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Mortandad Canyon: Elemental Concentrations in Vegetation, Streambank Soils, and Stream Sediments—1979

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MORTANDAD CANYON:
ELEMENTAL CONCENTRATIONS IN VEGETATION, STREAMBANK SOILS, AND STREAM SEDIMENTS - 1979

by

Roger W. Ferenbaugh and Ernest S. Gladney

ABSTRACT

In 1979, stream sediments, streambank soils, and streambank vegetation were sampled at 100 m intervals downstream of the outfall of the TA-50 radioactive liquid waste treatment facility in Mortandad Canyon. Sampling was discontinued at a distance of 3260 m at the location of the sediment traps in the canyon. The purpose of the sampling was to investigate the effect of the residual contaminants in the waste treatment facility effluent on elemental concentrations in various environmental media.

I. INTRODUCTION

Radioactive liquid wastes generated throughout Los Alamos National Laboratory (LANL) are collected in a double-walled sewer system (Emelity, et al. 1984) for delivery to the TA-50 radioactive liquid waste treatment facility. The wastes are treated in the waste treatment facility using a flocculation and precipitation process to remove contaminants (Emelity, Buchholz, and McGinnis 1977). Discharges into Mortandad Canyon from the liquid waste treatment plant were initiated in 1963. The composition and volume of the discharge has varied over time because of the variety of diverse processes that may be discharging into the sewer system at any given time (Hakonson et al., 1980). The treated effluent from the waste treatment facility is discharged into the upper reaches of Mortandad Canyon, from which it flows down the canyon until it sinks into the alluvium. Residual contaminants from the treated effluent adsorb onto sediment particles and/or percolate into the alluvial aquifers found at various depths in the canyon sediments. At a distance of 3260 m downcanyon from the point of effluent discharge, large sediment traps have been constructed in the stream channel to prevent the migration of contaminated sediments offsite. Streamflow in the canyon occurs only during snowmelt and rainfall events, so the sediment traps do not continuously accumulate sediments. When the traps become full, they are excavated so that overflow does not occur.

In 1979, as part of the ongoing surveillance and monitoring program, an effort was made to characterize contaminant profiles along the Mortandad stream channel. Samples of sediment from the stream channel, soil from the stream bank, and vegetation proximate to the channel were collected. Water samples were collected where water was present. This suite of samples was collected at 100 m intervals along the stream channel up to the Laboratory boundary at the sediment traps. The samples were analyzed for beryllium, cadmium, chlorine, chromium, fluorine, mercury, nitrate, phosphate, sulfate, and tritium. These were considered to be the residual contaminants of primary concern at the time. Had the inductively coupled plasma/mass spectrometer (ICP/MS) method of analysis existed in 1979, other elements undoubtedly would have been included in the analytical suite of chemicals. These data are being published now as part of the re-evaluation of contaminant transport in the canyons traversing Laboratory property that is being undertaken under the auspices of the Environmental Restoration Project.

II. METHODS

Sediment, soil, and vegetation samples were collected at 100 m intervals along the stream channel in Mortandad Canyon, starting at the point of discharge of the treated effluent from the TA-50 radioactive liquid waste treatment plant. The last sampling location was at the Los Alamos National Laboratory boundary at 3260 m, which is the location of the Mortandad Canyon sediment traps.

Sediment samples were taken from the center of the active channel, and soil samples were taken from the bank of the inactive channel. Vegetation samples were collected from channel-bank vegetation and consisted of grass where grass was available and other vegetation (mostly wavy-leaf oak, *Quercus undulata*) where grass was not available. Grass was not identified as to species.

Soil and sediment samples were passed through a coarse sieve (20 mesh) to remove matter such as pebbles and twigs, and the samples then were air-dried and ground in a Spex Industries shatterbox. Vegetation samples were dried in a forced-air circulation oven at 60°C for 2 days and then were ground in the shatterbox.

After the samples were prepared as described, they were submitted for a variety of elemental analyses. Several analytical techniques were used, including neutron activation analysis, atomic absorption, ion chromatography, ion selective electrode analysis, and some special analytical techniques. The procedures used for these analyses have been described in detail in Gautier and Gladney (1986) and Gladney et al. (1980). Quality assurance was provided by concurrent analysis of a variety of National Bureau of Standards (NBS), United States Environmental Protection Agency (EPA), and United States Geological Survey (USGS) reference materials using the approach documented in Gladney et al. (1981).

