish	61.5	3.9	0.76	2.2	0.2	0.98	3320	0.98	0.39	13	103	0.85	1610	17.6	0.1	6.4	34300	0.54	0.59	160	0.18	0.39	43.7
B009B3	Toppenish	41.8	3.4	0.34	2	0.17	0.86	3250	0.86	0.34	14.4	82.7	0.17	1610	18.5	9e-2	4.4	36000	0.51	0.52	137	0.17	0.34	48.3
B00975	Upriver	20.8	3.8	0.37	5.8	0.19	0.96	3060	0.96	0.38	8.3	55.7	0.59	1390	15	0.1	3.8	18900	0.56	0.58	70.7	0.19	0.38	30.5
B00976	Upriver	21.7	3.8	0.36	9.2	0.19	0.95	3530	0.95	0.38	7.7	66.6	0.18	1520	17	0.1	4.4	19200	0.55	0.57	78.8	0.2	0.38	33.5
B00977	Upriver	11.1	3.8	0.35	8.1	0.19	0.95	3620	0.95	0.38	5.8	47.9	0.44	1380	15.8	0.1	3.8	21900	0.53	0.57	57.9	0.48	0.38	34.4
B00978	Upriver	11.5	3.8	0.36	7.9	0.19	0.94	3520	0.94	0.38	6.3	50.2	0.18	1430	18.4	9e-2	4.8	20400	0.55	0.57	96.1	0.18	0.38	34.9
B009B9	Upriver	31.9	4	0.35	6	0.18	0.89	3200	0.89	0.36	9.2	58.5	0.3	1310	16	9e-2	3.6	21600	0.53	0.54	171	0.35	0.36	36
B009C0	Upriver	38.9	3.3	0.38	9.3	0.17	0.83	3440	0.83	0.33	7.1	61.5	0.19	1180	12.5	0.1	3.3	18500	0.57	0.5	145	0.38	0.33	27.2
B009C1	Upriver	21.8	4	0.34	7.3	0.2	1.1	3270	1	0.4	8	51.4	0.17	1270	19.9	9e-2	4	24400	0.5	0.6	130	0.34	0.4	36.2
B00985	West	27.5	3.9	0.38	4.6	0.19	0.97	2450	0.97	0.39	20.7	72.5	0.23	1370	17.8	0.1	3.9	18100	2.2	0.58	83.3	0.19	0.39	20.3
B00986	West	43.5	3.1	0.36	6	0.16	0.78	3420	0.78	0.31	11.2	91.2	0.18	1750	22	0.1	3.1	21700	0.55	0.47	61.5	0.18	0.31	22.9
B00987	West	41.8	3.7	0.35	6.1	0.19	0.93	3450	0.93	0.37	16.5	108	0.19	1690	28.3	8e-2	3.7	18300	0.67	0.56	48.1	0.18	0.37	21.7
B00988	West	38.4	4	0.36	4.6	0.2	1	3130	1	0.4	18.3	117	0.25	1780	24.8	0.1	4.4	26300	0.72	0.6	94.4	0.18	0.4	31.1

A.2

Draft Letter Report: Metals

WHC:MR-0255

Task 5: Biota