III. RESULTS

Tables 1 through 4 summarize the results of the chemical analyses for sediment, soil, vegetation, and water. Note that tritium (^3H) concentrations in sediment, soil, vegetation, and water are reported as pCi/L rather than μg/g. This is because tritium analyses were performed on water that was distilled from the samples.

As noted in the Introduction, sample collection occurred over a period of several days. Water samples were collected when water was present, but the significance of the analyses from the water samples is unclear because the samples represent several discharges from the treatment facility. These data are presented in this report simply to document the analytical results that were obtained from samples collected in Mortandad Canyon in May of 1979 so that the data are available for use in the ongoing Environmental Restoration Project canyon studies. Results of other contemporaneous studies in Mortandad Canyon were reported in papers by Hakonson et al. (1980) and Purtymun, Buchholz, and Hakonson (1977).

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Table 1: Sediment: Elemental concentrations, distance in meters downstream from discharge location*

Distance (m)	Be (μg/g)	Cd (μg/g)	Cl (μg/g)	Cr (μg/g)	F (μg/g)	NO_3 (μg/g)	PO_4 (μg/g)	SO_4 (μg/g)	^3H (pCi/L)	Hg (μg/g)
0	0.12 ± 0.02	0.14 ± 0.02	14 ± 1.4	31 ± 1	3 ± 0.3	< 0.5	6 ± 0.6	16 ± 0.2	0.2 ± 0.3	0.15 ± 0.02
50	0.16 ± 0.02	< 0.02	5 ± 0.5	44 ± 2	3 ± 0.3	1.6 ± 2	6 ± 0.6	7 ± 0.7	3.8 ± 0.4	0.05 ± 0.01
100	0.16 ± 0.02	0.08 ± 0.02	6 ± 0.6	34 ± 1	3 ± 0.3	1 ± 0.1	6 ± 0.6	9 ± 0.9	1.6 ± 0.3	1.7 ± 0.20
200	0.12 ± 0.02	< 0.02	3 ± 0.3	21 ± 1	3 ± 0.3	1 ± 0.1	< 1	< 2	4.7 ± 0.4	0.04 ± 0.01
300	0.13 ± 0.02	0.14 ± 0.02	3 ± 0.3	33 ± 1	3 ± 0.3	< 0.5	< 1	< 2	2.43 ± 0.6	0.18 ± 0.02
400	0.16 ± 0.02	0.21 ± 0.02	6 ± 0.6	28 ± 1	3 ± 0.3	28 ± 3	< 1	5 ± 0.5	2.56 ± 0.6	0.07 ± 0.01
500	0.15 ± 0.02	0.21 ± 0.02	5 ± 0.5	28 ± 1	3 ± 0.3	10 ± 1	6 ± 0.6	6 ± 0.6	3.06 ± 0.7	0.06 ± 0.01
600	0.16 ± 0.02	0.21 ± 0.02	9 ± 0.9	26 ± 1	4 ± 0.4	88 ± 9	5 ± 0.5	14 ± 1	4.13 ± 0.8	0.03 ± 0.01
700	0.12 ± 0.02	0.22 ± 0.02	7 ± 0.7	23 ± 1	3 ± 0.3	53 ± 5	7 ± 0.7	7 ± 0.7	3.6 ± 0.8	0.03 ± 0.01
800	0.13 ± 0.02	0.23 ± 0.02	7 ± 0.7	15 ± 1	3 ± 0.6	38 ± 4	< 1	6 ± 0.6	5.18 ± 1	0.04 ± 0.01
900	0.14 ± 0.02	0.23 ± 0.02	1 ± 0.1	16 ± 1	6 ± 0.6	31 ± 3	4 ± 0.4	5 ± 0.5	3.91 ± 0.8	0.04 ± 0.01
1000	0.15 ± 0.02	0.31 ± 0.02	< 0.1	19 ± 1	6 ± 0.6	13 ± 1	4 ± 0.4	9 ± 0.9	3.53 ± 0.8	0.03 ± 0.01
1100	0.12 ± 0.02	< 0.02	< 0.1	25 ± 1	5 ± 0.5	5 ± 0.5	4 ± 0.4	11 ± 1	3.22 ± 0.7	0.02 ± 0.01
1200	0.16 ± 0.02	< 0.02	< 0.1	26 ± 1	6 ± 0.6	11 ± 1	3 ± 0.3	6 ± 0.6	5.82 ± 1.1	0.05 ± 0.01
1300	0.17 ± 0.02	< 0.02	< 0.1	17 ± 1	6 ± 0.6	43 ± 4	4 ± 0.4	9 ± 0.9	4.84 ± 0.9	0.03 ± 0.01
1400	< 0.02	0.17 ± 0.02	< 0.1	15 ± 1	8 ± 0.8	61 ± 6	4 ± 0.4	7 ± 0.2	4.24 ± 0.9	0.07 ± 0.01
1500	< 0.02	0.13 ± 0.02	< 0.1	4.2 ± 0.5	8 ± 0.8	37 ± 4	5 ± 0.5	11 ± 0.1	6.19 ± 1.1	0.04 ± 0.01
1600	< 0.02	0.21 ± 0.02	< 0.1	11 ± 1	9 ± 0.9	51 ± 5	4 ± 0.4	9 ± 0.9	6.37 ± 1.1	0.05 ± 0.01
1700	< 0.02	0.21 ± 0.02	< 0.1	13 ± 1	9 ± 0.9	60 ± 6	6 ± 0.6	16 ± 2	6.49 ± 1.2	0.06 ± 0.01
1800	< 0.02	0.17 ± 0.02	< 0.1	2.7 ± 0.5	9 ± 0.9	59 ± 6	5 ± 0.5	11 ± 1	6.41 ± 1.2	0.11 ± 0.01
1900	< 0.02	0.15 ± 0.02	< 0.1	4.3 ± 0.5	3 ± 0.3	21 ± 2	2 ± 0.2	8 ± 0.8	6.96 ± 1.2	0.07 ± 0.01
2000	0.14 ± 0.02	0.16 ± 0.02	6 ± 0.6	5.4 ± 0.5	3 ± 0.3	96 ± 10	2 ± 0.2	13 ± 1	6.26 ± 1.1	0.04 ± 0.01
2100	0.07 ± 0.02	0.18 ± 0.02	< 0.1	6.8 ± 0.7	4 ± 0.4	13 ± 1	3 ± 0.3	< 2	5.36 ± 1	0.03 ± 0.01
2200	0.04 ± 0.02	0.20 ± 0.02	< 0.1	4.9 ± 0.5	4 ± 0.4	31 ± 3	5 ± 0.5	3 ± 0.3	5.16 ± 1	0.04 ± 0.01
2300	0.02 ± 0.02	0.21 ± 0.02	< 0.1	5.6 ± 0.5	6 ± 0.6	32 ± 3	4 ± 0.4	2 ± 0.2	4.84 ± 0.9	0.03 ± 0.01
2400	0.07 ± 0.02	0.11 ± 0.02	< 0.1	5.7 ± 0.5	3 ± 0.3	8 ± 0.8	5 ± 0.5	< 2	6.8 ± 0.4	0.03 ± 0.01
2500	< 0.02	0.14 ± 0.02	3 ± 0.3	5.7 ± 0.5	3 ± 0.3	13 ± 1	7 ± 0.7	< 2	4.5 ± 0.4	0.04 ± 0.01
2600	0.22 ± 0.02	0.16 ± 0.02	3 ± 0.3	6.1 ± 0.5	3 ± 0.3	12 ± 1	8 ± 0.8	< 2	9.8 ± 0.4	0.03 ± 0.01
2700	0.38 ± 0.04	0.15 ± 0.02	3 ± 0.3	2.5 ± 0.5	3 ± 0.3	19 ± 2	8 ± 0.8	< 2	4.5 ± 0.4	0.05 ± 0.01
2800	0.27 ± 0.03	0.09 ± 0.02	2 ± 0.2	1.2 ± 0.5	3 ± 0.3	4 ± 0.4	8 ± 0.8	< 2	4.6 ± 0.4	0.03 ± 0.01
2900	0.35 ± 0.04	0.15 ± 0.02	1 ± 0.1	3.1 ± 1	3 ± 0.3	7 ± 0.7	8 ± 0.8	< 2	9.4 ± 0.4	0.04 ± 0.01
3000	< 0.02	0.27 ± 0.03	0.8 ± 0.08	4.3 ± 0.1	3 ± 0.3	9 ± 0.9	10 ± 1	< 2	6 ± 0.3	0.03 ± 0.01
3100	< 0.02	0.10 ± 0.02	< 0.1	1.3 ± 0.5	2 ± 0.2	8 ± 0.8	6 ± 0.6	< 2	3.2 ± 0.4	0.02 ± 0.01
3200	< 0.02	0.12 ± 0.02	1 ± 0.1	1.3 ± 0.5	3 ± 0.3	7 ± 0.7	10 ± 1	< 2	5.0 ± 0.4	0.03 ± 0.01
3260	< 0.02	0.09 ± 0.02	0.7 ± 0.07	1.4 ± 0.5	4 ± 0.4	12 ± 1	11 ± 1	4 ± 0.4	1.7 ± 0.3	0.04 ± 0.01

* < values represent analytical detection limits

Table 2: Soil: Elemental concentrations, distance in meters downstream from discharge location*

Distance (m)	Be (µg/g)	Cd (µg/g)	Cl (µg/g)	Cr (µg/g)	F (µg/g)	NO_3 (µg/g)	PO_4 (µg /g)	SO_4 (µg/g)	^3H (pCi/L)	Hg (µg/g)
0	0.40 ± 0.04	0.04 ± 0.02	156 ± 16	23 ± 1	41 ± 1	354 ± 35	< 1	< 2	1.2 ± 0.3	0.77 ± 0.08
50	0.42 ± 0.04	0.07 ± 0.02	14 ± 1	21 ± 1	14 ± 1	3 ± 0.3	< 1	< 2	8 ± 3	0.03 ± 0.01
100	0.37 ± 0.04	0.23 ± 0.02	13 ± 1	25 ± 1	14 ± 1	< 0.5	26 ± 3	< 2	1.4 ± 0.3	0.04 ± 0.01
200	0.34 ± 0.04	0.02 ± 0.02	30 ± 1	26 ± 1	14 ± 1	21 ± 2	20 ± 2	< 2	6.6 ± 0.4	0.03 ± 0.01
300	0.30 ± 0.03	0.10 ± 0.02	5 ± 0.5	33 ± 1	11 ± 1	< 0.5	< 1	< 2	1.6 ± 0.3	0.04 ± 0.01
400	0.28 ± 0.03	0.04 ± 0.02	9 ± 0.9	27 ± 1	11 ± 1	< 0.5	< 1	< 2	2.1 ± 0.3	0.06 ± 0.01
500	0.36 ± 0.03	0.09 ± 0.02	14 ± 1	25 ± 1	13 ± 1	< 0.5	22 ± 2	10 ± 1	1.9 ± 0.3	0.03 ± 0.01
600	0.49 ± 0.03	0.39 ± 0.04	14 ± 1	32 ± 1	15 ± 1	< 0.5	52 ± 5	< 2	8 ± 3	0.09 ± 0.01
700	0.34 ± 0.03	0.02 ± 0.02	0.1 ± 0.01	24 ± 1	11 ± 1	< 0.5	< 1	< 2	2.9 ± 0.4	0.05 ± 0.01
800	0.51 ± 0.05	< 0.02	29 ± 3	30 ± 1	21 ± 2	11 ± 1	17 ± 2	36 ± 4	2.83 ± 0.07	0.18 ± 0.02
900	0.31 ± 0.03	0.05 ± 0.02	18 ± 2	16 ± 1	19 ± 2	30 ± 3	< 1	< 2	4.7 ± 0.4	0.04 ± 0.01
1000	0.36 ± 0.03	0.32 ± 0.03	16 ± 2	39 ± 2	15 ± 1	54 ± 5	31 ± 3	20 ± 2	3.3 ± 0.4	0.14 ± 0.01
1100	0.42 ± 0.04	0.24 ± 0.02	20 ± 2	36 ± 2	17 ± 1	22 ± 2	< 1	29 ± 3	3.0 ± 0.4	0.04 ± 0.01
1200	0.40 ± 0.04	0.10 ± 0.02	17 ± 2	21 ± 1	21 ± 2	22 ± 2	4 ± 0.4	40 ± 4	5.2 ± 0.4	0.03 ± 0.01
1300	0.61 ± 0.06	0.26 ± 0.03	14 ± 1	39 ± 2	15 ± 1	4 ± 0.4	< 1	29 ± 3	3.4 ± 0.4	0.20 ± 0.02
1400	0.45 ± 0.05	0.27 ± 0.03	< 0.1	11 ± 1	22 ± 2	11 ± 1	< 1	< 2	1.7 ± 0.3	0.05 ± 0.01
1500	0.37 ± 0.04	0.05 ± 0.02	< 0.1	17 ± 1	15 ± 1	63 ± 6	53 ± 5	< 2	4.1 ± 0.4	0.02 ± 0.01
1600	0.34 ± 0.03	< 0.02	< 0.1	17 ± 1	15 ± 1	7 ± 0.7	< 1	< 2	2.4 ± 0.3	0.15 ± 0.02
1700	0.40 ± 0.04	0.16 ± 0.02	< 0.1	30 ± 1	15 ± 1	16 ± 2	< 1	33 ± 3	2.0 ± 0.3	0.15 ± 0.02
1800	0.33 ± 0.03	0.19 ± 0.02	< 0.1	32 ± 1	21 ± 2	27 ± 3	37 ± 4	18 ± 2	2.5 ± 0.3	0.16 ± 0.02
1900	0.27 ± 0.03	0.28 ± 0.03	< 0.1	28 ± 1	9 ± 1	19 ± 2	31 ± 3	11 ± 1	1.0 ± 0.3	0.06 ± 0.01
2000	0.34 ± 0.03	0.54 ± 0.05	< 0.1	24 ± 1	15 ± 1	41 ± 4	34 ± 3	16 ± 2	2.3 ± 0.3	0.21 ± 0.02
2100	0.33 ± 0.03	0.61 ± 0.06	< 0.1	26 ± 1	6 ± 0.6	29 ± 3	41 ± 4	10 ± 1	8 ± 3	0.17 ± 0.02
2200	< 0.02	< 0.02	< 0.1	17 ± 1	8 ± 0.8	78 ± 8	42 ± 4	10 ± 1	1.7 ± 0.3	0.15 ± 0.02
2300	0.17 ± 0.02	< 0.02	< 0.1	14 ± 1	7 ± 0.7	< 1	28 ± 3	4 ± 0.4	8 ± 3	0.24 ± 0.02
2400	< 0.02	< 0.02	< 0.1	27 ± 1	10 ± 1	2 ± 0.2	25 ± 2	4 ± 0.4	1.3 ± 0.3	0.14 ± 0.01
2500	0.10 ± 0.02	0.23 ± 0.02	< 0.1	14 ± 1	18 ± 2	20 ± 2	35 ± 3	22 ± 2	1.9 ± 0.3	0.02 ± 0.01
2600	< 0.02	0.19 ± 0.02	< 0.1	18 ± 1	20 ± 2	6 ± 0.6	22 ± 2	25 ± 2	1.2 ± 0.3	0.02 ± 0.01
2700	0.15 ± 0.02	0.02 ± 0.02	< 0.1	17 ± 1	10 ± 1	17 ± 2	22 ± 2	9 ± 0.9	7 ± 3	0.12 ± 0.01
2800	< 0.02	0.24 ± 0.02	< 0.1	18 ± 1	11 ± 1	15 ± 1	36 ± 4	10 ± 1	4.4 ± 0.4	0.29 ± 0.03
2900	< 0.02	< 0.02	< 0.1	5.6 ± 0.6	4 ± 0.4	2 ± 0.02	24 ± 2	< 2	1 ± 0.0	0.02 ± 0.01
3000	< 0.02	0.09 ± 0.02	< 0.1	9.4 ± 1	8 ± 0.8	8 ± 0.08	23 ± 2	4 ± 0.4	1 ± 3	0.03 ± 0.01
3100	0.14 ± 0.02	0.26 ± 0.03	< 0.1	17 ± 1	8 ± 0.8	25 ± 2	36 ± 4	8 ± 0.8	3 ± 3	0.02 ± 0.01
3200	< 0.02	0.06 ± 0.02	< 0.1	10 ± 1	4 ± 0.4	16 ± 2	23 ± 2	8 ± 0.8	6 ± 3	0.02 ± 0.01
3260	0.07 ± 0.02	0.40 ± 0.02	20 ± 2	21 ± 1	10 ± 1	17 ± 2	48 ± 5	42 ± 0.4	1.4 ± 0.3	0.09 ± 0.01

* < values represent analytical detection limits

Table 3: Vegetation: Elemental concentrations, distance in meters downstream from discharge location*

Distance (m)	Be (μg/g)	Cd (μg/g)	Cl (μg/g)	Cr (μg/g)	F (μg/g)	NO_3 (μg/g)	PO_4 (μg/g)	SO_4 (μg/g)	^3H (pCi/L)
0	< 0.02	0.57 ± 0.06	3393 ± 339	12 ± 1	8 ± 0.8	< 100	3518 ± 352	900 ± 90	1.5 ± 0.3
50	0.23 ± 0.02	1.24 ± 0.12	3311 ± 331	22 ± 1	6.5 ± 0.7	372 ± 37	3006 ± 301	2203 ± 220	±
100	< 0.02	0.17 ± 0.02	545 ± 54	8.5 ± 1	30 ± 3.0	< 100	2420 ± 242	468 ± 47	9 ± 0.3
200	0.28 ± 0.03	0.63 ± 0.06	6473 ± 647	14 ± 1	4.8 ± 0.5	5822 ± 582	3189 ± 319	2467 ± 247	4.8 ± 0.4
300	< 0.02	1.29 ± 0.13	115 ± 11	4.1 ± 0.5	12 ± 1.2	2600 ± 260	3774 ± 377	1394 ± 139	7.7 ± 0.4
400	< 0.02	1.52 ± 0.15	6671 ± 667	8.1 ± 1	30 ± 3.0	1140 ± 114	2410 ± 241	2162 ± 216	5.5 ± 0.4
500	0.07 ± 0.02	0.89 ± 0.09	413 ± 41	11 ± 1	58 ± 5.8	1971 ± 197	1442 ± 144	694 ± 69	8.0 ± 0.4
600	0.03 ± 0.02	0.72 ± 0.07	2552 ± 255	17 ± 1	52 ± 5.2	234 ± 23	4856 ± 486	5539 ± 554	1.21 ± 0.5
700	0.33 ± 0.02	0.82 ± 0.08	4547 ± 455	11 ± 1	31 ± 3.1	623 ± 62	1994 ± 199	1675 ± 167	6.3 ± 0.4
800	0.52 ± 0.05	0.71 ± 0.07	8598 ± 852	15 ± 1	32 ± 3.2	4988 ± 499	3374 ± 337	2765 ± 276	1.98 ± 0.6
900	0.63 ± 0.06	0.56 ± 0.05	3836 ± 384	17 ± 1	14 ± 1.4	2664 ± 266	1595 ± 160	1625 ± 162	4.6 ± 0.4
1000	0.15 ± 0.02	0.67 ± 0.07	3162 ± 316	5.8 ± 0.5	57 ± 5.7	1439 ± 144	2781 ± 278	1011 ± 101	5.7 ± 0.4
1100	0.80 ± 0.08	0.29 ± 0.03	7242 ± 724	10 ± 1	21 ± 2.1	206 ± 21	1626 ± 163	3171 ± 317	4.3 ± 0.4
1200	0.12 ± 0.02	0.35 ± 0.04	888 ± 89	2.6 ± 0.5	4.5 ± 0.5	2493 ± 249	2178 ± 218	1189 ± 119	7.5 ± 0.4
1300	0.07 ± 0.02	0.12 ± 0.02	8018 ± 802	1.3 ± 0.5	52 ± 5.2	785 ± 79	3609 ± 361	2874 ± 287	5.8 ± 0.4
1400	0.38 ± 0.04	0.59 ± 0.06	6466 ± 647	4.8 ± 0.5	38 ± 3.8	2569 ± 257	1871 ± 187	3300 ± 330	4.2 ± 0.4
1500	0.48 ± 0.05	0.83 ± 0.08	7575 ± 757	9.4 ± 1	66 ± 6.6	3171 ± 317	2061 ± 206	2801 ± 280	8.5 ± 0.4
1600	0.24 ± 0.02	0.46 ± 0.05	5013 ± 501	11 ± 1	40 ± 4.0	< 100	1752 ± 175	1004 ± 100	1.52 ± 0.5
1700	1.04 ± 0.10	1.14 ± 0.11	4331 ± 433	2.3 ± 0.5	80 ± 8.0	3301 ± 330	1093 ± 109	1425 ± 142	1.63 ± 0.5
1800	3.90 ± 0.04	0.84 ± 0.08	10532 ± 1053	49 ± 2	54 ± 5.4	< 100	1652 ± 165	1540 ± 154	2.58 ± 0.6
1900	0.14 ± 0.02	0.38 ± 0.04	3032 ± 303	26 ± 1	6 ± 0.6	272 ± 27	2960 ± 296	2328 ± 233	1.5 ± 0.3
2000	0.19 ± 0.02	0.43 ± 0.04	10287 ± 1029	26 ± 1	10 ± 1.0	1459 ± 146	2712 ± 271	1965 ± 196	8.5 ± 0.4
2100	0.72 ± 0.07	0.55 ± 0.06	1099 ± 110	28 ± 1	4 ± 0.4	< 100	4540 ± 454	597 ± 60	2 ± 0.3
2200	0.16 ± 0.02	0.50 ± 0.05	2202 ± 220	27 ± 1	12 ± 1.2	660 ± 66	3349 ± 335	1813 ± 181	1.8 ± 0.3
2300	1.22 ± 0.12	0.43 ± 0.04	1450 ± 145	30 ± 1	3 ± 0.3	< 100	3949 ± 395	752 ± 75	1.2 ± 0.3
2400	0.07 ± 0.02	0.54 ± 0.05	2333 ± 233	3.5 ± 0.5	15 ± 1.5	< 100	5237 ± 524	889 ± 89	6 ± 0.3
2500	0.37 ± 0.04	0.89 ± 0.09	3198 ± 320	3.1 ± 0.5	4 ± 0.4	1205 ± 121	4508 ± 451	1635 ± 163	2.2 ± 0.3
2600	0.23 ± 0.02	0.68 ± 0.07	3249 ± 325	1.6 ± 0.5	4 ± 0.4	< 100	4268 ± 427	1173 ± 117	2.8 ± 0.4
2700	0.06 ± 0.02	0.45 ± 0.05	2094 ± 209	3.0 ± 0.5	3 ± 0.3	< 100	3489 ± 349	1157 ± 116	1.1 ± 0.3
2800	0.06 ± 0.02	0.37 ± 0.04	1780 ± 178	3.2 ± 0.5	2 ± 0.2	< 100	4141 ± 414	825 ± 82	5.0 ± 0.3
2900	0.05 ± 0.02	0.30 ± 0.03	553 ± 55	2.2 ± 0.5	7 ± 0.7	< 100	5401 ± 540	586 ± 59	3.0 ± 0.3
3000	0.16 ± 0.02	0.64 ± 0.06	1458 ± 146	2.4 ± 0.5	1 ± 0.1	213 ± 21	4235 ± 424	628 ± 63	1.5 ± 0.3
3100	0.06 ± 0.02	0.40 ± 0.04	1260 ± 126	3.7 ± 0.5	4 ± 0.4	< 100	4141 ± 414	991 ± 99	2.4 ± 0.3
3200	0.05 ± 0.07	0.77 ± 0.08	977 ± 98	2.2 ± 0.5	5 ± 0.5	< 100	3752 ± 375	2028 ± 203	5.0 ± 0.3
3260	0.07 ± 0.02	0.30 ± 0.03	2880 ± 288	2.3 ± 0.5	2 ± 0.2	< 100	5422 ± 542	825 ± 82	29.0 ± 0.4

* < values represent analytical detection limits

Table 4: Water: Elemental concentrations, distance in meters downstream from discharge location*

Distance (m)	Be (μg/g)	Cd (μg/g)	Cl (μg/g)	Cr (μg/g)	F (μg/g)	NO_3 (μg/g)	PO_4 (μg/g)	SO_4 (μg/g)	^3H (pCi/L)
0	0.6 ± 0.5	0.5 ± 0.3	5 ± 1	7 ± 1.9	0.6 ± 0.5	0.4 ± 2	< 2	2 ± 2	9 ± 3
50	0.2 ± 0.5	0.4 ± 0.3	5 ± 1	6.7 ± 0.5	0.6 ± 0.5	2 ± 2	< 2	4 ± 2	1.4 ± 0.3
100	0.1 ± 0.5	0.3 ± 0.3	5 ± 1	6.2 ± 0.3	0.5 ± 0.5	5 ± 2	< 2	4 ± 2	1.6 ± 0.3
200	0.2 ± 0.5	1.8 ± 0.3	6 ± 1	5.6 ± 0.3	0.4 ± 0.5	6 ± 2	< 2	4 ± 2	3.6 ± 0.4
300	0.1 ± 0.5	0.0 ± 0.3	20 ± 2	20 ± 0.4	2.1 ± 0.5	4 ± 2	43 ± 4	48 ± 5	5.75 ± 0.11
400	0.2 ± 0.5	1.0 ± 0.3	20 ± 2	19.4 ± 0.5	2.0 ± 0.5	533 ± 53	28 ± 3	47 ± 5	5.67 ± 0.1
500	0.2 ± 0.5	< 0.3	16 ± 2	19.3 ± 0.5	2.0 ± 0.5	354 ± 35	7 ± 2	47 ± 5	5.38 ± 0.1
600	0.2 ± 0.5	0.4 ± 0.3	28 ± 3	18.3 ± 0.3	2.0 ± 0.5	351 ± 35	46 ± 5	40 ± 4	5.11 ± 0.1
700	0.2 ± 0.5	< 0.3	18 ± 2	10.7 ± 0.3	1.2 ± 0.5	187 ± 19	22 ± 2	17 ± 2	3.23 ± 0.07
800	0.1 ± 0.5	< 0.3	12 ± 1	11.6 ± 0.3	1.3 ± 0.5	189 ± 19	< 2	22 ± 2	3.58 ± 0.08
900	0.2 ± 0.5	0.4 ± 0.3	17 ± 2	10.6 ± 0.4	1.1 ± 0.5	179 ± 18	30 ± 3	21 ± 2	3.32 ± 0.07
1000	0.2 ± 0.5	1.6 ± 0.3	9 ± 1	10.9 ± 0.3	1.1 ± 0.5	11 ± 2	262 ± 26	18 ± 2	3.18 ± 0.07
1100	0.1 ± 0.5	< 0.3	8 ± 1	10.1 ± 0.3	1.1 ± 0.5	157 ± 16	< 2	15 ± 2	2.95 ± 0.07
1200	0.1 ± 0.5	< 0.3	15 ± 2	10.8 ± 0.3	1.3 ± 0.5	184 ± 18	19 ± 2	28 ± 3	3.31 ± 0.07
1300	0.2 ± 0.5	0.2 ± 0.3	16 ± 2	10.6 ± 0.3	1.4 ± 0.5	206 ± 20	31 ± 3	29 ± 3	4.04 ± 0.08
1400	0.1 ± 0.5	0.1 ± 0.3	16 ± 2	10.7 ± 0.3	1.5 ± 0.5	208 ± 20	24 ± 2	17 ± 2	4.33 ± 0.09
1500	0.2 ± 0.5	0.3 ± 0.3	19 ± 2	9.3 ± 0.3	1.9 ± 0.5	242 ± 24	26 ± 3	32 ± 3	6.19 ± 0.11
1600	0.2 ± 0.5	0.3 ± 0.3	21 ± 2	8.7 ± 0.3	2.0 ± 0.5	249 ± 25	6 ± 2	52 ± 5	6.34 ± 0.11
1700	0.2 ± 0.5	1.0 ± 0.3	20 ± 2	8.7 ± 0.3	1.9 ± 0.5	236 ± 24	28 ± 3	38 ± 4	6.36 ± 0.11
1800	0.2 ± 0.5	0.7 ± 0.3	23 ± 2	8.9 ± 0.3	2.1 ± 0.5	217 ± 22	27 ± 3	41 ± 4	6.25 ± 0.11
1900	0.2 ± 0.5	0.6 ± 0.3	22 ± 2	9.0 ± 0.3	2.2 ± 0.5	210 ± 22	16 ± 2	43 ± 4	7.10 ± 0.12
2000	0.2 ± 0.5	0.7 ± 0.3	21 ± 2	9.1 ± 0.3	1.9 ± 0.5	213 ± 21	5 ± 2	40 ± 4	6.10 ± 0.1

* < values represent analytical detection limits